Global Phenomenon of e-health

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Advances in information and communication technology (ICT) have provided lots of opportunities to improve public health care all over the world. The things that were inconceivable a decade ago have become a reality due to health information technology (HIT). It has the capacity to lead us to health care perfection with good quality and efficiency. This has shown the potentiality transforming the delivery of health care to a new design with a change in the practice of medicine and the relationship between the physician and the patient[1]. HIT consists of a variety of technologies that enable the transmission of health information of the patients that has been stored and processed to the persons involved in health and health care. Among different types of HIT, electronic (e) health is of significance. E-Health refers to the use of information and communication technologies for health. It represents a commitment for networked global thinking to improve health care locally, regionally and worldwide by using ICT[2].

Man has practiced telemedicine since ancient times. A patient who is too sick to travel to a healer, his/her symptoms was described to the healer by an intermediary and the recommended therapy was carried back. Such an approach to telemedicine exists even today in remote, inaccessible areas of the country. This approach got an impetus when Kenneth Bird created a two-way audiovisual microwave circuit. It facilitated physician at Massachusetts General Hospital (MGH) in Boston to offer medical care to patients three miles away[3]. Today the integration of different media into a single system around computers with telecommunication, videoconferencing and real-time data transfer has brought about startling changes in telemedicine. Internet facility gave an impetus to the new technology. An e-mail message in April 1995 seeking international help for a Chinese student, Zhu Lingling suffering from a serious neurological disorder enabled to make the first recorded diagnosis of Guillain-Barre syndrome. Today it is possible to send routinely the clinical history, and imaging studies through the internet and carry out live demonstrations and remote consultations through videoconferencing[3]. It has opened a new chapter in health care delivery. The patient need not be transported to a place where the medical expert is based. Instead the knowledge of the expert is transported to the patient. Telemedicine is an application of ICT to deliver medical expertise from one place to another inside or outside the country, offering supportive health care at a distance, thus health care on line.

The transfer of medical information, images, text and sounds by using telephone and computer's network and software has been possible at an astonishingly rapid rate. Telemedicine refers to the use of ICT to link health care specialists with hospitals, clinics, primary care physicians and patients in order to provide remote diagnosis, treatment, consultation and continuing education. Telecommunication infrastructure offers the technology to pass the information electronically cutting across the institutional and geographic barriers to far off places linked to electronic networks. The telemedicine infrastructure consists of the equipment and mechanisms used to obtain and present clinical information, and to store and retrieve data. They include data digitizing and display, text processors and image processors and teleconferencing[4]. Electronic health record (EHR) system supplies patient's entire medical history, investigations and treatment. It is possible to treat a person in a far-off place by a physician in another part of the country or continent through the use of telemedicine. E-Health innovations such as electronic health records,

computer-assisted prescription systems and clinical databases are transforming health today. These developments are holding greater promise for the future, and are likely to bring about changes in the daily work of physician and other health care providers.

EHR is a system capable of performing eight functions electronically (functionalities). Of them the core functions are four and remaining are other functionalities[5].

Core functions

- Health information and data
- Results management
- Order entry and support
- Decision support

Other functionalities

- Electronic communication and connectivity
- Patient support
- Administrative support
- Reporting and population health management

Thus EHR is able electronically to collect and store data about patients, supply that information to providers on request, permit physician to enter and provide health professionals with advice for making health care decisions about individual patients[1].

E-Health is a global phenomenon. The development of eHealth provides a global view, to identify health trends, opportunity and emerging challenges to health. World Health Organization (WHO) has prepared the global baseline data on the existing state of eHealth. The complete profile of eHealth of the country can be accessed. It supports clinical care, provides information to the general public,

scientific information to professionals and provides a platform for publishing, disseminating health alerts. WHO on eHealth focuses on strengthening health systems in countries, fostering public-private partnerships in ICT, research and development for health supporting capacity building for eHealth and development and the use of norms and standards.ICT is gradually getting integrated into health systems and service in the country. WHO has taken the lead to strengthen health systems in countries fostering public-private participation in ICT The Global Observatory for e-Health will develop a set of tools and guidelines on e-Health policy[4]. WHO has planned to provide member states with strategic information and guidance on effective practices and standards on eHealth.

The objectives of the Global observatory for eHealth are

- To provide relevant, timely and high-quality evidence and information to support national governments and international bodies in improving policy, practice of management of eHealth
- To increase awareness and commitment of governments and the private sector to invest in promote and advance eHealth
- To generate knowledge that contributes to improve health through the use of ICT
- To disseminate research finding through publications.

Choudhry *et al* in a review on impact of HIT including HER,

on quality, efficiency and costs of medical care, have observed that implementation of a multifunctional HER system could increase the delivery of care that would adhere to guidelines and protocols, enhance the capacity of the providers of health care to perform surveillance and monitoring for disease conditions and care delivery, decrease rates of medication errors and lower utilization of care[6]. However the results on the efficiency of care and productivity of physicians were equivocal. In India more than one hundred projects in telemedicine have been created, and it has led to a significant increase in experience of expertise in the sphere of telemedicine. There is a necessity to establish e-Health governance bodies. Our country has to draw up a long-term strategic plan for the development and implementation of e-Health service.

Applications -The application of e-Health includes the following domains

- **Public services** - information services provided to the citizens usually via internet in a digital format
- **Knowledge services** - electronic information and education services aimed at health care professionals in training and practice. International and National electronic journals published in electronic format, and National open archives in which the authors deposit their works in digital format for dissemination of scientific information. A health professional can

upgrade his knowledge and skills through e-Learning by staying his place. eLearning is successfully utilized for education and training of students of health and medical sciences. It has brought about improvement in quality of education; and has increased accessibility to geographically isolated students. It has helped students with poor local learning facilities. It offers a cost-effective delivery of courses to large number of people throughout the world.

- **Provider services**- eHealth tools and services used in the provision of health care to citizens.

WHO in collaboration with public and private sector partners proposes to facilitate the development of general eHealth tools to monitor and evaluate eHealth services, accessibility to exiting tools, and knowledge exchange, and professional education. Together we must work to build a healthier world-a world where information and communication technologies help support and enhance health care services and are available to all. The findings of the global survey for eHealth confirm that the use of ICT is steadily being integrated into health systems and services worldwide. The survey has found that there has been strong growth since 2000 in many areas assessed. E-Learning can effectively improve the quality of education[7].

References

1. Blumenthal D, Glaser JP. Information technology comes to Medicine. N Engl J Med. 2007: 356; 2527-37

2. Eysenbach G. Editorial. What is eHealth? Jour Med Internat Res. 2001: 3; e20

3. Building Foundation for eHealth. Progress of Member States. Report of the WHO Global Observatory for eHealth. Geneva, World Health Organization, 2006

4. Shankar PS. Telemedicine Technology *in* Recent advances in Medicine-2. Mumbai, National Book Depot. 2003:101-104

5. Waegemann CP. Closer to reality personal health records health care IT system and accessibility on patient data. Health Manag Technol 2005: 26; 16-18

6. Choudhry B. Wong J, Wu S, *et al*. Systematic review: Impact of helath information technology on quality efficiency and costs of medical care. Ann Intern Med. 2006: 144; 742-52

7. WHO Global Observatory for eHealth. eHealth tools and services-need of the member states. Geneva, World Health Organization. 2006

Recent advances in intravenous anesthesia

Efforts to develop new hypnotic compounds continue, although several have recently failed in development. Propofol has been reformulated in various presentations with and without preservatives. Pharmacokinetic and pharmacodynamic differences exist between some of these preparations, and it is currently unclear whether any have substantial advantages over the original presentation. The use of target-controlled infusion (TCI) has been extended to include paediatric anaesthesia and sedation. Application of TCI to remifentanil is now licensed. Linking of electro-encephalogram (EEG) monitoring to TCI for closed-loop anaesthesia remains a research tool, although commercial development may follow. The availability of stereoisomer ketamine and improved understanding of its pharmacology have increased non-anaesthetic use of ketamine as an adjunct analgesic. It may be useful in subphynotic doeses for postsurgical patients with pain refractory to morphine administration.

Basic Life Support

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Basic life support (BLS) includes assessing and managing sudden cardiac arrest (SCA), heart attack, stroke, foreign body airway obstruction (FBAO); performing cardiopulmonary resuscitation (CPR) using defibrillation with automated external defibrillator (AED), if required.

SCA is one of the leading cause of death. Most patients demonstrate ventricular fibrillation (VF) at some point in their arrest. Resuscitation is the most successful if defibrillation is performed early preferably within 5 minutes of collapse. Asphyxial cardiac arrest is seen mainly in children but can also occur in victims of trauma, drug overdosage, drowning[1]. Treatment for VF SCA is immediate CPR along with delivery of a shock with defibrillator. CPR with both chest compression and ventilation is critical for resuscitation in asphyxial arrest. The American Heart Association uses 4 links in a chain (the "*chain of survival*") to illustrate the important time sensitive actions for victims of VF SCA [2]:

- Early recognition of the emergency and activation of the EMS / local emergency response system. (Ambulance –102)
- Early bystander CPR
- Early delivery of shock with a defibrillator
- Early advanced life support.

Adult BLS Sequence

The BLS Primary Survey is an '**ABCD**' (**A**irway, **B**reathing, **C**irculation, **D**efibrillation) approach using a series of sequential assessments. Each assessment is followed by appropriate action(s) if needed. After ensuring the safety of scene, the responsiveness of victim should be checked by tapping on shoulder and asking, "*Are you all right?*" or similarly in any other local language. If victim responds, than make a call for medical assistance and recheck victims condition frequently. If the victim is unresponsive, the rescuer should activate EMS and get an AED. CPR should be started. Victim should be placed on hard surface in supine position. Airway should be assessed and patency maintained using "*Head tilt – chin lift*" maneuver (lift up with 2 fingers on the chin while pushing down on the forehead with the other hand) in victims without evidence of head or neck trauma. If cervical spine injury is suspected, the airway is to be opened using a jaw thrust without head extension. Because maintaining a patent airway and providing adequate ventilation is a priority in CPR, use head tilt chin lift maneuver if jaw thrust does not open the airway. Breathing is to be assessed by "*Look-Listen-Feel*" while still maintaining an open airway

within maximum of 10 sec. Place your ear next to the victim's mouth and nose and listen for breathing, turning your head to observe the chest. Look for chest to rise. Listen and feel for air movement on your cheek. If patient is adequately breathing, then patient is to be placed in recovery position and assessed at frequent intervals. If the patient is not breathing or having occasional gasps, than 2 rescue breath is to be given over 1 sec each so as to have visible chest rise. If chest does not rise, reposition the head, make better seal and try again. These rescue breaths may be given mouth-to-mouth, mouth to mask or using bag mask ventilation. Place your mouth around the victim's mouth and pinch the nose closed or place the barrier device on the victim's face and place your mouth on the breathing piece or opening. Continue to tilt the head and lift the chin and give breaths. Avoid delivery of breaths that are too large or too forceful. When an advanced airway is in place during 2 person CPR, ventilate at rate of 8-10 breaths per minute without attempting to synchronize breaths between compressions. Instead, the compressing rescuer should give continuous chest compression sat rate of 100/min without pauses for ventilation. The 2 rescuers should change compressor and ventilator roles

approximately every 2 minutes to prevent compressor fatigue and deterioration in quality and rate of chest compression. There should be no pause in chest compression for delivery of ventilation. During adult CPR, tidal volume of approximately 500-600 ml (6-7 ml/kg) should suffice, so as to produce *visible chest rise*. When oxygen is available, health care providers should provide it a minimum flow rate of 10-12 L/min. If third rescuer is available, cricoid pressure may be applied in deeply unconscious victim (i.e. has no cough or gag reflex).

After giving 2 rescue breaths, carotid pulse should be checked taking not more than 10 seconds but spent at least 5 seconds in doing so. If "*definite pulse*" is present, continue giving breaths every 5-6 seconds and each breath to be given over 1 sec. If no pulse is present start with chest compressions. The rescuer should compress the lower half of the victim's sternum in the center (middle) of the chest, between the nipples. The rescuer should place the heel of the hand on the sternum in the center (middle) of the chest between nipples and then place the heel of the second hand on the top of the first so that the hands are overlapped and parallel. Depress the sternum approximately one-half to two inches (4-5 cm) and then allow the chest to return to its normal position. To give "*effective*" chest compressions, '*push hard and push fast*' at a rate of about 100 compressions per minute and allow the chest to recoil completely[3]. Emphasis must be given to minimize interruption in chest compressions during CPR. Thereafter cycles of 30 compressions and 2 breaths are given[4]. Once an advanced airway is in place, 2 rescuers no longer deliver cycles of CPR i.e. compressions interrupted by pauses for ventilation. Instead, the compressing rescuer should give continuous chest compressions at a rate of 100/min without pauses for ventilation. The rescuer delivering ventilation provides 8-10 breaths /min. the compression rate refers to the speed of compression s and not the actual number of compressions delivered /min.

These cycles should be continued till the AED arrives / ALS provider take over or victim starts to move. As soon as AED / defibrillator is available it is to be attached and rhythm analyzed. CPR should not be interrupted during attachment of AED pads. If the rhythm analyzed is shockable, one shock of 200 joules is to be delivered followed by resumption of CPR immediately for 5 cycles. If rhythm is not shockable, continue with CPR for another 5 cycles. Check rhythm every 5 cycles. For adult out of hospital cardiac arrest that is not witnessed by EMS provider, rescuers may give a period of CPR (about 5 cycles or about 2 minutes) before checking the rhythm and attempting defibrillation.

Special resuscitation situations

Drowning: Asphyxia is the predominant cause of cardiac arrest in drowning patient. Rescuers should provide CPR, particularly rescue breathing, as soon as an unresponsive submersion victim is removed from the water. When rescuing a drowning victim of any age, the lone healthcare provider should give 5 cycles (about 2 minutes) of CPR before leaving the victim to activate the EMS system.

Hypothermia: In an unresponsive victim with hypothermia, a healthcare provider should assess breathing to confirm respiratory arrest and assess the pulse to confirm cardiac arrest or profound bradycardia for 30-45 seconds because heart rate and breathing may be very slow, depending on the degree of hypothermia. If victim does not have a pulse, begin chest compression immediately. Do not wait until the victim is rewarmed to start CPR. Measures to warm the patient should be started.

Foreign Body Airway Obstruction (FBAO):

FBAO is usually caused by impacted food while eating and thus usually witnessed. It may cause either mild or severe airway obstruction. If mild obstruction is present and the victim is coughing forcefully do not interfere with the patients spontaneous coughing and breathing efforts. Attempts to relieve the obstruction only if signs of severe obstruction develop like signs of poor gas exchange and increase breathing difficulty: the cough becomes silent, respiratory difficulty increases and is accompanied by strider, or the victim becomes unresponsive. Chest thrusts, back slaps and abdominal thrusts are considered quite effective for relieving severe FBAO in conscious (responsive) adults and children >=1 year of

age[5]. AHA recommends abdominal thrust to be applied in rapid sequence until the obstruction is relieved[2]. If abdominal thrusts are not effective, the rescuer may consider chest thrust. Chest thrust may also be primarily considered in obese and pregnant victims. If the adult victim with FBAO becomes unresponsive, the rescuer should carefully support the patient to the ground, immediately activate EMS, and then begin CPR. During CPR, when airway is opened, the rescuer should look for an object in the victim's mouth and remove it finger sweep is to be done only when the provider can see solid material obstructing the airway of an unresponsive patient.

Paediatric BLS

The basic sequences of steps for CPR are almost similar to adults with few exceptions. Asphyxial arrest is more common in children than the cardiac cause for arrest, thus mandating 5 cycles of CPR before activating EMS. In children if 2 rescuers are present then cycles of compression to ventilation changes to 15:2. If the victim has perfusing rhythm (i.e. pulse present) but no breathing, then 12-20 breaths / minute (1 breathe every 3-5 sec) is to be given. The compression site for infant is just below the nipple line (lower half of sternum) and use 2-3 fingers or thumb encircling hands for chest compression in infants. The depth is approximately 1/3 to ½ of the depth of chest. For defibrillation, child pads are to be used. Infants <1 year of age, defibrillation is not recommended[2]. Brachial pulse in infant and carotid/femoral pulse is to be checked in child.

To summarize, components of CPR known to effect hemodynamics include ventilation rate and duration, compression depth, compression rate and number, complete chest recoil and hands off time. A timely action in a sequential manner for CPR can bring about good outcome for resuscitation.

References

1. Mogayzel C, Quan l, Graves JR, Tiedeman d, Fahrenbruch C, Herndon P, Out of hospital ventricular fibrillation in children and adolescents: causes and outcomes. Ann Emerg Med 1995;25:484-91.

2. Mary FH, Leon C, Robert H, 2005 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2005; 122(24):19.

3. International Liaison Committee on resuscitation. 2005 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Circulation 2005;112:III-I-III-136.

4. Babbs CF, Kern KB, Optimum compression to ventilation ratios in CPR under realistic, practical conditions: a physiological and mathematical analysis. Resuscitation 2002;54:147-57.

5. Heimlich HJ, A life saving maneuver to prevent food choking. JAMA1975;234:398-401.

Anesthesia, the Word

The following passage comes from The American Heritage Dictionary of the English Language, 3rd edition, printed by Houghton Mifflin Company, Boston, 1992. Oliver Wendell Holmes, a physician-poet and the father of the Supreme Court justice of the same name, wrote the following on November 21, 1846: "Every body wants to have a hand in a great discovery. All I will do is to give you a hint or two as to names-or the name-to be applied to the state produced and the agent. The state should, I think be called 'Anaesthesia' (from the Greek word anaisthesia, 'lack of sensation') This signifies insensibility... The adjective will be 'Anaesthetic'. Thus we might say the state of Anaesthesia, or the anaesthetic state" This citation is taken from a letter to William Thomas Green Morton, who in October of that year had successfully demonistrated the use of ether at Massachusetts General Hospital in Boston. Although anaesthesia is recorded in Nathan Bailey's Universal Etymological English Dictionary in 1721, it is clear that Holmes really was responsible for its entry into the language. The Oxford English Dictionary has several citations for anesthesia and anesthetic in 1847, indicating that the words gained rapid acceptance.

An Approach to a Case of Lower Gastrointestinal Bleeding

Commentary

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Lower gastrointestinal bleeding traditionally means bleeding from sites distal to the ligament of Treitz that presents as rectal bleeding. The may be overt or occult. Lower GI hemorrhage is defined as an abnormal intraluminal blood loss from a source distal to the ligament of Treitz. This bleeding may be overt or occult, and overt bleeding can be acute massive or chronic a useful subdivisions for clinical purposes.

Clinical presentation-Lower gastrointestinal bleeding may present as acute massive, chronic intermittent or occult rectal bleeding. Massive hemorrhage is a life-threatening condition and requires transfusion of at least 5 units of blood. Patients with massive hemorrhage present with a systolic blood pressure of less than 90 mm Hg and a hemoglobin level of 6 g/dL or less. These patients are usually aged 65 years and older, have multiple medical problems, and are at risk of death from acute hemorrhage or its complications.

Causes of lower GI bleeding- Most bleeding from the lower gastrointestinal tract is of colonic origin, with some from sites in the small intestine distal to the ligament of Treitz. However, around 15-20% of episodes of lower gastrointestinal bleeding are thought to arise from more proximal parts of the small intestine or the upper gastrointestinal tract. Hemorrhoids are probably the most common cause of lower GI bleeding. Anal fissures may also present as bleeding. If these local anorectal processes are excluded, the most common causes of lower GI bleeding in adults are-Diverticulosis; Angiodysplasia; NSAIDs; Neoplasma; Inflammatory bowel disease-Ulcerative colitis, Crohn's disease; Mesenteric vascular insufficiency – Ischemic colitis; Radiation colitis; Infectious colitis. Less common causes of lower gastrointestinal include-Meckel's diverticulum; Vasculitides; Small intestinal causes such as Vascular ectasias, Diverticula,Ulceration; Intussusception; Endometriosis; Bleeding in runners; Dieulafoy's lesions; Visceral arterial aneurysm; AIDS-HIV associated thrombocytopenia,Cytomegalovirus colitis, Idiopathic colonic ulcers,Colonic histoplasmosis, Kaposi's sarcoma of colon; Stercoral ulce. Based on the data of three large studies[1,2,3] published from India, the causes of lower GI bleeding are -Non-specific colitis,Ulcerative colitis, Rectal ulcers, Polyps, Neoplastic, Colonic tuberculosis, Enteric fever. Diverticular disease of colon is a rare entity in our country[4]; true incidence of which is not known.

Physical examination-Physical examination is helpful for assessing the extent of bleeding but any findings are too non-specific to determine the cause. Patients who lose 15-20% of their blood volume will present with orthostatic hypotension; shock occurs after 25-35% blood loss. Patients with chronic blood loss may not show Orthostatic changes, but often have signs of anemia such as pallor. The skin should be carefully inspected for stigmata of liver diseases as well as presence of telangiectasia. The abdomen should be assessed for organomegaly, masses, and tenderness. Presence of rebound tenderness or guarding should be noted and is relative contraindications to colonoscopy. The pitch and frequency of bowel sounds as well as any bruit should be noted.The perianal area should be inspected for fissures, hemorrhoids, masses, and fistula. Digital rectal examination should be directed at identifying masses and strictures; in addition any material on the gloved examining finger should be assessed for colour, amount, consistency, presence of stool, and tested for occult blood unless obvious. Anoscopy and sigmoidoscopy should be done in every patient with lower gastrointestinal bleeding because it may detect obvious, low-lying lesions such as bleeding hemorrhoids, anal fissure, rectal ulcer, proctitis, or rectal cancer. The procedure is dif-

ficult when bleeding is brisk, and it often is impossible to tell whether blood is coming from above the sigmoidoscope or from a lesion below. Presence of blood proximal to the anoscope does not preclude an anorectal source and warrants further investigation. Most patients with severe hemorrhage should have a complete examination of the colon before the bleeding is attributed to an anorectal lesion. A nasogastric lavage must be performed in every patient with severe rectal bleeding because the consequences of missing an upper gastrointestinal tract lesion may be catastrophic. If the aspirate is bloody, the site of bleeding is always in upper GI tract. Very few cases of bleeding from duodenal ulcer may be missed by nasogastric lavage. If the aspirate is clear, in most of the cases the source of blood loss is in the lower GI tract.

Diagnostic procedures-Diagnostic modalities appropriate for investigation of patients with lower gastrointestinal bleeding include radionuclide scanning, angiography, and colonoscopy.

Exclusion of Upper gastrointestinal Source-An upper GI source (e.g. bleeding duodenal ulcer) may be present in about 5% to 10% of patients with hematochezia and in some cases, will not be associated with a positive nasogastric aspirate. Thus patients with hematochezia and hemodynamic instability generally should undergo upper endoscopy to rule out an upper GI lesion before the more arduous evaluation of the lower GI tract is undertaken.

Colonoscopy -Colonoscopy is the procedure of choice in patients with lower GI bleeding unless bleeding is too massive or unless sigmoidoscopy or anoscopy has disclosed an obvious actively bleeding lesion (the presence of nonbleeding hemorrhoids must not deter the physician from seeking another, more proximal lesion, especially in patients over age 40). Colonoscopy offers the most direct way to visualize the colonic mucosa and can even be performed in patients who are actively, although not massively, bleeding. Emergency colonoscopy was first reported in acute lower GI bleeding in early 1970s. emergency colonoscopy is technically successful in most patients with acute bleeding, but requires colonic lavage for optimal visualization. Oral purge using balanced electrolyte solution is successful in most cases. The lavage should not be started until the patient is hemodynamically stable. The timing of the colonoscopy has a direct bearing on the positive yield of the colonoscopy. In one study, the number of positive diagnosis increased from 48% for delayed procedures to 85% when colonoscopy was performed while the patient was actively bleeding. Some investigators have proposed specific criteria for endoscopic diagnosis. The segmental localization of fresh blood in an area of colon inhabited by a potential bleeding source has also been used to apply validity to a colonoscopic diagnosis. A short segment of terminal ileum can often be visualized during routine colonoscopy.

The diagnosis of small bowel bleeding has been made when fresh blood has been found in the terminal ileum or coming through ileoceacal valve and UGIE is negative. The finding of fresh blood in the colon and no blood in the ileum suggests the colon as source of bleeding. Colonoscopy has a primary role in the majority of patients with lower GI bleeding and emergency colonoscopy offers a high diagnostic yield with excellent therapeutic and prognostic potential.

Criteria for colonoscopic diagnosis of bleeding site or level-

- Active colonic bleeding colonic site.
- Nonbleeding visible vessel
- Adherent clot
- Fresh blood localized to a colonic segment
- Ulceration of a diverticulum with fresh blood in immediate area.
- Absence of fresh blood in the terminal ileum with fresh blood in colon

Anigography-Rationale: bleeding localization facilitates limited bowel resection. Surgery without preoperative localization of the bleeding site, results in more extensive bowel resection and higher intraoperative and postoperative mortality. Transcatheter control of the bleeding site with either vasopressin or embolotherapy can allow for elective, rather than emergent, surgical resection. Theangiographic localization of gastrointestinal bleeding relies on the detection of contrast extravasation into the bowel lumen. This

is not seen in all patients even when there is clinical evidence of recent active bleeding, because of the intermittent nature of blood loss. During each arteriogram the injected contrast medium will be present only for a few seconds within the vessel from which the bleeding has occurred; if there is no active bleeding during that short period, contrast extravasation will not be seen.

When to consider angiography-Angiography is more likely to demonstrate the site of hemorrhage if there ongoing and active bleeding.

Radionuclide Scanning-Another diagnostic test in patients with acute lower GI bleeding consists of the use of an external gamma-counter to detect intestinal extravasation of intravenously administered techneticum 99m sulfur colloid (^{99m} Tc-SC). ^{99m} Tc has also been used to label red blood cells in vitro that, after reinjection into the patient, act as a blood pool scan. These scans are easy to perform, require no patient preparation, and are noninvasive. Active hemorrhage is conclusively diagnosed when a focus of activity is identified, increased in intensity over time conforms to small or large bowel anatomy, and shows antegrade or retrograde peristalsis.

Barium Enema-Contrast studies of the colon have no place in the diagnosis of ongoing lower GI bleeding. No only may the bleeding lesion be missed, but the interpretation may be misleading, particularly if diverticula are the only findings.

Overall diagnostic approach-Every patient presenting with acute lower GI bleeding should be promptly admitted in hospital. First and foremost, hemodynamic stablisation of the patient takes the priority. Upper GI bleeding must initially be excluded by nasogastric aspiration and upper GI endoscopy. Anoscopy and screening sigmoidoscopy should be carried out as early as possible after presentation to rule out local anorectal lesions. Further protocol of diagnostic evaluation depends on the profile of the patient. Colonoscopy is the most appropriate first investigation in majority of the patients. It should be carried out as early as possible after hemodynamic resuscitation has been carried out. The diagnostic yield of colonoscopy drops significantly after bleeding has stopped. Angiography may be considered as the first investigation in cases of massive lower GI bleeding where colonoscopy may be technically difficult. Angiography may demonstrate extravasation of the contrast material in the lumen of bowel. In cases of acute visible rectal bleeding where colonoscopy fails to demonstrate the source of bleeding, angiography should be the next investigation of choice. In patients of acute lower GI bleeding where the source has not been demonstrated by colonoscopy and angiography, radionuclide scanning may be undertaken. Another approach for diagnosis of patients of acute lower GI bleeding and failed colonoscopy (technically difficult or nonrevealing) is to carry out radionuclide scanning to localize the bleeding segment of the bowel, and then to go for targeted angiography to confirm the site, and sometimes the etiology of bleeding.Radionuclide scanning should be considered before angiography in cases of intermittent,, slow bleeding, after colonoscopy has proven to be inconclusive. If the radionuclide scanning shows early blush on the tracer uptake, angiographic cannulation of the appropriate vessel is carried out to confirm the bleeding site. In patients of slow, intermittent bleeding, if the radionuclide scanning is nonrevealing, it is highly unlikely that angiography would be of any use. Barium studies may help in a few cases to suggest the possible lesion which could cause lower GI bleeding.

Treatment -Three major aspects are involved in managing lower GI hemorrhage. The initial priority is to treat the shock. Blood should be available for transfusion and large bore IV access obtained. After initial resuscitation, a search is undertaken for the cause of bleeding in order to diagnose the bleeding point precisely. Localization of the source of bleeding is required to formulate an interventional plan.

Colonoscopic therapy-Colonoscopy is the usual initial investigation in most of the patients and can identify active bleeding or the stigmata of recent bleeding. The success rate of diagnosing a bleeding source during colonoscopy rages from 48 to 90%. Therapeutic colonoscopy is a procedure in evolution as endoscopic hemostasis has been reported as being successful.Diverticular bleeding is identified by active visible hem-

orrhage, a non-bleeding visible vessel, or an adherent clot. Mechanical methods, using a metal clip or elastic band, to seal a bleeding vessel or the diverticular mouth can be employed. Otherwise, more commonly, 1 or 2 ml aliquots of epinephrine (dilution 1:20,000) are injected into quadrants around the site to control the bleeding by inducing spasm of the vasculature in the region, or by temponade via occlusion of the lumen of the diverticulum. Non-bleeding visible vessels are treated with bipolar coagulation with 10 to 15W of power until flattening of the vessel is achieved. Non-bleeding adherent clots are injected with epinephrine in four quadrants around the pedicle of the clot and the clot is then shaved down to 3-4mm above the attachment with a polypectomy snare. By cutting it off without coagulation and without pulling the clot off its attachment, one minimizes the risk of re-bleeding. Endoscopy is usually successful for angiodysplasia and is reported as having an 85-90% success rate. Endoscopic coagulation of angiodysplasias is becoming a treatment of choice using either heated probe or lasers such as Nd: YAG and argon. Endoscopic control of bleeding can also be achieved using sclerosing agents. Absolute alcohol, morrhuate sodium and sodium tetradecyl sulfate can be used for sclerotherpy of lower GI lesions. Postpolypectomy hemorrhage may be immediate or delayed. The control of immediate bleeding complicating polypectomy essentially involves ensnaring the residual pedicle for a further 5-10mm. endoscopic hemostasis may also be carried out by injection of adrenalin followed by heater probe or bipolar/multipolar electrocoagulation. Successful endoscopic hemostasis has also been reported using the endoscopic haemoclip.

Angiographic therapy-Once the bleeding point is identified, angiography offers potential treatment options such as selective vasopressin drip and embolization. Following positive angiogram findings, the angiographic catheter may be left in place and vasopressin infusion stated. Vasopressin is a pituitary hormone that causes severe vasoconstriction in the splanchnic bed. Vasoconstriction reduces the blood flow and facilitates hemostatic plug formation in the bleeding vessel. The results are less than satisfactory in patients with severe atherosclerosis and coagulopathy and bleeding tumors.Superselective embolization of the mesenteric vessels is an alternative technique for treating massive lower GI bleeding.

Surgical Therapy -Several surgical options are used in the management of patients with lower GI bleeding:

- Emergency limited segmental resection for a known bleeding source in a patient with continued severe bleeding (Directed segmental resection).

- Elective segmental resection for a known bleeding source or for rebleeding from a known lesion.

- Emergency segmental colon resection for an unknown bleeding source (Blind segmental resection).

- Emergency total abdominal colectomy with ileorectal anastomosis (Subtotal colectomy) for an unknown bleeding source.

References

1. Anand AC Patnaik PK, Rana VS., Massive lower intestinal bleeding – a decade of experience. Trop Gastroenterol 2001 Jul-Sep;22(3):131-4.

2. Bhargava DK, Rai RR, Dasarathy S., Colonoscopy for unexplained lower gastrointestinal bleeding in a tropical country. Trop Gastroenterol 1995 Jan-Mar;16(1);59-63.

3. Goenka MK Kochhar R, Mehta SK., Spectrum of lower gastrointestinal hemorrhage: an endoscopic study of 166 patients. Indian J Gastroenterol 1993 Oct;12(4): 129-31.

4. Ibrarullah M, Kapoor VK, Kackcer L, Awasthi S. Diverticular disease of colon; Indian variant. Trop Gastroenterol 1991 Apr-Jun;12(2):87-90.

Obstetric anesthesia – complications and their management

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Anesthetic management of Obstetric patient seems simple enough but it poses a great challenge to the anesthetist because of the two lives involved, physiologic changes that each organ system undergoes, and also because complications are very common, often preventable and can prove fatal at times.

Why is obstetric practice so fraught with complications?

Leading causes of obstetric complications:-

- Ignorance and inexperience of attending staff
- Low general standards of care in labour room (LR)
- Poor administrative practices
- Wrong / delayed decision making
- Acid aspiration prophylaxis missing
- Inadequate monitoring
- Non-acceptance of peer review & fair criticism
- Poor understanding of the risk of anesthesia
- Failure to manage massive blood loss
- Lack of familiarization with "failed intubation drill"

Most complications can be avoided if an obstetric unit is well equipped with Monitors (SpO$_2$, NIBP, ECG, and CVP), easily operable OT Table, efficient suction apparatus, provision for O$_2$, IV drugs and fluids and a well equipped baby resuscitation corner.

Problems faced during Obstetric Anesthesia

- Difficult airway / Failed intubation
- Acid aspiration /Mendelson's syndrome
- Amniotic fluid embolism (AFE)
- Maternal awareness
- Supine hypotensive syndrome/Aorto Caval compression
- CNS Depression & Delayed recovery
- Hemorrhage (uterine rupture/atony)
- Anaphylactic reaction

  The four dreaded complications are discussed below:

Difficult airway / Failed intubation-Airway problem is a cause of concern in obstetric patients and failure to intubate the trachea can prove life threatening. All anesthetists should be familiar with the failed intubation drill and alternative management techniques. The standard goal of all obstetric management is "oxygenation without aspiration**"**

Factors predisposing obstetric patients to difficult airway

- Pharyngeal/laryngeal edema
- Airway bleeding- hyperemic airway mucosa
- Large breasts- problem with proper laryngoscopy and application of cricoid pressure
- Lateral wedge placement - abnormally tilts the thorax with loss of airway alignment
- Incomplete relaxation of vocal cords- less dose of relaxant or inadequate time for its effect
- Inappropriate size of laryngoscope blade / endotracheal tube (ET)
- Failure to evaluate the airway difficulty

  Airway assessment should be done in all patients coming for LSCS, pre operatively and findings recorded (irrespective of the anesthesia technique chosen)

- **Detailed history** of previous anesthetic exposure and problems, check the records if available
- Look for **malformations** – swelling, edema, tumors, and large tongue
- **Body habitus** - Obesity, multiple pregnancy, hydra-amnios increase intubation difficulty. Large breasts prevent proper direct laryngoscopy, rather than airway difficulty. A short blade or Polio blade is useful
- **Mallampati scoring** (1983, modified by Samsoon & Young 1985) – according to the laryngeal/pharyngeal

structures visualized with naked eye (prerequisite- observer should stand at eye level, using light source, patient sitting comfortably on a stool, head in neutral position, mouth open, tongue protruding maximally without phonation)

Grade 1 - soft palate, fauces, uvula and tonsillar pillars seen

Grade 2- soft palate, fauces, and uvula seen

Grade 3 - soft palate and base of uvula seen

Grade 4 - soft palate also not visible

- **Cormack & Lehans grading** (1984) – according to structure seen at laryngoscopy

Grade 1 - most glottis visible

Grade 2 - only posterior extremity of glottis visible

Grade 3 - no part of glottis visible, epiglottis visible

Grade 4 - not even epiglottis seen

Grades 1/ 2 – low risk for intubation - (1.3% risk)

Grade 3 - difficult intubation - (4.3% risk)

Grade 4 -   very difficult intubation –(6.6% risk)

- **Inter incisor gap / mouth opening** (normal - >5 cm, difficulty if less) Distance between line of vision (LOV) & lower incisor (N>2.5cm, difficulty if less)

- **Atlanto-occipital extension / neck mobility**- is important for aligning oral & pharyngeal axis at direct laryngoscopy. Best alignment is in sniffing position. Head is maximally extended and the angle traversed by the occlusal surface of maxillary teeth, from neutral position (N – 35°. If <1/3rd = difficult intubation)

- **Sternomental /thyrom-ental distance** – is the distance between the bony point of mentum & thyroid (N 6.5- 7.0 cm) or mentum & upper border of manubrium (N 12.5 – 13.5 cm). If distances are less than normal- predict difficult intubation.

- **Submandibular compliance**- at direct laryngoscopy, soft tissues is pushed into this space.

- A decrease in this spaces herald's difficulty in intubation, e.g. Ludwig's angina, tumor, scarring, burns, etc)

- **Cricothyroid membrane**- should be identified in any patient with difficult airway, for cricothyroid puncture in an emergency

- **Ease of mask ventilation** – is simplest & easiest to evaluate, needs no special equipment

Sensitivity and specificity of these tests depends on the accuracy with which they are performed and results vary with different studies. Use of scoring systems, along with history and examination, significantly increase the accuracy of predicting airway problem.

Measures in a patient with predicted difficult airway

- Timely intervention with regional technique

- Planned awake airway management followed by general anesthesia (GA)

- Early placement of epidural catheter

- Aspiration prophylaxis

Management in case of failure to intubate

- **CALL FOR HELP**

- Precaution to prevent regurgitation/aspiration by appropriate tilt of the OT table

- Clear the airway and continue O_2 by mask

- Reattempt intubation

- Allow patient to come out of the effect of suxamethonium chloride and attempt awake intubation

- LSCS can be performed under laryngeal mask airway (LMA)

- May have to perform retrograde intubation

- Cricothyroid puncture and jet ventilation

- Can allow LSCS under anesthesia with mask

- Fiber optic intubation

- Give regional anesthesia

- LSCS under field block

Equipment/ trolley preparation

- Routine obstetric patient – face masks (sizes 2,3,4), laryngoscope (different sized blades, Polio blade), endotracheal tubes with stylet (5.0-7.0 Magill), oral airways (sizes 7,8,9), LMA (sizes 3,4), esophageal tracheal combitube, Magill forceps, bougies

- Emergency obstetric patient – tube exchanger, cricothyroid kit, trans tracheal jet ventilation equipment, light

wand, retrograde intubation equipment

- Anticipated, non emergency airway difficulty – fiberoptic laryngoscope, accessories and drugs, fixed fiber optic blades (Bullard, Wu Scope, Upsher)

Mendelson's syndrome – Pulmonary aspiration-Curtis L Mendelson first described the occurrence of vomiting followed by inhalation of vomitus in 1946 in 66 full term pregnant patients. In his report all patients survived with no morbidity.23 deaths were reported between 1973-1978 from south Wales following regurgitation and aspiration. Overall mortality for pulmonary aspiration is 15%.One must remember that symptomatically pulmonary aspiration and amniotic fluid embolism (AFE), are very similar, major difference is good response to treatment in patients with aspiration, unlike AFE which is a non-treatable complication. Hence, early diagnosis and prompt intervention is essential.

Patients at risk

- All pregnant females
- Recent meal (prefer overnight fasting for elective LSCS)
- Use of narcotics, ergot alkaloids, magnesium, sedatives
- Hypotension, aortocaval compression, hemorrhage, sympathetic block
- Difficult intubation
- External pressure on abdomen/ uterus at labor
- Increased gastric secretion (N 2.5- 3 Lt/day)
- Decreased protective reflexes – PIH/ Ecclampsia, drugs (narcotics, magsulph, seda-

tives etc)

- Multiple pregnancies, polyhydarmnios, obesity, short stature
- Gastric pH < 2.5 (critical pH is 2.5) and volume > 25ml
- Decreased lower esophageal sphincter tone (LES)
- Decreased upper esophageal sphincter tone (UES)
- Application of cricoid pressure

Factors aggravating pulmonary aspiration in pregnancy

- Delayed gastric emptying
- Increased bowel transit time
- Decreased gastric tone
- Increased intra abdominal and intra gastric pressures (N 5 ± 2 mm Hg)
- Change in axis of stomach from vertical to horizontal
- Increased plasma progesterone ® Decreased gastric tone & mobility
- Increased acid pepsin secretion
- Lower Esophageal Sphincter Pressure $\pm$ (N 24 ± 3 mm Hg)
- Decreased barrier pressure to gastro esophageal reflux (N 18 ± 2 mm Hg)

Signs and Symptoms

- Asthma like - wheeze, tachycardia, cyanosis
- Acid/ chemical pneumonitis
- Broncho / bronchiolar spasm
- Peribronchiolar exudates
- Focal hemorrhages
- Areas of parenchymal necrosis

- Radiograph of chest shows mottling or opacities
- Usual course of the disease is 7-10 days (mild to moderate cases recover and severe cases need further care)
- Healing with pulmonary fibrosis

Incidence of aspiration has decreased with improvement in anesthesia technique.

- Use of succinylcholine for intubation (rapid onset and quick recovery)
- No IPPV following succinylcholine. Gentle breaths at rate of 6-8/min & low volume may be given.
- Avoidance of ergometrine in 3rd stage of labor. (Ergometrine is a potent vasoconstrictor and produces an increase hydrostatic pressure across the alveolar-capillary membranes in the lungs, thus has a propensity to cause intra-alveolar exudation of fluid and pulmonary edema, which further aggravates the damage done due to aspiration)
- Improved monitoring techniques
- Avoidance of GA & increased use of regional techniques

Methods to decrease gastric volume

- Increased forward GI motility – Prokinetics like metoclopramide
- Adequate preoperative fasting interval- clear liquids allowed in small quantities during labor but solids must be avoided. Once decision for

LSCS is taken, patient should be kept nil per orally (NPO)

Methods to increase gastric pH

- H_2 receptor antagonists like Ranitidine at night and in the morning
- Atropine/ glycopyrrolate premedication is controversial as it decreases oesophageal sphincter tone thus negative the effect of metoclopromide
- Sodium citrate orally 30 to 45 min preoperatively

Factors that decrease LOS Pressure (increased risk of regurgitation)

- Thiopentone, inhalation agents, anticholinergics
- Stomach tube for emptying the stomach
- Apomorphine to induce vomiting (to reduce gastric volume)

Increase LOS pressure barrier

- Metoclopramide
- Antacids
- Ranitidine
- Neostigmine

Anesthesia technique – precaution and care

- Timely decision for LSCS
- Treat all parturients as full stomach
- Prefer SAB/ epidural block. Avoid GA.
- Aspiration prophylaxis in all
- Remove gastric tube / Ryles tube at induction of anesthesia.
- Patient positioning (slight head up – decreased regurgitation)
- Skilled assistance should be available
- Adequate and appropriate equipment. Proper trolley preparation
- Use of correct cricoid Pressure / Sellick's maneuver
- Avoid high pressures & volumes for IPPV before intubation
- Familiarize one self with the failed intubation drill
- Care at intubation/ extubation

Recommendations

- Withhold oral feeds during labor
- Regional anesthesia as far as possible
- Take measures to decrease gastric volume & increase pH
- GA by competent anesthetist, with full appreciation of aspiration risk
- Well equipped delivery rooms for administration of safe anesthesia

Rapid sequence / Crash induction of GA

Advantage – decreases risk of regurgitation & aspiration

Technique

- Patient lying supine, in neutral position, on OT table (parallel to floor)
- Pre oxygenation for 3 to 5 min, normal tidal breaths
- Check for application of Sellick's maneuver
- Precalculated dose of Thiopentone (5-7mg/Kg)
- Assistant places thumb & finger on Cricoid cartilage
- Apply Cricoid pressure after loss of eyelash reflex
- Succinyl choline 2mg/Kg IV
- Continue oxygen by mask
- No Nitrous oxide
- No IPPV
- Direct laryngoscopy at 1 min after suxamethonium chloride. Intubate with 7.0 ETT
- Once ET in situ, inflate the cuff
- Reconnect circuit and ventilate
- Release cricoid pressure
- Auscultate for equal air entry

Sellick's maneuver

- Occludes cervical esophagus between cricoid cartilage & cervical vertebrae
- Pressure applied = 40 Newton force (100 cm H_2O or 74 mm Hg)
- Check for pressure to be applied (without discomfort to patient) preoperatively
- Apply pressure with thumb & index finger
- Remove only once ET in situ
- Double handed modification
- Disadvantage – 50% decrease in LESP

Amniotic Fluid Embolism (AFE)-AFE was first reported by Meyer in 1926. It is the most dangerous untreatable condition with mortality of 80-100%. It leads to sudden death in the peripartum period (failure to diagnose the cause & 25% deaths occur within 1 hour of onset of symptoms). It is also termed as **"obstetric shock".** Its incidence

is I: 8,000- 1: 80,000 and contributes to 10% of all maternal deaths. Average volume of amniotic fluid increases from 50 ml at 12 weeks to 1000 ml at 38 weeks of gestation. After this it decreases. It is hypotonic and is diluted with fetal urine. The damage to the lungs is irreversible because of the contents of the amniotic fluid.

Components of amniotic fluid

- p H   6.9 – 7.15
- Biochemical mediators – surfactant, endothelin, leukotrienes C4 & D4, IL-1, TNF-a, thromboxane A2, prostaglandin E1, E2, F1a, F2a, arachidonic acid, thromboplastin, collagen and tissue factor 3, phospholipase A2, PF3.
- Electrolytes- Na, K, Mg, Ca, Fe, PO_4, Cl, S, Mn, Zn
- Nitrogenous products - amino acids, urea, uric acid, creatinine, proteins
- Others–glucose, vitamins, enzymes, steroids, hormones, lipids
- Suspended particles- lanugo hair, vernix caseosa, fetal squames, meconium, fetal gut mucin, trophoblasts

Amniotic fluid enters the maternal circulation through a tear in the amniotic membranes (spontaneous/ manual rupture of membranes), or when uterine vessels are abnormally open (placenta accreta, rupture uterus, placenta abruptio, LSCS, retained placenta, trauma from intra uterine manipulation or instrumentation, uterine or cervical tears). During uterine contractions, a pressure gradient develops which drives the amniotic fluid into maternal circulation & to the lungs, causing chemical and physical damage, anaphylactoid reaction and multi system involvement.

Patients at risk

- Elderly, multipara, Multiple pregnancy
- Commoner with male fetus
- Polyhydramnios
- Artificial rupture of membranes (ARM), use of oxytocics, tumultuous labor
- First trimester curettage abortions
- Second trimester abortions using saline, glucose, prostaglandins, urea, hysterotomy
- Abdominal trauma, amniocentesis
- Placental rupture, Intra uterine death
- During LSCS
- Any time during pregnancy, labor, post delivery - with no obvious cause

Clinical features

- No prodromal symptoms (fever, chills, rigor, abdominal pain)
- Time course of presentation and symptoms are highly variable
- Usual presentation-sudden onset of dyspnea, hypotension, cardio respiratory arrest
- Classic triad–hypoxia, hemodynamic collapse & coagulopathy with no obvious cause
- Cyanosis, pallor, altered neurological state, coma- may occur in a few
- Grand mal seizures- 10-20% cases
- Coagulopathy- DIC, thrombocytopenia- 40% cases (decreased platelet counts, decreased fibrinogen, increased FDP, prolonged PTT & PT)
- In 15% cases bleeding from vagina, stitch line, IV and epidural cannulae sites, mouth and gums
- Auscultation- bilateral wheeze and crepitations
- In those who survive the initial insult- non cardiogenic pulmonary edema and renal failure, multi organ failure occurs (TEE- RV failure, bulging of interatrial & interventricular septums from right to left, severe TR, pericardial effusion, LV failure)
- Increased PCWP, decreased LVSWI, decreased SVR, increased PAP, PVR increased
- Signs and symptoms under GA - hypotension, decreased SpO_2 and $EtCO_2$, arrhythmias, pulmonary vascular spasm & edema, increased oozing from operative site
- Chest radiography- no findings or pleura effusion, cardiomegaly, pulmonary edema

Pathophysiology

Pathogenesis of the disease in AFE is due to –Anaphylactic reaction;Pulmonary vascular reaction;Alveolar membrane reaction;Cardiac dysfunction; Coagulation failure

Anaphylactic reaction-Fetal contents of amniotic fluid produce a reaction similar to anaphylactic shock. Symptoms are not due to histamine (absent

in amniotic fluid), nor due to a previous exposure to an antigen (AEF seen both in primigravidas as well as multigravidas), and also hallmark symptoms are absent (cutaneous flare, bronchospasm and upper airway swelling). Some obstetricians even term it as "anaphylactoid syndrome of pregnancy".

Pulmonary vascular reaction- Amniotic fluid contents (fetal squames, mucin, other fetal debris) block the pulmonary capillaries, with an increase in pulmonary vascular resistance and pressures. Metabolites of arachidonic acid, prostaglandins and leukotrienes, initiate a pulmonary response. Symptoms are irrespective of the volume of amniotic fluid embolised.

Alveolar membrane reaction- Pulmonary edema is due to alveolar capillary leakage secondary to acute micro vascular emboli, resulting in an ARDS like picture. Alveolar fluid has a higher concentration of proteins in AFE (unlike to that in cardiac failure). Increase in ECF volume and low colloid osmotic pressures in pregnancy; also contribute to accumulation of lung water in AFE.

Cardiac dysfunction-There is a biphasic pattern of hemodynamic disturbance in AFE. Initial pulmonary vascular spasm leads to transient pulmonary hypertension and profound hypoxia (cause of death). In survivors, a secondary phase of hemodynamic compromise occurs with hypoxia induced LV dysfunction, LV failure, pulmonary hypertension and subsequently RV failure.

Coronary vasospasm and direct myocardial depressant action of amniotic fluid adds to myocardial ischemia, aggravating cardiac failure and increased morbidity or delayed mortality.

Coagulation failure-Amniotic fluid causes platelet aggregation (thromboplastin like effect), and has factor X proactivator (initiates IV clotting) leading to DIC, and consumption of fibrinogen. Excessive bleeding in AFE is accompanied by hypofibrinogenemia and increased fibrinolytic activity.

Phase 1- hypoxia, hypotension, pulmonary hypertension, LV dysfunction, RV overload

Phase 2 – LV failure, ARDS, DIC, RV failure, refractory cardiopulmonary arrest, exsanguinations, Multi organ failure

Laboratory diagnosis

- All tests are only for understanding purposes and do not help in early diagnosis and treatment of AFE. They are also not of any prognostic value.

- Management is only according to the clinical condition of the patient

- Treatment should not be deferred pending results of these tests

- Definite diagnosis is only made at autopsy (fetal debris in alveoli & pulmonary capillaries)

- Smears of blood from central line may show presence of amniotic fluid in living patients

- Monoclonal antibodies to a glycoprotein in amniotic fluid and meconium

- Immune staining for mucin in maternal serum

- Fetal squames and mucin in pulmonary capillary blood may help in diagnosis

- Presence of amniotic fluid material in maternal pulmonary circulation is not pathognomic for AFE

- Noninvasive method- using TKH-2 (monoclonal antibody) for fetal mucin in maternal blood

- Measurement of zinc coproporphyrin-1 in maternal serum (component of meconium) (> 35 n mol/L diagnostic)

Differential diagnosis

- Acid Aspiration
- Pulmonary Thrombo-Embolism
- Venous Air Embolism
- Acute LVF
- Hemorrhagic or septic shock
- Placenta abruption or uterine rupture
- Acute MI
- Peripartum cardiomyopathy
- Acute anaphylactic shock
- Ecclampsia (if convulsions present)
- LA drug reaction (following epidural block)
- Total spinal / high block
- CVA

Preventive measures

- Unpredictability of AFE makes prophylactic measures difficult. Precautions should be observed routinely in all

- Avoid excessive uterine activity
- Avoid trauma at IU catheter in labor
- Do not strip membranes from Cervix in labor
- Intact membranes- avoid vigorous expulsive movements by parturient
- Avoid /care with syntocinon in prolonged labor /IUD
- Do early termination with curettage

Treatment

- No specific treatment. Care is mainly supportive and symptomatic
- CVS support and maintenance of BP(dopamine, dobutamine, Isoproterenol, nor adrenaline, adrenaline)
- Respiratory support- O_2, CPAP, IPPV, PEEP
- Initiate CPR
- If undelivered- monitor the fetus and initiate delivery
- Maintain urine output – 0.5-1 ml/ Kg/hr
- Pulmonary arterial catheterization for monitoring, fluid management and sampling
- Anticonvulsants
- Treatment of DIC & bleeding disorders- FFP, fresh blood, platelet transfusion, cryoprecipitate (fibrinogen, fibrinopectin)
- Avoid further trauma
- Treatment of complications-renal failure
- Anti prostaglandins- aspirin, indomethacin
- Industrial surfactant-pluronic F-68

- Steroids- hydrocortisone 500 mg 6 hrly
- Treatment of ARDS
- IV fluids and TPN – avoid over hydration

Recommendation St Georges' Hospital for AFE

- Blood Grouping, CM & screening for Antibodies in all patients at ANC
- Anticipate those at risk- previous PPH
- Ergometrine to be avoided. Prefer oxytocin
- Control source of bleeding
- IV fluids- RL, Hesteryl, Gelatin, albumin, dextran
- FFP/ Cryoprecipitate / Platelet concentrate
- 2 large bore IV lines
- Monitoring - BP, SpO_2, ECG
- Assess blood loss
- Maintain I/O
- Prompt Surgical intervention
- Warming of blood
- Inotropic support
- Consult hematologist
- Consult anesthetist

Long-term consequences

- Hemiplegia
- Permanent neurological damage
- Ischaemic occulopathy (bilateral retinal artery occlusion)

Maternal Awareness-A problem unique to obstetric anesthesia is mother's awareness of surgery and birth with subsequent unpleasant experience such as nightmares, following GA. Incidence varies inversely with the concentration of N_2O used prior to the delivery of the baby (9%

and 26% with 67% and 50% N_2O in oxygen, respectively). Awareness can be to tracheal intubation, delivery of the baby or to skin suturing, at the end of LSCS.

Causes

- Maternal pre / hyper oxygenation and consequent lower FiN_2O at induction
- Lighter planes of anesthesia (with use of muscle relaxants)
- Inadequate doses of IV induction agents (fear of hypotension)
- Machine malfunction or misuse
- Empty vaporizer / N_2O cylinder

Consequences of maternal awareness

- Maternal stress response- decreases utero-placental blood flow which leads to fetal hypoxia
- Nightmares, Bad dreams
- Withdrawn or scared attitude, disturbed mental state
- Fear of another anesthetic exposure, in case needed-Day time anxiety ,Post traumatic neurosis / Post Traumatic Stress Disorder (PTSD)

Prevention

- Check the Boyles apparatus and vaporizer output concentration
- Use of low dose (0.5 MAC) of volatile agents (0.5% Halothane, 0.6% Isoflurane, 1.0% Sevoflurane, 3.0% Desflurane) in a mixture of 50% N_2O in O_2
- Adequate or a bit extra dose of IV agent at induction-Thiopentone, Propofol

- Reduction in induction–delivery interval
- Repeat additional boluses of IV agent during induction-delivery period—Thiopentone, Ketamine, Benzodiazepine, Propofol
- Awareness monitoring- BIS

Bispectral Index (BIS) is the pharmacodynamic measure of anesthetic effects on CNS by EEG analysis, as an indicator of anesthetic awareness.

Management

- Believe the patient, talk to her and discuss
- Explain to her- helpful in withdrawn or depressed patients
- Prescribe sedatives for short term
- Psychotherapy

BIS Analysis		
BIS	**Clinical endpoint**	**clinical situation**
100	awake/light sedation	wake/resting state Sedation for special procedures At emergence from GA
70	low recall	Short surgical procedure Deep sleep Light GA
60	mod hypnosis	during GA
40	deep hypnosis	barbiturate coma Profound hypothermia Burst suppression
00	EEG suppression	no CNS function

History of Nitrous Oxide

Nitrous oxide was first produced by the English chemist and Presbyterian minister, Joseph Priestley, in 1772 and further investigated by Humphrey Davy in 1800 at the Pneumatic Medical Institution in Bristol. In his book on nitrous oxide, Davy recorded that breathing the gas helped to relieve toothache - from which he was suffering at the time - and suggested: 'it may probably be used with advantage in surgical operations'. But the pain-relieving properties of nitrous oxide were not explored any further until nearly fifty years later. Initially, society was more interested in nitrous oxide as a source of amusement and entertainment. It is for this reason, no doubt, that nitrous oxide was commonly called 'Laughing Gas'. (This term has always seemed rather odd to the author, because in his experience, laughter is rarely observed!)

Although nitrous oxide was the first anaesthetic ever to be used, it was soon replaced by ether and chloroform. This was because the latter were more potent and convenient to use. Because they were more potent, however, ether and chloroform were more dangerous - especially if consciousness was lost. It was soon appreciated that they were not safe for use during labour except when given by someone experienced in anaesthesia: even then, tragedies sometimes occurred.

It was in response to this challenge that Dr Minnitt invented his Gas and Air machine in 1933. It was designed to deliver a mixture of nitrous oxide and room air in suffficient concentrations to relieve pain - but not, loss of consciousness. Minnitt's machine proved to be very effective and soon became available for midwives to use during labour. Gas and Air remained popular in Britain for many years - until it was replaced by machines which delivered nitrous oxide in oxygen - instead of air.

Anesthesia for Ophthalmic Surgery

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Skillful anaesthetic management is integral to optimal outcomes after ophthalmic surgery. Ophthalmic patients are often at the extremes of age (from sick premature newborn to frail elderly) and not uncommonly have extensive associated systemic or metabolic diseases. The knowledge of eye anatomy, mechanism of oculocardiac reflex, physiology of intraocular pressure (IOP) and effects of anaesthetics on IOP, systemic effects of the drugs used topically for eye disease and effect of surgical manipulation is important for proper anaesthetic management. Patient selection, preoperative evaluation, preparation, monitoring, sedation and local anaesthesia techniques are also important for ophthalmic surgery especially in elderly patient.

Intraocular pressure dynamics
The pressure within the eyeball is intraocular pressure (IOP) and is normally in the range of 10-21 mm Hg. The diurnal variation for normal eyes is between 3 and 6 mmHg. The aqueous humor is produced by ciliary body. Then it flows through the posterior chamber between lens and the iris, through pupil, and out into anterior chamber. In the posterior part of the anterior chamber, it eventually comes to the angle formed by the juncture of the iris and the cornea. The aqueous is then filtered through trabecular meshwork and enters in the canal of Schlemm. Then it passes through collector channels into the episcleral veins, where it mixes with the blood.
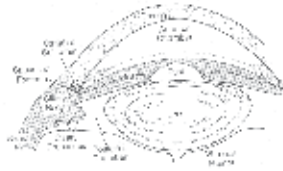

Figure1. Anatomy of the anterior eye.

Blinking increases IOP by 5mmHg and squeezing increases IOP by 26mmHg. In the open globe i.e. during surgery or traumatic perforation, IOP is equal to atmospheric pressure. A rise in the IOP will tend to decrease intraocular volume by causing drainage of aqueous or extrusion of vitreous through the wound, which can lead to permanent visual loss. IOP should be controlled before, during and after the ophthalmic surgeries.

The most important influences on IOP are movement of aqueous humor, changes in choroidal blood volume, central venous pressure and extraocular muscle tone.

Factors increasing IOP

- Obstruction to aqueous humor outflow by the use of mydriatic drugs in shallow anterior chamber
- External pressure on the eye from a tightly fitted face mask
- Raised venous pressure i.e. by coughing, straining, vomiting, valsalva maneuvers
- Increase in choroidal blood volume i.e. Raised arterial pressure, respiratory acidosis, hypoxia and hypercarbia (vasodilation of intraocular blood vessels)
- Rise in the content of the sphere i.e. retrobulbar hemorrhage, injection of a large volume of local anaesthetic.
- Decrease in the size of the globe without a proportional change in the volume of its contents.
- Prone position.
- Suxamethonium - the precise mechanism is unknown but may be due to contraction of extraocular muscles during fasiculation or dilation of blood vessels. The effect is maximal at 2-4 minutes returning to normal within 7 minutes.
- Ketamine
- Laryngoscopy and endotracheal intubation increase IOP significantly i.e. at least 10- 20mmHg, this increase may be due to rise in the arterial pressure.

Factors lowering IOP
- Reduced venous pressure i.e. Head up tilt.
- Lowered arterial pressure - at systolic pressures <90 mmHg, IOP is proportional

to the blood pressure changes.

- Hypocarbia by constricting choroidal vessels.
- Intravenous induction agents (except ketamine),inhalational agents (the fall in IOP is proportional to the inspired concentration), nondepolarising muscle relaxants , relax extraocular muscle tone, depress the CNS, improve the outflow of aqueous humor, reduce aqueous production and lower venous and arterial blood pressure.
- Reduction in aqueous volume i.e. by acetazolamide which inhibits production.
- Reduction in vitreous volume i.e. by mannitol which exerts an osmotic effect.

Oculocardiac reflex (OCR)

OCR was first described in 1908 by Aschner and Dagnini. It is a trigemino-vagal reflex, the afferent pathway is via the long and short ciliary nerves to the ciliary ganglion terminating in the trigeminal sensory nucleus. The efferent pathway is from the motor nucleus of the vagus nerve.OCR can be evoked in all age groups and during a variety of ocular procedures, including strabismus surgery, cataract extraction, enucleation, scleral banding and viteroretinal surgery. It is also associated with local ophthalmic injections, retrobulbar haematoma, oculopression and stretching of the eyelids. Hypercapnia increases sensitivity to the reflex. It can cause a wide variety of cardiac dysrhythmia ranging from bradycardia and ventricular ectopy to sinus arrest or ventricular fibrillation. The use for routine prophylaxis is controversial, but anticholenergic medication (intravenous or intramuscular) prevents OCR. It is self extinguishable with repeated traction on the extraocular muscles.

Management - Temporary

Figure2. Anatomy and physiology of the OCR

cessation of surgical stimulation until heart rate increases; Ensure adequate ventilation, oxygenation and depth of anaesthesia; Intravenous atropine 10μg/kg if OCR still persists; Infiltration of the rectus muscle with local anaesthetics in strabismus surgery.

Oculorespiratory reflex

ORR results in shallow breathing, bradypnoea or respiratory arrest and commonly seen in strabismus surgery. The afferent arc of the reflex is same as in OCR, but the efferent arc is from pneumotaxic center in the pons and the medullary respiratory center. Atropine has no protective effect.

Oculoemetic reflex

This is a vagally mediated response to surgical manipulation of extraocular muscles and is responsible for the high incidence of PONV associated with strabismus surgery.

Post operative nausea vomiting (PONV)

Nausea and vomiting after emergency eye surgery can be a major problem and may lead to dehydration, electrolyte imbalance, and prolonged stay in the recovery room and may lead to delay in discharge from PACU. Measures to minimize PONV include:

- Allay preoperative anxiety
- Oral clonidine (4μg/kg) as premedication
- Minimize the use of narcotics
- Avoid anticholinesterase
- Insertion and removal of an orogastric tube to decompress the stomach after the induction of anaesthesia.
- Maintain adequate hydration with intra venous crystalloids
- Prophylactic antiemetic drugs if family history of PONV or other risk factors are present. Using a combination of small doses of anti-emetic drugs from different pharmacological classes may enhance efficacy and reduce side effects. Droperidol (25-75μg/kg iv), Metoclopramide (100-250μg/kg iv), Ondansetron (50-200μg/kg iv), Dexamethasone (150μg/kg iv).

Anaesthetic implications of ophthalmic drugs

Topical medications used for eye diseases are often instilled preoperatively as well as in the operating room. They can migrate through the puncta into the nasolacrimal duct and on to the nasal mucosa with subsequent absorption into the systemic circulation. Infants and elderly patients are more susceptible. Systemic effects can be minimized by lowering

concentration of the drugs, instillation of 1-2 drops and occlusion of punctum during instillation of drops.

Atropine - Systemic absorption will cause tachycardia, fever and other anticholinergic effects.

Timolol - A non selective beta blocking agent, it can cause bradycardia, hypotension, congestive heart failure and exacerbation of asthma.

Echothiophate (organophosphate) - It reduces plasma cholinesterase activity. Succinylcholine, mivacurium and ester local anaesthetics require reduced doses.

Adrenaline - Topical 2% (0.8mg per drop) adrenaline is used decrease aqueous humor secretion and enhance outflow in open angle glaucoma. Systemic symptoms i.e. tachyarrythmias, premature ventricular contraction, angina may occur in some cases.

Phenylephrine - It is an alpha agonist mydriatic drug and can cause transient hypertension to pulmonary oedema and cardiac arrest. If beta blockers were used in response to iatrogenic hypertension, it can induce unopposed alpha adrenergic stimulation, exacerbate symptoms and produce life threatening consequences like severe myocardial ischaemia in CAD, cerebral aneurysm rupture. A single drop of phenylephrine 10% contains 4mg of drug i.e. 2.5% solution is recommended.

Scopolamine - It is a mydriatic and cycloplegic drug and its systemic absorption can cause disorientation and hallucinations.

Acetylcholine - It is a cholinergic agonist and it is used to produce complete miosis after cataract surgery. Systemic effects include bradycardia, hypotension, salivation, bronchospasm and increased bronchial secretions.

Mannitol - Its administration can cause transient hypervolemia followed by hypovolemia and potential for hypotension.

Effects of anaesthetic drugs

Anticholinergic drugs

Topically administered anticholinergic drugs (i.e. atropine) result in pupillary dilatation, which may precipitate angle closure glaucoma.However, premedication doses of systemically administered atropine are not associated with intraocular hypertension even in patients with glaucoma.

Benzodiazepines

All benzodiazepines produce anxiolysis, as well as varying degrees of amnesia and sedation through dose-dependent central nervous system depression and may decrease IOP.

Diazepam (0.1 - 0.2 mg/kg i.v.) is characterized by a long elimination half-life with postoperative re-sedation. The effects of diazepam are intensified with older patients

Midazolam (0.05 - 0.1 mg/kg i.v., 0.03 - 0.2 mg/kg/h i.v. infusion) is a more rapid-acting agent with a relatively short elimination half-life of about 2 - 4 hours. It allows a more predictable recovery after brief procedures. Oral (0.25-0.5 mg/kg) or nasal (0.2mg/kg) midazolam is commonly used as premedication in children.

Opioids

Opioids are often used in combination with sedative drugs to supplement analgesia produced by local anaesthetics. Intravenous administration of potent opioids fentanyl and remifentanil results in a significant reduction in IOP. Opioid given intramuscularly produce only a moderate reduction in IOP. A combination of fentanyl and droperidol also reduces the IOP by 12 % in normocapnic patients.

Remifentanil is the estrase metabolized opioid drugs, with the half-life of about 3.5 min. For conscious sedation with remifentanil, infusion rates of 0.025 - 0.1 µg/kg/min are recommended. When combined with propofol at lower dosages, remifentanil provides superior anlagesia during the performance of nerve blockade, thereby enhancing patient comfort during the surgical procedure without compromising haemodynamic stability or respiratory depression.

Induction agents

Barbiturates - Intravenous barbiturates are safer to use as they reduce IOP by about 40 % after an induction dose of thiopental. Intraocular pressure is reduced, by their central depressive effect on diencephalic and by improved outflow of aqueous humor.

Propofol produces a greater reduction in IOP and limits the increase in IOP during intubation as well. Propofol's rapid onset and short duration of action ensures prompt responsiveness to changes in its infusion rate with optimal titration. It has a low

incidence of side-effects and PONV. Low-dose infusions of propofol have less depressant effect on cardiovascular and respiratory variables. Monitoring of oxygen saturation is recommended and supplemental oxygen via nasal cannulae (4l/min) should be given throughout the surgical procedure. Propofol is administered for ophthalmological procedure as loading doses of 0.2 - 0.5 mg/kg and maintenance dosages (0.8 - 3 mg/kg/h).

Ketamine The reports about the effects of ketamine on IOP are conflicting. Data indicates that ketamine given after premedication with diazepam and meperidine does not affect IOP and that intramuscularly administered ketamine may even lower IOP in children. However it should be avoided in open eye injuries, as a sole agent. If it is to be used, it is best to use with small doses of a benzodiazepine to blunt its excitatory effects and ventilation should be controlled with a muscle relaxant, if IOP control is important. Its use is limited in ophthalmology because of side effect such as nystagmus with contraction and squeezing of the eyelids.

Inhalational agents

Inhalational anesthetics decrease IOP in proportion to the depth of anaesthesia. The reduction in IOP is greater under conditions of controlled ventilation. The decrease in IOP may be due to drop in blood pressure which reduces choroidal volume; relaxation of the extraocular muscles lowers wall tension; pupillary constriction facilitates

aqueous outflow; and an effect on the hypothalamic centers in the brain.

Intraocular gas injection and Nitrous oxide (N2o)
Long acting gases such as sulphur hexafluoride (SF6) or per fluoropropane (C3F8) have been used in the management of retinal deattachment, macular hole surgery, pneumatic retinopexy and a variety of other situation wherein long acting temponade is desirable.

These gases are inert, insoluble in water and poorly diffusible. Nitrous oxide is 34 times more soluble than nitrogen and 117 times more soluble than SF6 and rapidly diffuses into the intraocular gas bubble and causes rapid expansion with subsequent rise in IOP. This may lead to retinal artery occlusion, retinal ischaemia and eventually visual loss.

If nitrous oxide administration is continued even after gas injection within 19 minutes, IOP increases from 14 to 30mmHg and both bubble size and IOP decreases (from 29 to 12mmHg) within 18 minutes of discontinuation of N2O. This rapid and wide variation in bubble size during general anaesthesia may adversely affect the outcome of surgery. Administration of N2O should be discontinued at least 20 minutes before an intravitreal injection of gas. It is preferable to avoid N2O altogether when intravitreal injection of gas is planned. SF6 gas bubble remains for at least 10 days. Other intravitreal gases may remain for as long as 21 to 28 days. It is recommended to avoid nitrous

oxide within 3 to 4 weeks of surgery with intravitreal injection of gas as a second exposure to N2O might cause reexpansion of the bubble and elevate IOP. Recent data suggest that anaesthetist should avoid N2O altogether for patients who have recently undergone retinal surgery, unless there is evidence by indirect ophthalmoscopy that the gas has totally reabsorbed.

Neuromuscular blocking agents

Succinylcholine Intraocular pressure increases by 5-15 mm Hg after injection of succinylcholine. The increase in IOP is maximal within 1 minute and is almost dissipated by 5-6 minutes. Increase in IOP is principally through prolonged contracture of extraocular muscles and may be due to congestion of the choroidal vessels and distortion of the globe with axial shortening. This increase in IOP will cause spurious measurements of IOP during examination under anaesthesia in glaucoma patients, may cause extrusion of ocular contents through an open surgical or traumatic wound. The prolonged contracture of the extraocular muscles may lead to abnormal forced duction test for 20 minutes and may influence the type of strabismus surgery performed. Precurarization with non depolarizing blockers has little or no effect on this increase. How ever other factors, such as inadequate anaesthesia, elevated systemic blood pressure, and insufficient neuromuscular blockade during laryngoscopy, and tracheal intubation might

increase intraocular pressure more than succinylcholine.

Nondepolarizing Muscle Relaxants - These agents either reduce IOP or have no effect on it. Atracurium has no significant effect whilst vecuronium produces a small but significant reduction. Rocuronium in a dose of 0.9- 1.2 mg/kg can be used for intubation in open eye injuries to prevent rise in IOP.

Regional anaesthesia for ophthalmic surgery

Regional anesthesia is a common technique used to provide anesthesia for ocular surgeries. Patient comfort, safety and low complication rates are the essentials of local anaesthesia. At present there is no perfect technique of ophthalmic regional anaesthesia and each technique has its own risk/benefit profile.

Advantages of local blocks over general anaesthesia-It can be performed as day care surgery; Produce good akinesia and anaesthesia, Minimal influence on intraocular pressure, and Require minimum equipment

Disadvantages-Not suitable for some patients (children, mentally handicapped, deaf, language barrier) ; Risk of complications
Types of regional anaesthesia:
1. Non-akinetic - It includes topical drops, subconj - unctival, deep fornix anaesthesia and lidocaine gel.
2. Akinetic blocks -
   a. Needle techniques: Intraconal block (Retrobulbar block), Extraconal block (Peribulbar block)
   b. Blunt cannula techniques: Sub-Tenon's block.

Retrobulbar block: Local anaesthetic agent is injected into the part of the orbital cavity (the muscle cone), behind the globe that is formed by 4 recti muscles and the superior and inferior oblique muscles. The conjunctiva is anaesthetized and a three cm needle is inserted half way between the lateral canthus and the lateral limbus in the lower conjunctiva and first directed backwards under the globe and then after the equator of the globe has been passed the needle direction is changed upwards and inwards to enter the space behind the globe between the inferior and lateral recti muscles. After aspiration 4 ml of local anaesthetic solution is injected slowly. Retrobulbar block has largerly been replaced by peribulbar block because of the higher incidence of complications and the occasional need for an additional facial nerve block.

Figure3. Direction of needle during retrobulbar block

Peribulbar block

Injection of local anaesthetic through an inferotemporal site blocks the nasociliary, lacrimal, frontal, supraorbital and supratrochlear branches of the ophthalmic division of the trigeminal nerve and the infraorbital branch of the maxillary division.

Injection through medial compartment blocks the medial branches of the nasociliary nerve, the long ciliary nerves, the infratrochlear nerve and medial components of the supraorbital and supratrochlear nerves.

Technique of the peribulbar block

Two transconjunctival injections are administered.
1. Inferotemporal injection The needle is placed half way between the lateral canthus and the lateral limbus and advanced in the sagital plane, parallel to the orbital floor passing under the globe without pressure to the syringe. When the needle tip is past the equator of the globe, its direction is changed to point slightly medial (20°) and cephalad (10° upwards) and advanced until the hub (at 2.5 cm) is at the same depth as the iris. Following negative aspiration 5 ml of the solution is slowly injected. If resistance is encountered, the needle tip should be repositioned.
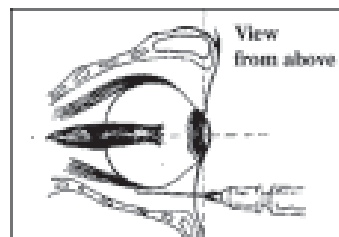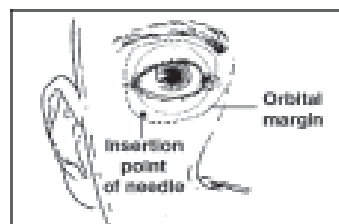

Figure 4. Peribulbar block. An inferotemporal injection

2. Nasal injection

The same needle is inserted through the conjunctiva on the nasal side, medial to the caruncle and directed straight back parallel to the medial orbital wall pointing slightly cephalad (20°) until the hub of the needle is at the same level as the iris. It may require firm gentle pressure when traverses through the tough medial canthal ligament. After negative aspiration another 5ml of the local anaesthetic is injected.

The eye is closed and pressure is applied with a Macintyre oculopressor for 10 minutes at a pressure of 30 mmHg to lower IOP by reducing aqueous humor production and increasing its reabsorbtion.
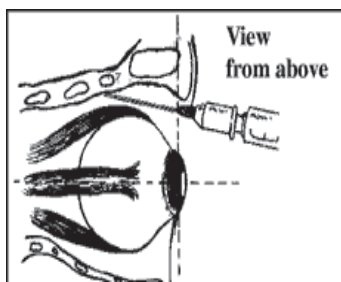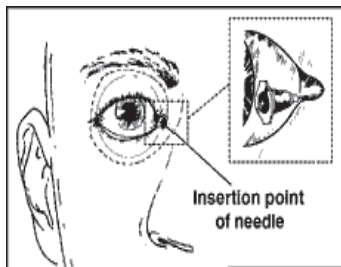

Figure5. Peribulbar block. A nasal injection

Assessment of the block is done after an interval of 10 minutes. The signs of a successful block are:

- Ptosis (drooping of the upper lid with inability to open the eyes)
- Either no eye movement or minimal movement in any direction (akinesia)
- Inability to fully close the eye once opened.

If, after 10 minutes the block is inadequate, a supplementary injection of 2-5 ml of the anaesthetic mixture may be required. If the residual eye movements are downward and lateral, the supplementary injection is given at the inferotemporal site and if upward and medial, at the nasal site. Pressure is then reapplied for a further 10 minutes.

Complications of regional blocks

Due to the local anaesthetic agents

Intravascular injection and anaphylaxis : Resuscitation facilities must always be readily available.

Related to Adjuvant

Epinephrine: Vasoconstrictors are added to the local anaesthetic to prolong duration and minimize bleeding from small blood vessels. In addition, the surge in plasma levels of the local anaesthetic is reduced, which may prevent peak dose-related side-effects. However epinephrine should be avoided in patients with high-risk circulation as it can result in a rise in blood pressure.

Hyaluronidase: Hyaluronidase has been shown to improve the effectiveness, the quality of block as it increases the permeability of connective tissue by the hydrolysis of hyaluronic acid and also reduces IOP following needle blockade. The amount of hyaluronidase varies from 5 to 150 IU·ml-1. Rare allergic reactions, orbital pseudotumour and orbital swelling have been reported.

Due to the block technique

- **Haemorrhage:** Retrobulbar haemorrhage is characterised by a sudden rise of IOP and usually requires postponent of surgery. It is very rare with peribulbar injections. Subconjunctival haemorrhage is less significant. Surgery need not be postponed.

- **Subconjunctival** oedema (chemosis): This may interfere with suturing and can be minimised by slowing the rate of injection and by gentle pressure to the closed eye.

- **Penetration or perforation of the globe:** This is more common in myopic eyes as they are longer and thinner than normal. A diagnosis can be made if there is pain at the time the block is performed, sudden loss of vision, hypotony, a poor red reflex or vitreous haemorrhage. It can be avoided by careful insertion of the needle tangentially and by not going "up and in" until the needle tip is clearly past the equator of the globe.

- **Central spread of local anaesthetic:** This is due either to direct injection into the dural cuff which accompanies the optic nerve to the sclera or to retrograde arterial spread. A variety of symptoms may follow including drowsiness, vomiting, contra-lateral

blindness caused by reflux of the drug to the optic chiasma, convulsions, respiratory depression or arrest, neurol-ogical deficit, and even cardiac arrest. These symp-toms usually appear within about 5mins of the injection.

- **Oculocardiac reflex** may follow traction on the eye. An effective local block ablates the oculocardiac reflex by providing afferent block of the reflex pathway. However the institution of the block and especially rapid distension of the tissues by the solution or by haemorrhage might occasionally provoke it. Careful monitoring is essential for early detection.

Nerve Injury

Optic Nerve Damage -This may result from direct placement of the needle into the nerve, injection of local anaesthetic into the nerve sheath leading to compression or due to ischaemia secondary to vascular occlusion following vasoconstriction of blood vessels with epinephrine-containing local anaesthetic solution. Surgical decompression of the optic nerve sheath may be indicated. This complication can be avoided by appropriate placement of a short needle <31 mm while the eye is in the neutral position.

Optic Nerve Atrophy- This is a delayed complication. Optic nerve damage and retinal vascular occlusion may be caused by direct damage to the optic nerve or central retinal artery, injection into the optic nerve sheath or haemorrhage within the nerve

sheath. These complications may lead to partial or complete visual loss. Careful needle placement is essential. Any resistance to injection requires repositioning of the needle.

Damage to the Motor Nerve of the Inferior Rectus and Inferior Oblique Muscles- This occurs following direct trauma to the supplying nerve during injection. This complication is frequently reported during poorly interpreted classical retrobulbar technique where a needle is introduced through the skin at the junction of medial 2/3rd and lateral 1/3rd. This complication can be avoided by introducing the needle into the inferotemporal quadrant as far lateral as possible and below the lateral rectus muscle

Prolonged Extraocular Muscle Malfunction

It usually presents as diplopia and ptosis 24-48 h postoperatively. A possible mechanism may be the prolonged exposure of the thin fibres of muscle with highly concentrated local anaesthetic agent, direct injection into any of the delicate orbital muscles or damage to the motor nerve supplying the muscle. If there has been no nerve damage, function normally returns in 2-3 weeks. If recovery is delayed for more than 6 weeks, there is a 25% chance of permanent damage.

Complications of 7th Nerve Block

The facial nerve block is performed to block the orbicularis oculi muscle during low volume classical retrobulbar block. This block is very painful and associated with skin bruising.

Many complications such as hemifacial palsy, spread of local anaesthetic to the vagus nerve, glossopharyngeal or spinal accessory nerves, neurogenic pulmonary oedema and other rare complications have been reported. Modern needle block utilizing higher volume local anaesthetic usually blocks the terminal branches of 7th nerve and paralysis of the orbicularis per se is not required

Sub-Tenon's Block (Parabulbar block)

This block is a simple, safe and effective technique and can be used for cataract surgery, for viteroretinal surgery, panretinal photocoagulation,trabecule-ctomy, strabismus surgery, optic nerve sheath fenestration and the delivery of drugs. This technique is also increasingly favoured in patients who are on anticoagulants, aspirin and non-steroidal anti-inflammatory drugs (NSAIDs).

After obtaining surface anaesthesia on the conjunctiva and cornea by topical agents, sub-Tenon's space in accessed through the inferonasal quadrant as it allows good fluid distribution superiorly while avoiding the area of access for surgery and damage to the vortex veins. Under sterile conditions, the patient is asked to look upwards and outwards and the conjunctiva and Tenon capsule are gripped with non-toothed forceps, 5 to 10 mm away from the limbus and a small incision is made through these layers with scissors to expose the white area and the sub-Tenon cannula is inserted following the globe and local anaesthetic is

injected. It blocks sensation from the eye by action on the short ciliary nerves as they pass through the Tenon capsule to the globe. Akinesia is obtained by direct blockade of anterior motor nerve fibres as they enter the extraocular muscles.
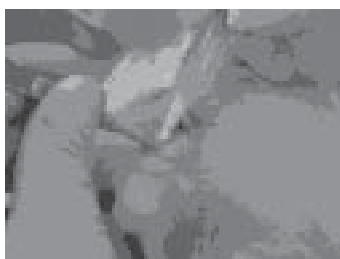

Figure6. Sub-Tenon's block (Parabulbar block)

Complications of Sub-Tenon's Block

Minor complications:

- Pain during injection: The use of smaller cannulae, slow injection or warming of the local anaesthetic agent can reduce the incidence of pain
- Chemosis: Chemosis is the swelling of the conjunctiva and signifies anterior spread of the injected anaesthetic agent. This usually occurs when the sub-Tenon's capsule is inadequately dissected or a higher volume of local anaesthetic is injected. It usually resolves after the application of local pressure.

- Subconjunctival haemorrhage: This occurs following severing of small blood vessels during dissection of the conjunctiva, Tenon's capsule or following injection. Gentle pressure and epinephrine-containing solution may help. This can be minimized by careful dissection and thus avoiding damage to fine vessels.
- Leakage of local anaesthetic during injection: This is likely to occur if dissection of Tenon's capsule is not complete or if there is resistance to injection. Incomplete anaesthesia and residual muscle movement may be more frequent in such cases.
- Akinesia: It is variable and volume-dependent. Superior oblique and eyelid muscles may remain active.

Major complications

- Orbital and retrobulbar haemorrhage
- Rectus muscle paresis and trauma
- Globe perforation
- Central spread of local anaesthetic
- Orbital cellulitis

The exact mechanism of these complications is not clear but they may be due to forceful or inappropriate placement of the metal posterior sub-Tenon's cannula. Careful dissection, slow introduction of metal cannula or use of smaller or flexible cannula may offer benefits, but at the expense of an increase in the incidence of chemosis and

subconjunctival haemorrhage and a decrease in akinesia.

Topical ophthalmic anaesthesia

Topical anaesthesia of the cornea can be used for small corneal incision phacoemuscification that allows minimal manipulation of the pain sensitive ocular surface structures. There are three main modalities of administering topical anaesthesia for cataract surgery i.e. eye drops application, eye drops plus intracameral anaesthesia and gel anaesthesia. The main advantages of topical anaesthesia technique are minimal pain during administration, faster postoperative functional recovery without complications of injection, less PONV, less bleeding and lower cost. Limitations include lack of akinesia so can be used in uncomplicated cataract, and the need of cooperative and communicative patients.

Frontal nerve block

This block is usually performed for ptosis surgery. A 25-gauge, 1.5 inch sharp needle is inserted below the mid superior orbital rim with the needle lumen facing the orbital roof to a depth of 1.5 inches. Then 1.5-2ml of anaesthetic solution is infiltrated followed by gentle digital pressure. If the patient is adequately blocked, a complete ptosis will result with the inability to open his eye.

Infraorbital nerve block

This block provides excellent anaesthesia for surgery on the lower lid, central and mid face, lateral aspect of nose and upper lip. This block can be performed via a cutaneous or intraoral route. Cutaneous route: the infraorbital

foramen is palpated approximately 6 mm below the infraorbital rim and parallel to the mid-pupillary axis. A 30-gauge 0.5-inch needle should be directed perpendicular to, without entering, the foramen. Several boluses of 0.5 - 1.0ml can be placed around the foramen. Intraoral route: A 30-gauge 0.5-inch needle should be introduced into the gingival sulcus above at the superior aspect of the canine fossa. 1.0-2.0 ml of anaesthetic solution should be placed around the foramen. A regional nerve block of the upper eyelid achieves effective sensory anesthesia, without compromising motor function. This helps in an accurate assessment of intraoperative height during upper lid surgery.

Monitored anaesthesia care

The "conscious sedation" or "monitored anaesthesia care" (MAC) is defined as a specific anaesthesia service involving monitoring of vital signs provided during a planned procedure in connection with regional anaesthesia. The goal of conscious sedation for surgery under regional anaesthesia is to enhance patient comfort, preservation of protective airway reflexes, to avoid painful stimuli and to help maintain haemodynamic stability during the whole surgical procedure. Sedation during ophthalmic surgery is distinctly lighter than for other surgery because it is essential that the patient remains alert and can cooperate with the surgeon. Sedation and analgesia can be achieved by careful intravenous titration after preoperative screening and

preparation and the assessment of risk for adverse events. The choice of drugs and strategy should be based on patient preference, cooperation and patient acceptance. Continuous insufflation of oxygen-enriched air is needed to ascertain that CO_2 has been flushed away. Because of the risk of life-threatening complications in ophthalmic regional anaesthesia, the anaesthesiologist must be present. Careful surgical draping with the use of a bar to hold up the drapes can allow a tent to be made to allow better ventilation

Figure 7. Surgical draping during monitored anaesthesia care

Choice of sedative agents

The centrally active adjuvant drugs to optimize surgical conditions for both patient and surgeon include benzodiazepines (midazolam), sedative doses of hypnotic agents (propofol) and short acting opioid analgesics (remifentanil).

Anaesthesia for specific procedure

Cataract

Most common ophthalmic surgery is the cataract extraction. Bilateral paediatric cataracts are commonly associated with systemic disease and should be

operated within the first few weeks of life. Lens extraction is preformed after maximal mydriasis with topical agents. Anaesthesia should provide complete akinesia and meticulous control of IOP with controlled ventilation. In healthy adults, phacoemuscification is usually performed under regional or topical anaesthesia. Postoperative pain is minimal and can be controlled with non steroidal anti-inflammatory drugs.

Glaucoma

Infantile glaucoma has onset within the first 3 years of life and has the classic triad of symptoms which includes tearing, photophobia and blepharospasm. Concomitant congenital abnormalities such as craniofacial dysostoses, various chromosomal trisomies and other syndromes are not uncommon.

The aim of anaesthetic management in glaucoma surgery is to control IOP within the normal range and avoid its increase during anaesthetic procedure i.e. laryngoscopy, intubation. Atropine premedication in normal doses is not harmful. At the time of extubation coughing and straining on endotracheal tube should be avoided.

Intraocular tumors

In children, retinoblastoma is the predominant primary eye neoplasm. Besides surgery these children used to visit hospital for fundoscopic examination, ultrasound, laser, cryotherapy and thermotherapy and to follow progress/regress of the disease and to provide therapy on a continuous basis. Measure to allay the anxiety should be taken i.e. premedication and if required parenteral presence. A complete blood count may be indicated for those who have received recent chemotherapy.

Access to the eye for the surgeon and ultrasonographer can be important with use of a mask such as a Rendell-Baker mask, tailored to hug the bridge of the nose and taper away from the eyes or a laryngeal mask airway can be used to prevent pressure on the eyes with the ill fitting face mask. Incidence of OCR is high and itraoperative blood loss may be significant during enucleation surgery. Enucleation and exanteration are also associated with significant postoperative pain.

Strabismus Surgery

Strabismus is a misalignment disorder of extraocular muscles characterized by amblyopia with or without anisometropia. Strabismus may be inherited, developmental or acquire and can have associated comorbidities particularly neuromuscular disorders. They may have increase risk for malignant hyperthermia (MH) or may have an undiagnosed cardiomyopathy. The risk of MH may be reduced by avoiding succinylcholine and halothane. To detect MH early, body temperature, ECG and especially end tidal concentration of carbon dioxide should be monitored. During surgery OCR is not infrequently encountered in infants and children due to the traction on the extra ocular muscles. Squint surgery is often accompanied with PONV, may be due to oculo-gastric reflex. Local anaesthetic near the extraocular muscle during surgery will reduce afferent impulses and postoperative pain. Following surgery, motion sickness because of diplopoa may also produce nausea and emesis. Total intravenous anaesthesia is an attractive alternative in patients susceptible to MH and PONV.

Surgery for nasolacrimal system

If the naso-lacrinal duct is blocked, first step is syringing and probing and steps should be taken to avoid respiratory obstruction due to laryngospasm. This can be achieved either by intubation or inserting LMA with continuous suction through ipsilateral nare or pharynx or positioning the patient with a pillow under the shoulders to divert irrigation fluid away from the larynx.

For dacrocystorhinostomy, topical vasoconstrictors are used to minimize bleeding at the nasal mucosa and endotracheal intubation along with pharyngeal packing is required.

Oculoplastic surgery

These surgeries include lid surgery, orbital fractures, orbitotomy etc. In adults most of these surgeries can be performed under regional blocks. In children and in complicated cases like orbital floor repair general anaesthesia is required. These surgeries are more extensive and painful. Local anaesthesia can be supplemented during or after surgery before extubation to reduce postoperative pain.

Paediatric ophthalmic surgery

Paediatric patients lack the maturity to remain still and are readily traumatized by unfamiliar environments and separation from parents. General anaesthesia is mandatory for children even for simple refraction, measuring IOP, ultrasonography or electroretinography. Ophthalmic pathologies requiring surgery include congenital or traumatic

cataract, glaucoma, nasolacrimal duct stenosis, penetrating eye injuries, intraocular tumors, retinopathy of prematurity (ROP).

Many ophthalmopathies can be associated with other congenital disorders including congenital heart disease and airway abnormalities that may have important anesthesia implications.

Renitopathy of Prematurity (ROP)

ROP, a disease of neovascularization of the retina is a leading cause of infant blindness. This neovascularization causes poor visual acuity, tractional retinal detachment, amblyopia and ultimately blindness.

These premature, low birth weight infants have markedly higher incidence of bronchopulmonary dysplasia, cardiac anomalies, episodic bradydysrhythmias, anemia, intraventricular hemorrhage and necrotizing enterocolitis.

Post operative breath holding and aponea are potential serious complications. Perioperative risk of aponea is dependant on post conceptual age, gestational age and prior history of aponea at home. Combined analysis of several studies has found that at 48 weeks post conceptual age, neonates have an approximately 5% risk of postoperative aponea, where as those at approximately 55 weeks have a less than 1% probability. Anaesthetic management of these ex-premies also includes maintenance of normothermia, precise intravenous fluid management, and monitoring of serum glucose levels. Arterial oxygen tension should be kept between 60-90mmHg i.e. SpO2 at 90% to 95%.

Preterm infants should be observed after surgery with pulse oximetry and aponea- monitoring as inpatient setting. A paediatric transport team and facility for postoperative ventilation should be arranged before the day of surgery.

Examination Under Anaesthesia

In children general anaesthesia is required for even simple refraction, measuring IOP, ultrasonography or electroretinography. After proper preoperative evaluation and fasting, general anaesthesia can often be provided satisfactorily via a face mask or laryngeal mask airway. Decision for insertion of an intravenous cannula is on indivisual basis, if vein is visible and procedure is short than one can avoid iv cannula, provided equipment are ready for emergency insertion. These patients are allowed to breath spontaneously with O2, N2O and inhalational agent to maintain 1.0 -1.3 MAC. An indicator of inadequate level of anaesthesia is the upward rolling of the eyes in response to pressure on the eye lids by an eye speculum, a natural protective reflex, known as Bell's phenomenon. Since this reflex is lost under deep anaesthesia and eyelids are open with the eyes readily visible throughout the procedure. Belling of the eye may be a useful monitor of anaesthetic depth. Sevoflurane is an ideal inhalational agent for children undergoing examination under anaesthesia because of its favorable cardiovascular profile and lack of respiratory irritation. But emergence delirium is the most often encountered drawback in children younger than 6 years of age.

Anaesthesia for Emergency Eye Surgery

Anaesthesia for emergency eye surgery can present special problems to the anaesthetist and is a challenge as a patient with a penetrating eye injury and full stomach confronts special problems. The commonest eye emergencies are

1. Traumatic injuries
   a. Blunt
   b. Penetrating ("open eye")
2. Chemical burns of the eye
3. Retinal artery occlusion.

The incidence is highest in young adult males and children. Non-traumatic surgical "emergencies" include spontaneous retinal detachment, infections, and complications of previous surgery.

Timing of surgery

Ideally all patients should be fasted before undergoing general anaesthesia to minimise the risk of aspiration and subsequent lung injury. Decision for delay in surgery should be taken after establishing the degree of urgency to prevent the risk to the eye with the surgeon. Penetrating injuries may need to be dealt more urgently due to the risk of infection, endophthalmitis, vitreous loss and retinal detachment. Proper preoperative evaluation should be done to rule out any other medical or surgical disease and should be optimized prior to surgery if time allows.

A fast of six to eight hours for solid food and 2-4 hours for clear fluids is normally suggested in the uncomplicated patient. The most important time interval is that between the last meal and the time of the injury. Alcohol also delays gastric emptying. If surgery is necessary in a patient with a full stomach then a rapid sequence induction technique should be used.

Choice of a local or general anaesthetic technique

The choice of technique will depend on patient factors as well as local facilities and surgeon preferences. Extra-ocular, anterior segment and vitreo-retinal eye surgery is routinely performed using local anaesthetic techniques. But for emergency cases, general anaesthetic is often preferable because the patient must be able to lie flat, still and protect his or her own airway safely for the duration of the procedure, and spread of local anaesthetic agents is poor in patients with eye and orbital infections. Local anaesthetic injection is associated with an increase in intra-ocular pressure which may lead to vitreous loss and also oculocompression after the block can not be applied in open eye injury.

Thus, children, uncooperative or intoxicated patients and open globe injury patients are usually better candidates for a general anaesthetic.

Sedation

Sedation should be used cautiously and titrated in a patient with a full stomach as it can cause airway problems and patient confusion. Small doses of a short acting agent such as midazolam, propofol, fentanyl or alfentanil can be administered. The key to good sedation is to maintain verbal contact with the patient.

Choice of drugs for general anaesthesia

If possible, early administration of histamine H2 - receptor antagonist such as ranitidine (1-1.5mg/kg iv) with metoclop-ramide (0.15mg/kg iv) will decrease gastric acidity and volume, respectively, and provide some protection.

Prior to rapid sequence induction of anaesthesia, precautions must be taken to blunt the cardiovascular and IOP responses to laryngoscopy and tracheal intubation. Intravenous administration of lidocaine (1.5mg/kg) and of sufentanil (0.05-0.15µg/kg), remifentanil (0.5-1.0 µg/kg) 3 to 5 minutes before induction, may help in attenuating the increase in IOP after tracheal intubation. A beta adrenergic receptor blocking drug such as labetalol (0.03mg/kg IV) may also help in blocking the cardiovascular response to tracheal intubation, especially in patients with angina or hypertension.

Most intravenous induction agents reduce intra-ocular pressure therefore preventing further damage to the injured eye. An adequate dose of thiopentone or propofol will ensure adequate depth of anaesthesia during tracheal intubation. Ketamine should be avoided in open eye injuries. All the non-depolarising muscle relaxants can be used without adverse effects on the eye.

Suxamethonium use in penetrating eye injury anaesthesia is controversial as it increases IOP. The extent of the rise in intra-ocular pressure will depend on the other drugs used and the response to laryngoscopy and intubation. Adequate fasting prior to surgery will allow suxamethonium to be avoided for the majority of urgent cases. For rapid sequence induction, the relative risks need to be weighed, i.e. prevention of aspiration (potentially life threatening) verses ocular damage (potentially sight threatening). Suxamethonium avoiding techniques include the use of large doses of vecuronium (0.2mg/kg) or rocuronium (0.9-1.2mg/kg) to speed up its onset of action as part of a modified rapid sequence induction technique. A more rapid- acting rocuronium (60secs) with duration of 30 to 40 minutes can also be used for a rapid sequence induction technique. During general anaesthesia for open eye surgery, depth of anaesthesia must be adequate to ensure lack of movement or coughing. To ensure profound neuromuscular blockade, train of four must be monitored to prevent any movement and coughing during surgery.

Airway management and mode of ventilation

Patient should be intubated and ventilated to ensure a secure airway and to facilitate mild hypocarbia to reduce IOP. The proseal laryngeal mask airway is also a good alternative with controlled ventilation as its insertion avoids the pressor

response to laryngoscopy and intubation. The laryngeal mask does not protect against aspiration of gastric contents so its use in emergency anaesthesia is limited except in difficult intubation.

Analgesia and control of nausea and vomiting

After the completion of surgery under general anaesthesia, surgeon can perform a local anaesthetic block before waking up the patient.

Postoperative pain after eye surgery can be managed with oral analgesia i.e. paracetamol and a non steroidal anti-inflammatory drug (ibuprofen, diclofenac, ketoprofen). If possible opioids should be avoided as it will reduce nausea and vomiting.

Drug	Dose
Paracetamol (Acetominophen)	Children: 90 mg/kg total per 24 hours orally or rectally in 4-6 divided doses Adults: 1g orally or rectally. 4g total per 24 hours
Ibuprofen	Children: 10mg/kg orally. 4 doses maximum in 24 hours. Adults: 400 mg orally. 4 doses maximum in 24 hours.
Diclofenac	Children: 1mg/kg orally or rectally. 3 doses in 24 hours. Adults: 150 mg total by any route in 24 hours
Ketorolac	0.25-1.0 mg/kg intramuscularly or intravenously. 3-4 doses in 24 hours.

Nausea and vomiting after emergency eye anaesthesia can be a major problem. Anti-emetic prophylaxis may help prevent PONV. Using a combination of small doses of anti-emetic drugs from different pharmacological classes may enhance efficacy and reduce side effects. A smooth induction, intubation and extubation will also help in reducing the incidence of PONV.

A practical approach to emergency eye anaesthesia

- Assess the indication for emergency anaesthesia in discussion with the surgeon and if possible allow adequate fasting.
- A thorough full preoperative assessment including a history and examination.
- Are there any medical/trauma issues that need addressing first?
- Decide on choice of anaesthetic technique. Tell the patient what to expect if a local anaesthetic technique is to be used.
- If a general anaesthesia is chosen and the patient has a full stomach, anti aspiration prophylaxis should be given and a rapid sequence induction technique should be planned.

- In case of a child intravenous cannula can be inserted after application of EMLA cream in their parent's presence and preoxygenated with 100% oxygen avoiding pressure on the affected eye from the mask. The patient is induced with an intravenous anaesthetic agent (eg thiopentone 4-7mg/kg or propofol 2-3mg/kg) and a rapid onset muscle relaxant (suxamethonium 1-1.5mg/kg or rocuronium 0.9 -1.2mg/kg). While the patient is being induced cricoid pressure should be applied by an assistant (Sellick's manouvre) thus occluding theoesophagus behind. Laryngoscopy should be performed gently and trachea is intubated after which the cricoid pressure can be removed. Spraying the vocal cords with lignocaine can minimise the pressor response to intubation. This may also decrease the risk of coughing on intubation. The endotracheal tube tie should not be tight around the neck as this impedes venous drainage and raises IOP. A nasogastric tube should be inserted to decompress stomach.

- The anaesthesia is maintained with O2, N2O and an inhalational agent. A short acting analgesic should be administered.

- Control ventilation should be initiated during the procedure aiming for low to normal end-tidal carbon dioxide with longer acting muscle relaxant along with neuromuscular monitoring. A slight head up tilt helps reduce IOP.

- At the end of the procedure, the patient should be extubated on their side and once airway protective reflexes have returned. In patients not deemed at risk of aspiration, extubation with the patient deep and breathing spontaneously may prevent coughing. Intravenouslignocaine 1.5mg/kg or remifentanil 0.5μg/kg 3-5mins before extubation can help in prevention of coughing and straining as this increases the risk of ocular haemorrhage.

- If the patient does not have a full stomach, general anaesthesia should proceed as for an elective patient. If available laryngeal mask airway insertion will prevent laryngoscopy and intubation i.e. increase in IOP.

- Post operatively nausea, vomiting and pain should be kept to a minimum as they can cause rises in intra-ocular pressure. Oral analgesia and an anti-emetic should be administered. Some patients may need stronger analgesia early after surgery i.e. titrated small doses of intravenous opioid (fentanyl, alfentanil, morphine, pethidine) should be given to control pain.

Congenital syndromes with eye involvement

Down syndrome

These patients may have strabismus, cataract, mental retardation, congenital heart defects (CHD), macroglossia, atlantoaxial instability, hypothyroidism, hypotonia and seizure disorder

Sturge-weber syndrome

These patients have secondary glaucoma along with cavernous cutaneous hemangiomas of the face, ectopia lentis, cerebral cortex and lower airway, CHD and high output failure and seizure disorder.

Crouzon's syndrome
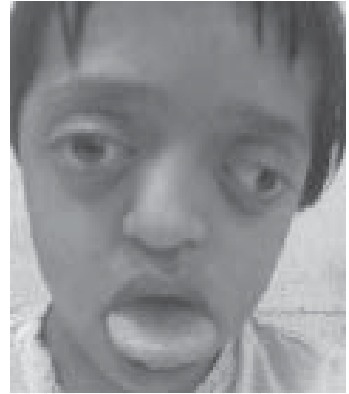
Theses patients may have glaucoma, cataract, strabismus, proptosis, hypertelorism craniofacial abnormalities, possible difficult intubation and elevated intracranial pressure.

Goldenhar syndrome

These patients may have glaucoma, cataract, strabismus, lid coloboma, lacrimal duct defects, hemifacial microsomia, possible cervical spine abnormalities, possible difficult mask ventilation and intubation, hydrocephalus, preauricular tag and rare CHD.

Marfan syndrome - These patients may have subluxated lenses, retinal detachment, cataract, strabismus, heart valve defects, thoracic aneurysm and kyphoscoliosis.

Homocystinuria -These patients presents with subluxated lenses, glaucoma, retinal detachment, optic atrophy, marphanoid habitus with kyphoscoliosis and sternal deformity and susceptible to thromboembolic complications during anaesthesia. Hyperinsulinemia and hypoglycemia make them more susceptible for convulsion.

Suggested reading

1. Varvinski A, Eltringham R: Anaesthesia for Opthalmic Surgery Part 2 : General Anaesthesia: Update in Anaesthesia 1998; 8 (5): 1.

2. Wilson A, Soar J. Anaesthesia for Emergency Eye Surgery: Update in Anaesthesia 2000;11 (10): 1-2.

3. Kumar CM, Dodds C. Ophthalmic Regional Block. Ann Acad Med Singapore 2006; 35:158-67

4. Kumar CM., Dowd TC.. Complications ofOphthalmic Regional Blocks: Their Treatment and Prevention: Ophthalmologica 2006; 220:73-82.

5. Holloway KB. Control of the eye during general anaesthesia for intraocular surgery. British Journal of Anaesthesia. 1980; 52: 671- 9.

6. Wilson I, Eltringham R. Anaesthesia for Ophthalmic Surgery: Update in Anaesthesia1996; 3(6): 1-3.

7. Donlon JVJ, Doyl DJ, Feldman MA. Anaesthesia for Eye, Ear, Nose and Throat Surgery. Miller's Anaesthesia 6th edition, New York: Churchill Livingstone: 2005 (2); 2527-2537.

8. Joshi C, Bruce DL: Thiopental and Succinylcholine action on intra ocular pressure. Anesth Analg 1975; 54: 471.

9. Libonati MM, Leahy JJ, Ellison N. The use of succinylcholine in penetrating eye injuries. Anesthesiology 1985; 62: 637.

10. Hauser MW, Valley RD, Bailey AG.. Anesthesia for Pediatric Ophthalmic Surgery : Smith's Anesthesia for Infants and Children 7th edition, Mosby Elsevier: 2006; 770-788.

11. Ophthalmic Anaesthesia. Ophthalmology Clinics of North America: 2006 (19).

12. Philip BK. The use of remifentanil in clinical anaesthesia. Acta Anaesth Scand 1996; 40: Suppl.109, 170-173

13. Johnson RW, Forrest FC. Anaesthesia for ophthalmic surgery. In: International Practice of Anaesthesia; Prys-Roberts and Brown: Edition I (1996); Volume 2; 110: 1-29.

14. Smith I, Monk TG, White PF et al. Propofol infusion during regional anesthesia: sedative, amnestic and anxiolytic properties. Anesth Analg 1994; 79: 313-9

15. Smith I, White PF, Nathanson M, Gouldson R. Propofol: An update on its clinical uses. Anesthesiology 1994; 81: 1005-43

16. Stevens MH, White PF. Monitored anesthesia care. In Miller RE, ed. Anesthesia 4th edition. New York: Churchill Livingstone, 1994; 1465-1480.

Ether anesthesia

Chloroform Inhaler, Junker's, with Buxton's Bottle, fitted with improved automatic safety valve, graduated to 8 drms., complete with double rubber belows, tubing, malleable mouth tube, and Tyrrell's mask with flannel cover

Chloroform Inhaler, Junker's, with Rigby's Safety Bottle, fitted with ball valve. It is impossible to blow liquid chloroform. Graduated to 16 drms., complete with double rubber belows, tubing, malleable mouth tube and celluloid face piece

Anaesthesia for Noncardiac Surgery in Heart Transplanted Patient
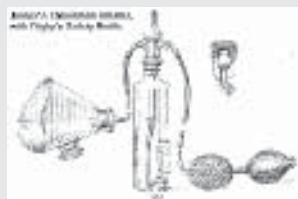
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First heart transplant was done in South Africa by Dr Christian Barnard in 1967. The usual indication for heart transplantation includes idiopathic or ischemic cardiomyopathy, viralcardiomyopathy, and systemic diseases such as amyloidosis and complex congenital heart disease[1]. Subsequent surgical intervention may be required for disease acquired as a consequence of immunosuppression such as malignancy, infection, and steroid induced osteoporosis or unrelated problems pertaining to other body organs[2,3].

Anatomy and Physiology of the Transplanted Heart- Because portions of both native and donor right atria are present, two P waves may be seen on the electrocardiogram (ECG)[3]. Native sinus activity is not transmitted across the midatrial suture line[4]. Mitral Regurgitation is common because of alterations in atrial geometry caused by transplantation[5]. Moderate to severe Tricuspid Regurgitation is often present[6]. Preoperative evaluation and intraoperative management of the patient with prior cardiac transplant requires an understanding of some of the unique features inherent to transplantation[7,8]. In addition to denervation, the transplanted heart is at risk for coronary

vasculopathy, rejection, and arrhythmias.

Denervation-The aorta and the main pulmonary arteries are transected, the cardiac plexus is interrupted and the heart is denervated. The recipient atrium remains innervated, but haemodynamically unimportant, while the donor atrium is denervated and is responsible for the electrophysiological responses of the transplanted heart.Anaesthetic management of the denervated heart must take into account its abnormal response to changing physiologic demands and pharmacologic agents[2,9]. The loss of efferent sympathetic innervation prevents the heart from rapidly changing rate and contractility in response to exercise, hypovolemia, or vasodilatation. Afferent nerve interruption impairs rennin angiotensin-aldosterone regulation, vasoregulatory responses to changes in cardiac filling pressures, and eliminates the afferent signals perceived as angina. Responses that are normally mediated via Autonomic Nervous System (ANS) are absent. Heart Rate (HR) is unresponsive to drugs or physiologic compensatory responses such as Carotid massage, Valsalve maneuvers[2]. The denervated heart retains its intrinsic control mechanisms

which include: a normal Frank-Starling Effect demonstrated with volume loading and in response to exercise, normal impulse formation and conductivity and intact alpha and beta adrenoceptors responding normally to circulating catecholamines[2].The denervated heart responds in a twofold sequential manner. Initially the denervated heart relies upon the Frank Starling mechanism[7,10]. Following that, the increased CO is maintained by a HR which slowly increases over 5-6 minutes in response to increasing circulating catecholamines. Thus, increasing preload is useful before anaesthetic manoeuvres such as rapid thiopentone induction or spinal anaesthesia. In the transplanted heart, chronotropic responses to exercise and stress are delayed and the peak rate is attenuated[11]. This finding implies that the response to surgical response surgical stress or stimulation may be delayed and may persist after adequate drug therapy has been administered to control the stress. The donor SA node determines HR. Because of the lack of ANS innervation, the transplanted heart beats at the intrinsic rate of donor's SA node, usually 90-110 beats per minute, which reflects the intrinsic rate of depolarization at the donor

sinoatrial node in the absence of any vagal tone[3]. Permanent pacemaker insertion may be required.Incomplete and unpredictable sympathetic reinnervation may occur in the transplanted heart. While parasympathetic reinnervation has been demonstrated in animals, only sympathetic reinnervation has been demonstrated in human cardiac transplants[12].Other effects associated with heart denervation include loss of sympathetic response to laryngoscopy and intubation.

Cardiac function following transplantation

Ventricular function - Myocardial metabolism normal; Ventricular function slightly reduced;Contractile reserve normal;Frank-Starling mechanism intact; Left ventricular mass/end diastolic wall thickness are normal; Diastolic relaxation abnormal; Preload dependence for ventricular output;Exercise response - Cardiac output increases owing to increased venous return,HR increases owing to catecholamine increases. A restrictive hemodynamic pattern is seen with volume administration in early weeks following transplantation[13]. Diastolic relaxation and compliance may be abnormal, necessitating higher filling pressures to maintain CO, particularly in the early postoperative period. Diastolic function normalizes over time[14].

Coronary Circulation-Changes in Coronary Circulation following transplantation are-

Resting coronary flow increased by absence of a-adrenergic tone;Coronary flow regulated by pH and PCO_2 with intact autoregulation;Vasospasm and vasoconstriction in response to acetylcholine possible(responsive to adrenoceptor agonist and antagonist); Coronary atherosclerosis accelerated and silent ischemia likely.

Accelerated Coronary atherosclerosis - Allograft coronary vasculopathy remains the greatest threat in long term survival after heart transplantation[15]. Allografts are prone to the accelerated development of an unusual form of coronary atherosclerosis that is characterized by circumferential, diffuse involvement of entire coronary arterial segment, as opposed to the conventional form of the coronary atherosclerosis with focal plaques often found in eccentric positions in proximal coronary arteries[16]. Although the etiology of coronary vasculopathy is multifactorial, recurrent graft rejection is a major contributing factor[2]. The pathophysiologic basis is likely due to an immune cell mediated activation of vascular endothelial cells to up regulate the production of smooth muscle cell growth factors. The criterion standard for evaluating transplanted coronary artery disease has been Angiography[2]. However, this modality may underestimate the degree of diffuse intimal hyperplasia in the patients with coronary vasculopathy. Coronary Intra Vascular Ultra Sonography

(IVUS) has been established as a very useful and reliable modality[17]. Dobutamine Stress Echocardiography (DSE) has been shown to be a safe and reliable screening method[18].The anaesthesiologist should assume that there is a substantial risk of coronary vasculopathy in any heart transplant recipient beyond the first 2 years, regardless of symptoms, the results of noninvasive testing, and even angiography.

Silent Ischemia-Because afferent cardiac innervation is rare, substantial portions of recipient with accelerated vascul-opathy have silent ischemia[3]. Thus, the presenting signs are those resulting from ischemia such as left ventricular dysfunction, ventricular arrhythmias, or even sudden death[2].Patients who present for an urgent or semielective operation with a positive DSE, IVUS, and angiographic evidence of coronary vasculopathy are a special challenge. Detection of intraoperative MI may be problematic. Monitoring Electrocardiogram (ECG) for ST changes consistent is of some value. Unexplained hypotension should raise the suspicion of MI. TranesophagealEchocardiography (TEE) is a more sensitive monitor for changes in cardiac function.

Perioperative Management- A history of good exercise and the absence of cardiac failure symptoms comprise sufficient preoperative evaluation for minor procedures. All patients receive

immunosuppression, and preoperative evaluation includes serum sampling to determine adequate levels[2].

Preoperative evaluation-It includes review of previous records, ECGs, Chest X Ray, and Myocardial biopsy results. Other investigations include Haemoglobin, Blood Urea Nitrogen, Serum Creatinine, Electrolytes, Liver Function Test, Echocardiography (ECHO) (to evaluate ventricular function) or Exercise stress test (to check for graft coronary artery disease), Pacemaker (evaluate its function) and evaluation for rejection and infection.

Evaluation for rejection - Cardiac transplant recipients usually experience 2-3 episodes of rejection within the first year after transplant[19]. Usual presentation includes fatigue, relative hypotension, S3 gallop, elevated JVP, and other symptoms of left ventricular dysfunction. Patients may have pericardial effusion, worsening systolic/diastolic function on ECHO and atrial / ventricular arrhythmias. These signs and findings should prompt emergent myocardial biopsy.

Arrhythmias are more prominent during episodes of rejection, and this can compound the intraoperative morbidity in patients undergoing noncardiac surgery[2,20]. Small ECG complexes should also alert the physician to the possibility of impending rejection, as should an increased frequency of transient ischemic attacks. The gold standard for determining the presence of acute rejection is Endomyocardial biopsy[21]. The allograft vasculopathy is believed to be secondary to immunologically mediated endothelial injury, but other recipient factors (dyslipidemia, diabetes, HTN) and donor factors (e.g. older donor, age, donor HTN) may also play a role[22,23].

Cardiac Dysrhythmias-Cardiac dysrhythmias in adult heart transplant recipients are common and have been used as a predictor of rejection[3]. Other reasons include lack of vagal tone, rejection, and increased endogenous catecholamine concentrations[3]. Class IA antiarrhythmics normally act via a combination of indirect, atropine like properties and direct suppression of Purkinje system automaticity. While these agents remain useful in the treatment of supraventricular tachycardia or Atrial flutter, the absence of ameliorating tachycardia unmasks their potent negative inotropy after heart transplantation. Class IB drugs suppress ventricular automaticity independently of the ANS, and are thus equally effective in the denervated heart. Beta-adrenergic blocking drugs, class II, retain their usual activity. Bretylium, a class II agent, also exhibits mixed direct and indirect effects through the autonomic system. The net effect on the denervated heart remains poorly understood, thus limiting its use to refractory VT or VF. The Calcium Channel Blockers (CCB), which constitute class IV, directly suppress the sinus and AV nodes and thus retain their usual efficacy after heart transplantation. These drugs, however, possess potent negative inotropic actions as well.Digoxin acts in a biphasic manner. Early reduction in AV conduction that characterizes the response to digoxin is largely vagally mediated. Later in the course of digoxin therapy, direct action will influence AV conduction in the transplant recipient. Adenosine retains its efficacy in terminating supra ventricular tachycardia via a direct SA node depression and slowing of Atrial HIS conduction. The management of ventricular and atrial arrhythmias is similar to that in other cardiac surgical patients, including electrical cardioversion when arrhythmias are associated with hemodynamic instability

Immunosuppressive drugs-All transplant patients who come for surgical procedures will be on some antirejection protocol[1]. It is important for anaesthesiologists to know how these drugs interact with anaesthetic drugs and also side effects immunosuppressive drugs may exhibit. (table 1)Because cyclosporine or tacrolimus levels must be kept within the indicated therapeutic range, the blood levels of patients receiving these drugs should be monitored daily during the perioperative period. Clinically, significant reductions of cyclosporine or tacrolimus blood levels can be caused by dilution with massive fluid infusion.

Table-1: Immunosuppressive Drugs : mechanism, interactions and toxicity.			
Drug	**Mechanism of action**	**Interactions**	**Toxicity**
Azathioprine	Decreased synthesis / utilization of RNA/ DNA precursors,	Allopurinol slows its metabolism	Anemia Leukopenia Cholestatic jaundice Hepatitis, Pancreatitis
Steroids	Inhibition of release/ action of leukotrienes; interference with antigen receptor interactions		Pituitary-adrenal axis suppression, cushingoid features Psychoses Glucose intolerance HTN,Skin fragility Ulcers,Osteoporosis
Cyclosporine	Inhibits synthesis of IL1 and other lymphokines; causes lymphocytolysis	Metabolism decreased by metoclopramide, cimetidine,verapamil, diltiazem, alcohol	HTN Nephro/Hepatotoxicity Neurotoxicity
Tacrolimus	Inhibits production of IL2 and other lymphokines	Similar to cyclosporine	Nephrotoxicity Glucose intolerance HTN, Neurotoxicity
Mycophenolate mofetil	Inhibition of inosine monophosphate dehydrogenase	Increases levels of acyclovir	Irritation of GIT (diarrhoea, ulcers, perforation, bleed) Nephro/hepatotoxicity Bone marrow suppression
Muromonab CD3 antibody (OKT3)	Inhibits antigen recognition by binding to the CD2 surface antigen of lymphocytes lymphocyte opsonization		GI problems Cytokine release syndrome
Antithymocyte globulin	Opsonization of lymphocytes		Allergic reactions Serum sickness Fever, Chills

Azathioprine antagonize competitive neuromuscular blocking (NMB) drugs by phosphodiesterase inhibiting properties necessitating larger doses of nondepolarizing muscle relaxants (NDMRs)[9]. Clinically relevant doses of azathioprine do not antagonize NMB drugs in humans.Corticosteroids are commonly reduced to minimal levels as time from transplantation progresses[9]. However, augmented doses of corticosteroids are the mainstay for treating rejection episodes. Cyclosporine nephrotoxicity is dose related, partially reversible

and the most frequent and important injury[9]. One tentative advantage of mycophenolate mofetil may be reduced coronary atherosclerosis[24].

Effects of specific drugs in Transplanted Hearts - Denervation has important implications in the choice of pharmacologic agents used after cardiac transplantation[3]. The response of the transplanted heart to cardiovascular drugs depends on their mechanism of action. Experimental evidence suggests an increased adrenergic responsiveness to directly acting drugs following denervation[7]. Drugs that act indirectly on the heart via the sympathetic (ephedrine) or parasympathetic (atropine,pancuronium, edrophonium) nervous system will generally be ineffective. Indirect drugs that depend on autonomic pathways are absent e.g. the chronotropic effects of atropine, pancuronium, or opioids are absent. Drugs with a mixture of direct and indirect effects will exhibit only their direct effects (leading to the absence of the normal increase in refractory period of the atrioventricular node with digoxin, tachycardia with norepinephrine infusion, and bradycardia with neostigmine). Thus, agents with direct cardiac effects (such as epinephrine or isoproteronol) are the drugs of choice for altering cardiac physiology after cardiac transplantation. The vagotonic effects of neostigmine would not be expected in transplanted hearts. However few reports has been reported[25,26] of bradycardia with the use of neostigmine. Infusions of isoproteronol should be available to treat bradycardia unresponsive to atropine. Ephedrine may also be used to treat bradycardia or hypotension. Propranolol blocks the effects of isoproteronol and norepinephrine at the SA node. Atropine may not reverse succinylcholine induced bradycardia in the transplanted hearts, so succinylcholine is usually avoided[3]. Epinephrine and norepinephrine have an augmented inotropic effect in heart transplant recipients. In addition, both tend to have a higher b to a or inotropic to vasoconstrictor ratio[27].

Perioperative management- Many of the perioperative problems in the transplanted population have not been studied, and there are no formal recommendations for their management. Preoperative assessment should focus on the transplanted organ function, state of immunosuppression, presence of rejection or infection and the function of other organs[1,3,9]. Immunosuppressive must be maintained and the dose should not be altered perioperatively unless the route needs to be changed from oral to intravenous[2].

Infections concerns- Cardiac transplant recipients are always at risk for infection, particularly when high doses of immunosuppressive therapy are needed[7]. The lung is the most common site of infection, so that a screening chest X-ray is essential prior to anaesthesia. Aseptic precautions in the instrumentation and management of the airway and vascular access sites are mandatory. Antibiotic coverage for the perioperative period is recommended. The immunos-upressed patients doesn't present with typical signs and symptoms of sepsis – fever, leucocytosis, etc[1]. So, a very high index of suspicion is required. Hypertension is often seen in these patients are typically treated with CCBs, although ACE inhibitors and diuretics may be used as well. Usually beta-blockers are avoided after heart transplantation because cardiac responsiveness during exercise and presumably stress is dependent on circulating catecholamines[3]. Although end stage renal failure is infrequent, renal dysfunction continues to be a concern with chronic immunosuppressive therapy. Coadministration of nephrotoxic drugs, like NSAIDs must be monitored closely to avoid acute deterioration of renal function. Anaesthetic drugs that are excreted by renal clearance should also be closely monitored.

Lymphoproliferative malign-ancies account for virtually all paediatric malignancies[3]. Children may require anaesthesia in he course of diagnosis and treatment of these malignancies. The incidence of post transplant lymphoproloferative disease in tonsils after transplantation is low but may cause airway obstruction and should be evaluated in allograft recipients[28].

Monitoring- Standard peroperative monitoring of the ECG, arterial pressures, oxygen saturation, and capnography may all that is required in a well patient[1,9]. The nature of the peroperative monitoring should be decided after consideration of the patient's preoperative condition and the proposed surgery. Invasive monitoring should be limited to minimize the risk of infection[7]. The ECG should be monitored for both ischemia and arrhythmias. The presence of two P waves, one from the native atrium and the other from the transplanted atrium is expected[3]. Central Venous Pressure (CVP) monitoring or the placement of a pulmonary artery catheter is not usually indicated for short, minor surgical procedures. However, because heart transplant recipients are preload – dependent and may be prone to myocardial dysfunction and/or ischemia, invasive hemodynamic monitoring is extremely useful during surgery that involves large volume shifts. There is a role of TEE in addition to, or instead of, invasive hemodynamic monitoring. All peripheral, central, and arterial cannula should be sited under full aseptic techniques. Disposable sterile tracheal tubes should be used and all intravenous infusions fitted with bacterial filters and injection ports kept capped and sterile.

Anaesthetic techniques - Standard premedication may be used, as in nontransplant patients[1]. Orotracheal intubation is preferred over nasal intubation to avoid potential infection caused by nasal flora [9](nasotracheal intubation associated with infection by diptheroids and staphycoccal commensals from the nasopharynx and skin.) The use of Laryngeal Mask Airway is acceptable.

In general, an intravenous induction followed by tracheal intubation and ventilation using a neuromuscular blocking agent, an opioid and an inhalational agent, or spontaneous breathing with an inhalational agent, seem to be the most popular. Because patients with transplanted hearts usually have increased systemic vascular resistance and are dependent upon venous return for CO, any technique that may suddenly reduce either the venous return or vascular resistance must be carefully monitored and conducted. If an epidural or spinal tech is planned coagulation should be normal. Regional anaesthetics such as spinal or epidural require adequate fluid preloading to avoid hypotension. Incremental dosing through an epidural catheter poses less risk of hypotension in the transplant patient. Both Regional Anaesthesia (RA) and General Anaesthesia (GA) can be used, depending on usual considerations of the procedure and the patient condition[1]. GA is usually preferred, as there is a possibility of impaired response to hypotension after spinal or epidural anaesthesia. Reversal of muscle relaxation can be performed safely without the use of muscarinic antagonists. However as parasympathetic reinnervation has not been shown to occur in humans, routine use of muscarinic antagonists would mostly be beneficial to block the muscarinic side effects of anticholinestrases. Caution should be used with anaesthetic agents with significant negative inotropy as these may limit the heart's ability to respond to changes in end diastolic volume. Reflex mechanisms to compensate for the inherent depressant effects of some anaesthetic agents are not functional due to cardiac denervation. Signs of light anesthesia or hypovolemia, such as tachycardia, will be delayed until circulating catecholamines can influence the cardiac b receptors directly and will persist longer after appropriate treatment[3]. The rapid changes in preload and systemic vascular resistance that accompany spinal or epidural anesthesia represent a significant threat of hypotension with a heart devoid of sympathetic reflex compensation. Conversely, rapid fluid administration may precipitate diastolic dysfunction in transplanted hearts manifesting occult restrictive hemodynamic.

Postoperative concerns- Early extubation is desirable to minimize the risk of pulmonary infection from prolonged mechanical ventilation[1]. The function of other organs compromised by immunosu-

ppressive drugs or chronic heart failure such as the liver or kidneys should be closely monitored[2]. Because these patients are at risk for silent ischemia, the ECG should be carefully observed using ST segment trend analysis[3]. Immunotherapy should be resumed at preoperative doses using alternative routes if necessary because oral intake is precluded by the surgical procedure or ileus. Fluid balance must be carefully monitored, as hypovolemia or hypervolemia are both undesirable. Evidence of infection should be sought and promptly investigated and treated. NSAIDs should be avoided and Epidural nerve block, wound infiltration or peripheral nerve blocks can be used for postoperative pain management. Although the effect of transplantation and, in particular, if cyclosporine on intravascular coagulation is controversial, special consideration should be given to Deep Venous Thrombosis prophylaxis in transplant recipients, particularly if other risk factors are present[1].

In conclusion, transplant recipients have considerable medical, physiological, and pharmacological problems; therefore, a clear understanding of the physiology of the transplanted organ, the pharmacology of the immunosuppressive drugs and anaesthetic drugs, and the underlying surgical conditions is essential for these patients to safely undergo anaesthesia and surgery. Local, regional, general anaesthesia can

safely be given to recipients, and successful anaesthetic and perioperative management can be provided.

References

1. Georgia K, Vassilios S, Nikolaos A, Kassiani T, Lila P, John P. Anesthetic and perioperative management of adult transplant recipients in nontransplant surgery. Anesth Analg.1999;89:613-22.

2. Cheng DCH, Ong DD. Anesthesia for noncardiac surgery in heart transplanted patients. Can J Anaesth. 1993;40:981-86.

3. Shaw IH, Kirk AJB, Conacher ID. Anaesthesia for patients with transplanted hearts and lungs undergoing noncardiac surgery. Br J Anaesth. 1991;67:772-78.

4. Valantine HA, Appleton CP, Hatle LV, et al. Influence of recepient atrial contraction on left ventricular filling dynamics of the transplanted heart assessed by Doppler Echocardiography. Am J Cardiol. 1987;59:1159.

5. Stevenson LW, Dadourian BJ, Kobashigawa J. Mitral regurgitation by Doppler echocardiography after orthotopic cardiac transplantation. Am J Cardiol. 1987;60:119.

6. Lewen MK, Brigg RJ, Miller RW. Tricuspid regurgitation by Doppler echocardiography after orthotopic cardiac transplantation. Am J Cardiol. 1987;59:1371.

7. Bricker SRW, Sugden JC. Anaesthesia for surgery in a patients with a transplanted heart. Br J Anaesth 1985;57:634-37.

8. Fawzy G Estafanous, Paul G Barash, JG Reves. Cardiac Anaesthesia: principles and clinical practice. 2nd edition. 2001. Lippincott Williams and Wilkins, Philadelphia.

9. Sharpe MD, Gelb AW. Anesthetic considerations for the previously transplanted patient. Anesthesiology Clinics of North America. 1994;12(4):827-40.

10. Pope Se, Stinson EB, Daughters GT. Exercise response of the denervated heart in long term cardiac transplant recipients. Am J Cardiol. 1987;46:213.

11. Carter R, Rawas AOA, Stevenson A, et al. Exercise responses following heart transplantation: 5 year follow up. Scott Med J. 2006:51:6-14.

12. Givertz MM, Hartley LH, Colucci WS. Long term sequential changes in exercise capacity and chronotropic responsiveness after cardiac transplantation. Circulation. 1997;96:232.

13. Young JB, Winters WL, Bourge R, Uretsky BF. Function of the heart transplant recipients. J AM Coll Cardiol. 1993;22:31.

14. St Goar FG, Gibbons R, Schnittger I. Left Ventricular diastolic function. Doppler echocardiographic changes soon after cardiac

transplantation. Circulation. 1990;82:872.

15. Parry A, Roberts M, Parmeshwar J, et al. The management of post cardiac transplantation coronary artery disease. Eur J Cardiothoracic Surg.1996; 10:528-32.

16. Hunt SA. Current status of cardiac transplantation. JAMA. 1998;280:1692.

17. Mehra MR, Ventura HO, Steptilon DD. Presence of severe intimal thickening by intravascular sonography predicts cardiac transplant events in cardiac allograft vasculopathy. J Heart Lung Transplant. 1995;14:632.

18. Akosh KO, Mohanty PK, Funai TM. Noninvasive detection of transplant coronary artery disease by dobutamine stress schocardiography. J Heart Lung Transplant. 1994;13:1024.

19. Hunt SA. Complications of heart transplantation. J Heart Transplant.1983;3:70.

20. Reginald YG, Greg W. The preoperative evaluation of the transplanted patient for nontransplant surgery. Surg Clin N Am.2006;86:1147-66.

21. Kanter SF, Norman DJ, Shield CF. anaesthesia for major operations who have transplanted hearts, a review of 29 cases. Anesthesiology. 1977;46:65-68.

22. Hosenpud J, morris TE, Shiplet GD. Cardiac allograft Allopathy. Transplantation. 1996;61:939.

23. Libby P, salomon RN, Payne DD. Functions of vascular wall cells related to the development of transplantation: associated with coronary artreriosclersosis. Transplant Proc. 1989; 21:3677.

24. Gregory CR, Prastt RE, Huie P, et al. Effects of treatment with cyclosporine FK 506, rapamycin, mycophenolic acid, or deoxypergualin on vascular smooth muscle proliferation in vitro and in vivo. Transplant Proc. 1993;25:770.

25. Backman SB, Ralley FE, Fox GS. Neostigmine induced bradycardia in a heart tranplant patient, Anesthesiology. 1993;78:777.

26. Beebe DS, Shumway SJ, Maddock R.Sinus arrest after intravenous noestigmine in two heart transplant recipients. Anesth Analg. 1994;78:779.

27. Rundquist B, Eisenhofer G, Dakak NA, et al. Cardiac noradrenergic function one year following cardiac transplantation. Bllod Press 1993;2(4):252-61.

28. Shaw IH, Kirk AJB, Conacher JD. Anaesthesia for patients with transplanted heart and lungs undergoing noncardiac surgery. Br J Anaesth. 1991;67:772.

How Nitrous Oxide Works

Like other anaesthetics that we breathe, nitrous oxide depresses the normal function of the brain - depending on its dose or concentration. But exactly how nitrous oxide produces analgesia remains a mystery. Whatever the mechanism may be, it is necessary for the gas to reach the brain in a concentration which is sufficient to relieve pain. This is achieved via the lungs and bloodstream.

When nitrous oxide is inhaled, it mixes with the air already in our lungs and then passes into the circulation. This transfer to the bloodstream occurs easily and quickly. Once it enters the blood, incidentally, the gas goes into solution - it does not form bubbles! From the lungs, nitrous oxide starts to reach the brain (and other organs) within 15 seconds. The actual amount of gas which reaches the brain depends upon the concentration that is inhaled and how long it is breathed. When used in labour, the concentration of nitrous oxide reaching the brain rises rapidly

Anticoagulants and Anesthetic Considerations

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Anaesthesiologists many times encounter patients on drugs that alter the coagulation profile. These patients might either be on long term anticoagulation or might require anticoagulation postoperatively. They may be patients of all age groups i.e. pregnant obstetric patients or geriatric patients who may need to undergo surgery under general or regional anesthesia. They may be receiving anticoagulants, antiplatelet drugs or thrombolytics. In brief, the mechanism of action of these drugs, tests needed for monitoring their effects, preoperative preparations and anaesthetic implications of their use will be discussed.

Pharmacology of Heparin and LMWH

Heparin is a naturally occurring negatively charged polysaccharide with a complex structure. Heparin is heterogeneous with respect to molecular size. Its molecular weight ranges from 3,000 to 30,000 daltons (with a mean molecular weight of 15,000 daltons) and 45 polysaccharide chain length. About one third of heparin molecules contain a pentasaccharide sequence which bind to anti thrombin III (AT III) a naturally occurring, slow acting inhibitor of coagulation. Binding of heparin to this cofactor dramatically increases its inhibitory effect. The heparin AT III complex inactivates a number of coagulation enzymes including factor IIa, factor Xa, IXa, XIa, XII (Fig 1). Large heparin molecules (containing more than 18 saccharides) are able to bind simultaneously to thrombin (IIa) and AT III and to inhibit thrombin. Factor IIa is ten times more sensitive than factor

Fig 1: Mechanism of Anticoagulation
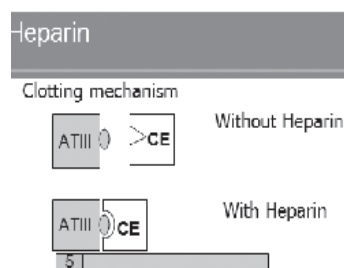
ATIII – antithrombin III, CE – clotting enzymes

Xa to inhibition by standard heparin.

Clearance of Heparin-The chain length of the molecules also influences clearance of heparin. The high molecular weight chains are cleared more rapidly from circulation than the lower molecule weight species. At therapeutic doses heparin is cleared mainly through rapid

saturable dose-dependent mechanism i.e. by binding to receptors on endothelial cells and macrophages where it is depolymerized. The slower unsaturable mechanism is renal. Therefore as the dose of heparin increases the elimination half-life increases and the anticoagulant response is exaggerated disproportionately.

Bioavailability of Heparin-The bioavailability and anticoagulant
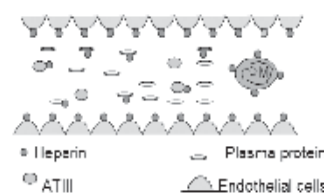
Fig 2 : Reason for decreased Bioavailabilty

effect of standard heparin is reduced (only 40%) due to binding to plasma proteins, platelets, endothelial cells and acute phase reactants (Fig 2). The preferred routes of unfractionated heparin (UFH) administration are continuous intravenous infusion or subcutaneous route. Heparin is poorly absorbed from the gastrointestinal tract and intramuscular injections cause haematomas. Intravenous route is

preferred when rapid anticoagulation is desired. Onset after subcutaneous route occurs after 1-2 hours. This can be overcome by using an intravenous loading dose.

Clinical uses of UFH

- Thromboembolic prophylaxis
- Treatment of venous thrombosis
- Early treatment of patients with unstable angina & acute myocardial infarction (acute coronary syndromes) : Heparin is combined with aspirin in patients with acute MI, with thrombolytic therapy in patients with evolving MI and with GPIIb/IIIa antagonists in high risk patients with unstable angina or in those undergoing high risk angioplasty. Heparin dose is usually decreased when used in combination with

Table 1. Pharmacological Venous Thromboembolism Prophylaxis and Treatment Regimens and Treatment Regimes for Acute Coronary Syndromes	
Total Hip or Knee Replacement Thromboprophylaxis Adjusted -dose unfractionated heparin	3500, U SC q 8 hours started 2 hours before surgery ; after surgery, the dose is adjusted to maintain the APTT within the upper normal range
Low molecular weight heparin Ardeparin sodium	50 U/kg SC q 12 h, started 12 -24 hours after surgery
Dalteparin sodium	5000 U SC qd , started 12 hours before surgery , or 2,500 U SC given 7 hours after surgery, then 5,000 U SC daily
	750 U SC q 12 hour, started 2 hours before surgery
Danaparoid sodium	
Enoxaparin sodium	30 mg SC q 12 h, started 12-24 hours after surgery, or 40 mg SC qd , started 10-12 hours before surgery
Tinzaparin Warfarin sodium	75 U/kg SC qd, started 10-12 hours before surgery5mg orally , started the night before or immediately after surgery adjusted to prolong the INR=2.0-3.0
General Surgery thromboprophylaxis Unfractionated heparin	5,000 U SC q 8-12 hours, started 2 hours before surgery
Low molecular weight heparin Dalteparin sodium Enoxaparin sodium	2,500 U SC qd, started 1-2 hours before surgery 40, mg SC qd , started before surgery
Acute Coronary Syndrome and Venous Thromboembolism Therapy Enoxaparin sodium	1 mg/kg SC q 12 hours (outpatient DVT or non q-wave MI)1 mg/ kg SC q 12 hours, or 1.5 mg/kg SC qd (in patient treatment of DVT or PE)
Dalteparin Tinzaparin	120 U/kg q 12 hours or 200U/kg qd (non q -wave MI)175 U/kg qd

antiplatelet drugs & thrombolytics.

- For patients undergoing cardiac surgery using cardiopulmonary bypass vascular surgery, coronary angioplasty and stents.
- Long-term heparin therapy is only used during pregnancy in-patients with prosthetic valves or in-patients in who have embolic complications while taking adequate doses of warfarin.

The dose of heparin varies with the indication for which it is being administered and the doses used for indications are enlisted in Table 1.

Monitoring-The activated partial thromboplastin time (APTT) is most appropriate for monitoring anticoagulant response to heparin. The APTT should be measured 6 hours after a bolus dose of heparin and the continuous I/V infusion rate should be adjusted based on results.

Pharmacology of Low molecular weight heparin (LMWH)

Low molecular weight heparin is produced by chemical or enzymatic deploymerization of standard heparin. It has a mean molecular weight of 4000-6500 daltons and a chain length of 13-22 sugars. As inhibition of factor Xa requires only a pentasacchride high – affinity binding sequence low molecular weight heparin retains full anti Xa activity with relatively less anti IIa (thrombin) activity. Low molecular weight heparin has a much lower affinity for plasma and matrix proteins resulting in greater than 90% bioavailability after subcutaneous administration and a very predictable and reproducible anticoagulant effect when dosed on a weight adjusted basis.

Clearance of LMWH- LMWH does not bind to endothelial cells or macrophages and is not subject to the rapid degradation that standard heparin suffers. Although clearance of LMWH is by first order kinetics through the renal route producing a half life two to four times as long as unfractionated heparin (UFH), this is not clinically apparent until low creatinine clearance values ($<15ml\ min^{-1}$) are present. (Table 1). The superior pharmacokinetic properties of LMWH over UFH are its only clear advantage. Different LMWHs vary both biochemically and pharmacologically. (Table 2). There are no trials to recommend one specific LMWH over another

Monitoring-The activated partial thromboplastin time is a relatively insensitive measure of LMWH. The anti-Xa levels can be measured and is a more sensitive measure of LMWH anticoagulant activity. However, because of the predictable and reproducible anticoagulant effect, laboratory monitoring of LMWH therapy is not required nor is it predictive of the risk of bleeding. In certain clinical situations such as morbid obesity and renal failure, the dose can be difficult to determine and anti Xa assay may need to be performed.

Reversal of Anticoagulation

Unfractionated Heparin- The effects of UFH wear off so rapidly that an antagonist is rarely required except after the high doses administered to facilitate CPB. To reverse the action of UFH equimolar amounts of protamine sulphate can be used (1 mg protamine neutralizes the action of 100U UFH).

LMWH- A dose of 1 mg protamine /100 LMWH anti Xa units reverses 90% of anti IIa and only 60% of Xa activity.Recommendation for treatment of LMWH overdose consist of administering 1 mg of protamine/100 anti Xa U for enoxaparin within first 8 hours of administering LMWH. If bleeding continues a 2nd dose of 0.5mg protamine /100 anti Xa U can be administered. Smaller doses are needed beyond 8 hrs after LMWH administration.

Clinical Uses

- Prevention of venous thrombosis-LMWH were first evaluated for prevention of thrombosis in high-risk surgical patients. LMWH has become the anticoagulant of

Table 2: Main differences between Unfractionated Heparin & LMWH	
Heparin	**LMWH**
1. Lesser bioavailability (40%)	1. Enhanced bioavailability (90%)
2. Inconsistent anticoagulant effect	2. Consistent anticoagulant effect
3. Shorter duration	3. Longer duration
4. Both anti II a & Xa activity	4. Greater anti Xa activity
5. Monitoring of effect using APTT	5. No need for routine monitoring of anti Xa activity

choice for the prevention of venous thrombosis following major orthopedic surgery and in anticoagulant eligible victims of major trauma.. The risk of bleeding is comparable to low dose UFH or warfarin. Europe and North America differ in their dosage regimens for DVT prophylaxis.European regimens typically administer the first dose 6 hours preoperatively and use a once daily schedule (enoxaparin 20-40 mg once daily). North American LMWH prophylaxis regimens (for hip or knee replacement surgery) administer the first dose 12-24 hours postoperatively and on a twice daily dosing schedule (enoxaparin 30 mg twice daily).Recently efficacy of single daily administration with postoperative initiation of therapy has been approved for Dalteparin. (2,500 U 6-8 hours postoperatively, the next dose 5,000 U to be given 24 hrs later).

- Treatment of venous thromboembolism-Higher doses of LMWH are required for treatment of DVT and pulmonary embolism. Unstable angina & NQMI-In the essence (Efficacy and safety of subcutaneous Enoxaparin in non Q wave coronary events) trial it was found than enoxaparin 1 mg /kg, twice a day when compared with UFH resulted in significantly lower risk of death, myocardial infarction and recurrent angina both at 14 days & 30 days of the

follow –up. All patients also received aspirin.

- Q wave MI-LMWH reduced mural thrombus formation in patients with acute MI at the price of increased bleeding that may have been related to the concomitant thrombolytic therapy.

- "Bridge therapy" in chronically anticoagulated with warfarin eg. parturients, patients with prosthetic cardiac valves, or with history of atrial fibrillation. Out patient LMWH is a suitable alternative when warfarin is stopped in anticipation of surgery.

Side effects of Heparins

- **Haemorrhage**- is rare in patients on prophylactic doses of UFH or LMWH but is a frequent complication of therapeutic heparin therapy. Many patient factors are known to increase the risk of bleeding including length of treatment, presence of cardiac, hepatic or renal dysfunction, aspirin or other NSAID recent surgery, trauma or invasive procedures. The incidence of major bleeding in anticoagulated patients has been estimated as approximately 5%.

- **Heparin Induced Thrombocytopenia (HIT) -**The incidence is 1.1 – 2.3% in patients receiving therapeutic doses of intravenous bovine or porcine heparin. Affected patients are generally receiving high dose UFH but rare cases of subcutaneous hep-

arin resulting in HIT have also been reported.Two clinical syndromes have been described. Type I involves mild thrombocytopenia in which platelet count rarely falls below 1 lakh/ mm^3 during first few days of treatment and recovers rapidly even if heparin is continued. The patient is normally asymptomatic and no specific treatment is required.Type II HIT is characterized by a delayed onset of severe progressive thrombocytopenia with platelet counts in the range of 50,000/ mm^3. An immune mechanism is suggested which may lead to thrombocytopenia as well as thrombosis such as lower limb thrombosis, thrombotic cerebrovascular accidents or acute myocardial infarction. Alternative anticoagulants may need to be started such ac warfarin orgaran or ancrod. LMWH have a high incidence of cross-reaction with heparin dependant antibody therefore may not be useful.

- **Osteoporosis-**Long term UFH (6 month or longer) as used during pregnancy may cause osteoporosis. Animal data suggests that LMWH may have less effect on bone density than UFH. Pharmacology of Warfarin-Warfarin sodium depletes the vitamin K dependant factors II, VII, IX, and X and proteins C and S. It has excellent bioavailability, reaches maximal blood concentrations in 90 minutes

and has a half-life of 24-48 hours. Patients fully anticoagulated with warfarin usually have an INR of 2.0 to 3.0 (Prothrombin time 1.3 to 1.5 times normal). The only exception is patients with mechanical prosthetic valves for whom an INR of 2.5 to 3.5 is recommended. For patients on long term warfarin therapy, the goal is to balance the risks of thromboembolism against perioperative bleeding. Bleeding may occur if the level of any clotting factor is decreased to 20-40% of baseline.

Monitoring - The prothrombin time (PT) and the international standardized ratio (INR) are most sensitive to the activities of factor VII & X and relatively insensitive to factor II.The INR is a calculated value derived from testing each thromboplastin against an international standard thromboplastin. An INR of 1.5 is associated with a factor VII activity of 40%. Thus INR of less than 1.5 should be associated with normal hemostasis and surgery can be safely performed. To withdraw warfarin prior to surgery if the INR is 2.0 to 3.0 it should be allowed to fall spontaneously to 1.5 or less by withholding four scheduled doses. The INR should be measured the day before the surgery. Once the INR reaches 1.5 surgery can be safely performed. After warfarin is restarted, it takes

3 days for the INR to reach 2.0. Therefore if warfarin is withheld for 4 days before surgery and treatment is started as soon as possible after surgery, patients can be expected to have a subtherapeutic INR for approximately 2 days prior and 2 days after surgery. However as the INR is increased to some extent for much of this period, patients still have partial protection against thromboembolism. However, alternative prophylaxis may need to be started with heparin for patients on prosthetic valves.

Pharmacology of Antiplatelet drugs and thrombolytic agents

Antiplatelet agents include NSAIDS, thienopyridinederivatives (ticlopidine and clopidogrel) and platelet GP IIb/ IIIa receptor antagonists (abciximab, eptifibatide and tirofiban).

- **Nonsteroidal antiinflammatory drugs (NSAIDS)-** NSAIDS act by inhibiting the platelet cyclooxygenase (COX) enzymes and preventing synthesis of thromboxane A2. COX exists in 2 forms COX1 regulates constitutive mechanisms while COX2 mediates pain and inflammation. Platelets from patients taking COX2 inhibitors have normal platelet adherence to subendothelium and normal primary hemostatic plug formation. Celecoxib, Refecoxib are antiin-flammatory agents that primarily inhibit COX2 an inducible enzyme, which is not expressed in platelets

and thus does not cause platelet dysfunction. After single & multiple dosing there have been no findings of significant disruption of platelet aggregation.Depending on the aspirin dose administered it may have opposing effects on hemostatic mechanism. Aspirin in low dose 60-325 mg/day inhibits platelet thromboxane A2 while larger doses (1.5 – 2g/day) also inhibit the production of prostacyclin (a potent vasodilator and platelet aggregation inhibitor) by the vascular endothelial cells. Platelet function is affected for the life of the platelet (5-11 days) following aspirin ingestion, other non steroidal analgesics (naproxen, piroxicam, ibuprofen) produce a short term defect which normalizes within 3 days.

- **Antiplatelet drugs -** The antiplatelet effect of theinopyridine derivatives ticlopidine and clopidogrel result from inhibition of adenosine diphosphate (ADP) induced platelet aggregation. These antiplatelet drugs prevent both primary and secondary platelet aggregations. They also interfere with platelet fibrinogen binding and subsequent platelet - platelet interactions. They demonstrate both time and dose dependant effects. Steady state is achieved within 7 days for clopidogrel and 14-21 days for ticlopidine and prior to an elective surgery the drugs should be discontinued for the same duration.

- **Serious Events** - Serious haematological adverse reactions including agranulocytosis, thrombotic thrombocytopenic purpura and aplastic anemia.
- **Platelet GPII b/IIIa receptor antagonists -** inhibit platelet aggregation by interfering with platelet fibrinogen and platelet – von Willebrand factor binding. Because fibrinogen and von Willebrand factor have multiple binding sites they can bind to multiple platelets causing cross – linking and platelet aggregation. Contraindications include a history of surgery within 4-6 weeks.Time to normal platelet aggregation after discontinuation. of therapy ranges from 8 hours (eptifibatide, tirofiban) to 24-48 hours (abciximab).
- **Thrombolytics-**Streptokinase, urokinase, recombinant tissue plasminogen activator dissolve fibrin clots by activating the endogenous fibrinolytic system. Streptokinase and urokinase have low fibrin selectivity and produce significant degradation of plasma proteins including fibrinogen. Recombinant t-PA is highly selective activating only fibrin bound plasminogen.While the plasma half- life of thrombolytic drugs is only hours, it may take days for the thrombolytic effects to resolve. Fibrinogen and plasminogen are maximally depressed at 5 hours after thrombolytic

therapy and remain significantly depressed at 27 hours.

Clinical Uses - Unstable angina, peripheral arterial occlusions, deep vein thrombosis, pulmonary embolism, occluded indwelling catheters and shunts.

Side effects - Bleeding complications, reocculsion of treated vessels. Clot lysis resulting in elevated fibrin degradation products, which have anticoagulant effect by inhibiting platelet aggregation. Patients may receive intravenous heparin concurrently increasing chances of bleeding.

New anticoagulants

- **Thrombin inhibitors** inhibit both free and clot bound thrombin. They include recombinant hirudin derivative desirudin, L ariginine derivative argatroban. These medications are indicated for treatment and prevention of thrombosis in patients with heparin – induced thrombocytopenia and as an adjunct to angioplasty procedures. Monitoring is by APTT and action is present for 1-3 hours after I/V administration. There is no antidote and antithrombin effects cannot be reversed pharmacologically. Reports of spontaneous intracranial bleed are present.
- **Fondaparinux**Fondaparinux an injectable synthetic pentasacchride produces its antithrombotic effect through factor Xa inhibition. The

plasma half-life is 21 hours allowing for single daily dosing with the first dose administered 6 hours postoperatively.

Regional Anaesthetic implications of Anticoagulation

Spinal haematoma defined as symptomatic bleeding within the spinal neuraxis is a rare but catastrophic complication of spinal or epidural anesthesia. Though the exact incidence of this complication is not known, an extensive review of literature has calculated an incidence of spinal haematoma of less than 1 in 150,000 epidurals and less than 1 in 220,000 spinal anesthetics. Neurological compromise presents as progression of sensory or motor blocks, bowel/ bladder dysfunction and not usually as back pain. The neurological deficit tends to be reversible in patients who undergo laminectomy within 8 hours of onset of neurological symptoms.

Regional Anaesthetic Management of Unfractionated I/V and S/C Heparin

- During subcutaneous (mini dose) prophylaxis there is no contraindication to the use of neuraxial techniques. The risk of bleeding may be reduced by delay of the heparin injection until after the block. Risk of bleeding may be greater in debilitated patients after prolonged therapy.

Patients receiving heparin for greater than 4 days should have platelets assessed prior to neuraxial block and catheter removal because of the risk of heparin induced thrombocytopenia.

- Intraoperative coagulation with heparin during vascular surgery with neuraxial techniques. 5-10,000 units of heparin are given intraoperatively during vascular surgery to prevent coagulation during cross clamping of arterial vessels. In such patients. Avoid administering a centrineuraxial block in patients with other coexisting coagulopathies. Delay heparin administration for one hour after needle placement. Indwelling epidural catheters should be removed 2-4 hours after last heparin dose and after assessing the patient's coagulation status and reheparinization should be done 1 hr after catheter removal. Monitor the patient postoperatively to provide early detection of motor blockade. Although blood on needle or catheter or even difficult needle placement may increase risk of spinal haematomas, there is no data to support cancellation of the case. Direct discussion with the surgeon and assessment of risk benefit ratio is warranted.

- Full Anticoagulation of cardiac surgery with neuraxial techniques-Currently insufficient data is available to determine risk of neuraxial haematomas with full anticoagulation of cardiac surgery. The use of thoracic epidural analgesia during cardiac bypass surgery remains controversial because of the risk of spinal cord damage from an epidural haematomas.

Current Recommendations for Regional Anaesthetic Management of LMWH

Preoperative LMWH

- Patients on LMWH thrombophylaxis they have an altered coagulation profile and therefore needle placement should be done 10-12 hours after the LMWH dose.

- In patients on higher doses of LMWH for treatment of acute coronary syndromes and venous thromboembolism e.g. enoxaparin 1.5 mg/kg daily, enoxaparin 1mg/kg twice daily etc. will require delay of at least 24 hrs to assume normal hemostasis at the time of needle insertion.

- Neuraxial techniques should be avoided in patients administered a dose of LMWH 2 hrs preoperatively (general surgery) because at this time peak anticoagulant activity occurs.

Post operative LMWH - patients with postoperative initiation of LMWH can safely undergo single injection and continuous catheter techniques.

- **Twice daily dosing -** This technique is associated with an increased risk of spinal haematomas. The first dose is given not earlier than 24 hours postoperatively regardless of anaesthetic technique. Epidural catheters should be removed prior to initiation of thromboprophylaxis. If a continuous technique is selected, the epidural catheter can be left in situ overnight, removed the following day & LMWH administered 2 hours after catheter removal.

- **Single daily dosing-** The first LMWH dose should be administered 6-8 hours postoperatively, next dose 24 hours later. Indwelling neuraxial catheters may be safely maintained, however the catheter should be removed 10-12 hours after the last dose of LMWH. Subsequent LMWH should occur 2 hours after catheter removal. The presence of blood during needle & catheter placement should result in delay of initiation of LMWH for 24 hours postoperatively.

Regional Anaesthetic Management of the patient on Oral anticoagulants

- The management of patients receiving warfarin remains controversial. For a regional block to be performed the anticoagulant must be stopped (ideally 4-5 days prior to the procedure) and the PT/INR measured prior to initiation of the block. neuraxial block. Early after discontinuation of warfarin

PT/INR predominantly reflects factor VII levels. Despite acceptable factor VII levels adequate levels of II, IX and X may not be present until the PT/INR is within limits.

- For patients receiving an initial dose of warfarin prior to surgery, the PT/INR should be checked prior to neuraxial block if the first dose was given more than 24 hours earlier or a second dose of oral anticoagulants has been administered.

- Patients given low-dose warfarin (5mg mean daily dose) should have PT/INR monitored on a daily basis and checked before catheter removal. The catheter should be removed when the INR is <1.5, which correlates to clotting factor activities greater than 40%.

- Neurological testing of sensory and motor function should be performed during epidural analgesia and continued for 24 hours following catheter removal.

Regional Anaesthetic Management of the Patient receiving antiplatelet medications

NSAIDS alone represent no added risk for the development of spinal haematomas in patients receiving centrineuriaxial anesthesia. The actual risk of spinal haematoma with ticlopidine and clopidogrel and GP IIb/IIIa antagonists is unknown. The suggested time interval between discontinuation of thienopyridine therapy and neuraxial block is 14 days for ticlopidine and 7 days for clopidogrel. Platelet GP II b/III a have profound effect on platelet aggregation. Following administration time to normal platelet aggregation is 24-48 hours for abciximab and 4-8 hours for eptifibatide and tirofiban. G II b / IIIa inhibitors are are contraindicated within 4 weeks of surgery, if one is administered in the postoperative period following a neuraxial technique, the patient should be carefully monitored neurologically. COX2 inhibitors have minimum effect on platelet aggregation and should be considered in patients requiring anti-inflammatory therapy in the presence of anticoagulation.

Regional Anaesthesia Management of a patient on Thrombolytic/ Fibrinolytic Therapy

- Thrombolytic therapy can be administered inadvertently to patients who have had centrineuriaxial block few days prior to developing a myocardial ischemia and requiring the thrombolytic therapy. Therefore prior to giving thrombolytic therapy, patients should be asked if spinal/ epidural puncture or steroid injection has been given. Guidelines recommend avoidance of these drugs for 10 days following puncture of non-compressible vessels.

- Similarly patients who have received thrombolytic therapy should be cautioned against spinal or epidural anaesthesia. Data is not available to clearly outline length of time neuraxial puncture should be avoided.

- In case a patient has received both therapies concomitantly 2 hourly neurological monitoring should be done, and drugs causing minimal motor blockade should be used. Removal of epidural catheter. There are no definite recommendations for catheter removal in patients concomitantly receiving epidural and thrombolytic therapy. The measurement of fibrinogen level (one of the last clotting factors to recover) may help in making a decision.

Management of Anticoagulation in Patients with prosthetic heart valves for General Anaesthesia

- Anticoagulation can be continued in patients with prosthetic valves who are scheduled for minor surgery such as dental extraction in which blood loss is expected to be minimal.

- For major surgical procedures where significant blood loss is anticipated, it is common to discontinue warfarin 3-5 days preoperatively and begin heparin administration until 2-4 hours prior to surgery.

- Postoperatively in patients with mechanical aortic valves anticoagulation can be restarted 2 days postoperatively as the risk of arterial thromboembolism is lower (1-3%) compared to mechanical mitral valves

(5%). For patients with mitral prosthetic valves anticoagulants can be started 12 hours postoperatively after ensuring adequate surgical hemostasis. Anticoagulant therapy is particularly important during pregnancy in parturients with prosthetic heart valves as the incidence of systemic embolization is greatly increased. As warfarin is teratogenic when pregnancy is a possibility warfarin is discontinued and subcutaneous heparin / LMWM administered until delivery.

Management of Anticoagulation in patients with venous and arterial thromboembolism

Venous thromboembolism.

- Elective surgery should be avoided in the first month after an acute episode of venous thromboembolism. If the surgery is unavoidable I/V heparin should be administered before and after the procedure while the INR is below 2.0. If the APTT is in the therapeutic range stopping continuous I/V heparin six hours before surgery should be sufficient for heparin to be cleared before surgery. Heparin should not be restarted 12 hours after major surgery and should be delayed longer if there is any evidence of bleeding from the surgical site. Heparin should be restarted without a bolus at

no more than the expected maintenance infusion rate. The APTT should be checked 12 hours after restarting therapy to allow time for a stable anticoagulant response.

- For patients receiving anticoagulants for venous thromboembolism for more than 1 month after an acute episode but for less than three months, preoperative I/V heparin therapy is not justified routinely. However postoperative I/V heparin is recommended until warfarin is resumed & INR is above 2.0.

- Patients on anticoagulants for more than 3 months since their last episode do not need preoperative anticoagulation. They should receive postoperative prophylaxis with LMWH until oral anticoagulation is re-established.

Arterial Thromboembolism

- Elective surgery to be avoided in the first month after an arterial embolism. They should receive preoperative I/V heparin if surgery is essential. Postoperative heparin is recommended if the risk of postoperative bleeding is low.

- In all other patients who receive anticoagulants to prevent arterial thromboembolism e.g. mechanical heart valves or nonvalvular atrial fibrillation patients the risk of embolism is not

enough to warrant preoperative or postoperative I/V heparin. Subcutaneous low dose heparin or LMWH in the dose for prophylaxis against arterial thromboembolism in high-risk patients is recommended.

References

1. Horlocker TT, Wedel DJ, Benzon H, Brown DL, Enneking FK, Heit JA, Mulroy MF, Rosenquist RW, Rowlingson J, Tryba M, Yuan CS. Regional Anesthesia in the anticoagulated patient: Defining the Risks(The second ASRA Consensus Conference on Neuraxial Anesthesia and Anticoagulation). Regional Anesthesia and Pain Medicine.2003;28(3):172-97.

2. Hirsh J, Warkentin TE, Shaughnessy SG et al. Heparin and Low Molecular Weight Heparin. Chest 2001; 119:64s-94s.

3. Kearon C, Hirsh J. Management of anticoagulation before and after surgery. The New England Journal of Medicine.1997; 336 (21):1506-11.

Anaesthetic Management in Chronic Renal Failure

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Chronic renal failure (CRF) is an irreversible deterioration in renal function which classically develops over a period of years. It initially manifests with biochemical abnormalities, but eventually there is loss of excretory, metabolic and endocrine functions of the kidney leading to the development of signs and symptoms of renal failure which are referred to as uraemia. End stage renal disease (ESRD) is the degree of irreversible loss of renal function that is incompatible with life. Etiology of ESRD is shown in Figure 1.

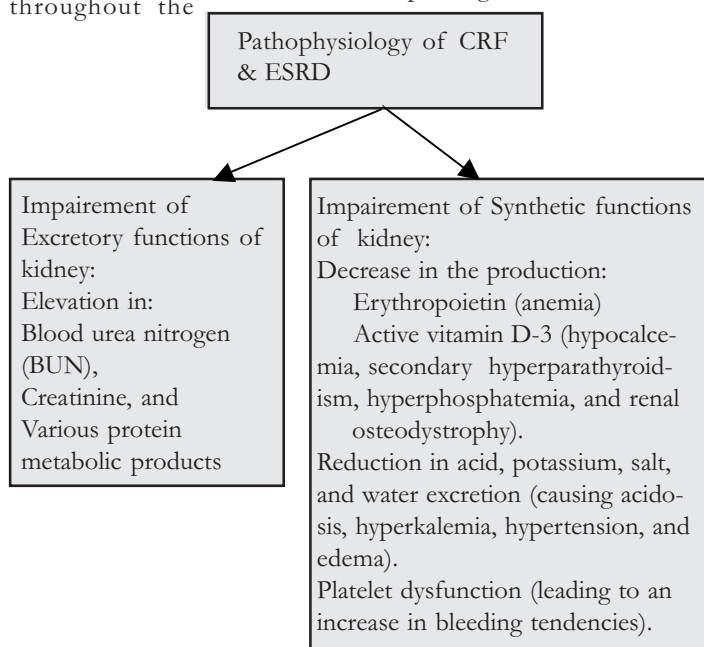| Figure 1:Etiology of End Stage Renal Disease |
| --- |
| 1. Glomerulonephritis |
| 2. Diabetes mellitus |
| 3. Cystic disease4. Hypertension |
| 5. Pyelonephritis |
| 6. Analgesic nephropathy |
| 7. Metabolic nephropathy |
| 8. Vascular nephropathy |
| 9. Dysproteinemias |

Patients with CRF have a high prevalence of hypertension. Whether hypertension is a cause or a result of CRF remains debatable. CRF may be categorized as mild (GFR of 60-89 mL/min/1.73 m^2), moderate (GFR of 30-59 mL/min/1.73 m^2), severe (GFR of 15-29 mL/

min/1.73 m^2), or end-stage renal disease (ESRD) (hemodialysis or peritoneal dialysis is initiated as the GFR falls to <15 mL/min/1.73 m^2).Kidney transplantation is one of the most cost-effective methods of treating ESRD, it confers a 40% to 60% decrease in the death rate when compared to those on dialysis[1]. The overall graft survival rate among cadaveric kidney transplant recipients is greater than 70%, and it is approximately 80% in recipients of a live donor kidney[2].

Pathophysiology of CRF and ESRD-CRF leads to a steady decline in GFR and urine production, which has deleterious effects on multiple organ systems throughout the

body. Pathophysiology is shown below:

Pre-operative evaluation (History and Examination)- Since the kidneys are essential for adjusting body fluid volumes, electrolyte composition, acid-base balance and haemoglobin concentration, screening for potential dysfunction of multiorgan systems is essential during the pre-anaesthetic check-up. CRF can be associated with excess surgical morbidity, the most important of which include acute renal failure, hyperkalemia, volume overload, and infections. The above underscore the need for early involvement of a nephrologist.

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┌─────────────────────────┐
│ Pathophysiology of CRF  │
│ & ESRD                  │
└─────────────────────────┘
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Impairement of Excretory functions of kidney: Elevation in: Blood urea nitrogen (BUN), Creatinine, and Various protein metabolic products	Impairement of Synthetic functions of kidney: Decrease in the production: Erythropoietin (anemia) Active vitamin D-3 (hypocalcemia, secondary hyperparathyroidism, hyperphosphatemia, and renal osteodystrophy). Reduction in acid, potassium, salt, and water excretion (causing acidosis, hyperkalemia, hypertension, and edema). Platelet dysfunction (leading to an increase in bleeding tendencies).

Cardiovascular

- Hypertension- Over 50% of adult patients with renal disease need treatment for hypertension, which is often resistant to drug therapy[3], and these patients are on multiple antihypertensives, e.g. ACE inhibitors, calcium channel blockers, â - blockers, diuretics, clonidine.
- Coronary artery disease- The incidence of myocardial ischaemia in renal transplant patients is ten times that in general population of the same age and sex[4]. Angina is frequent, probably partly due to severe anaemia. Arrhythmias are also common, exacerbated by electrolyte imbalances.
- Pulmonary oedema- It may be due to fluid overload, hypoproteinemia or left ventricular failure.
- Pericarditis and pericardial effusion are also common in CRF.

Haematologic

- Anaemia- It is normocytic normochromic in type. It occurs due to decreased production and haemolysis of red blood cells. This anaemia is unresponsive to oral iron therapy. Pallor, tachycardia, and presence of a systolic murmur should be looked for and noted. Usually these patients are taking oral erythropoietin.[5]. Pre-operative haematocrit of at least 25% should be achieved.
- Platelet dysfunction- In spite of having normal counts, there can be thrombasthenia and prolonged bleeding times.

- Heparin- This drug is used during haemodialysis, and would potentates bleeding during surgery if surgical intervention is carried out soon after the dialysis.

Respiratory-The presence of pulmonary infections as well as pleural effusion should be ruled out in these patients. It should be kept in mind that they have an increased risk of postoperative atelectasis due to decreased surfactant levels in lung. Both cardiogenic and non-cardiogenic pulmonary oedema can occur in these patients.

Nutritional-These patients can by hyperglycaemic and hyperlipidaemic, and also have severe malnutrition due to protein loss, anorexia and decreased appetite due to gastritis. A rise in blood sugar may be accompanied by a rise in serum potassium, making arrhythmias more likely[6].

Gastro-intestinal- They have gastroparesis and are prone for regurgitation, and may have hepatic dysfunction.

Neurological - A detailed history of depression, excessive somnolence, seizures, polyneuropathy and autonomic dysfunction should be elicited, as these are common in ESRD patients, and have anaesthetic implications.

Immunological - These patients are immunosuppressed and are prone to repeated bouts of infections.

Biochemical-These may not be evident by history and examination, but only by investigations.

Potassium – There is an excess of this electrolyte in the body due to reduced excretion, which is exacerbated by drugs, hypercarbia and surgical trauma. Hyperkalemia can lead to cardiac arrhythmias, even ventricular arrhythmias and cardiac arrest intra-operatively. So, pre-operative dialysis, and a serum electrolyte level after dialysis is essential in these patients. Drugs that may cause hyperkalemia include the following:

Drugs that inhibit renin-angiotensin-aldosterone system

- Inhibitors of renin synthesis: â-blockers (eg, metoprolol, atenolol), clonidine, methyldopa, some nonsteroidal anti-inflammatory drugs (NSAIDs, eg, ibuprofen, naproxen), cyclooxygenase-2 inhibitors (eg, celecoxib)
- Inhibitors of angiotensin II synthesis: ACE inhibitors (eg, enalapril, fosinopril)
- Inhibitors of aldosterone synthesis: Angiotensin II receptor blockers (eg, losartan, candesartan), heparin, low molecular weight heparin (eg, enoxaparin), immunosuppressive drugs (eg, cyclosporin, tacrolimus)
- Inhibitors of aldosterone receptor: Potassium-sparing diuretics (eg, spirolactone)
- Blockers of distal Na^+/K^+ channels: Potassium-sparing diuretics (eg, triamterene, amiloride), antibiotics (eg, trimethoprim sulfamethoxazole, pentamidine)

Drugs that cause release of K^+ from muscles: Succinylcholine, antipsychotics (eg, haloperidol).

Sodium - A rise in serum sodium concentration indicates hypovolemia and haemoconcentration, while a drop indicates a volume overload.

Calcium and phosphate - There is hypocalcemia and hyperphosphatemia, with renal osteodystrophy and calcification of arteries.

Aluminium and magnesium- The excess of these cations might be due to haemodialysis or consumption of an excess of antacids, and these may potentiate neuromuscular blockade.

Acid-base changes- Due to decrease in the excretion of hydrogen ions, there can be a fall in the extra- and intra-cellular pH and fall in bicarbonate ion levels.

Glucose- Hyperglycaemia is caused due to reduced excretion of glucose by kidneys[6], and this also leads to increased levels of serum potassium.

Albumin- Decreased levels of plasma albumin leads to increased free fraction of protein-bound drugs like phenytoin, warfarin, benzodiazepines.

Investigations

- Haemoglobin concentration, Haematocrit.
- Coagulation profile: BT, CT, Platelet count, PT, aPTT, TEG.
- Blood grouping and cross matching.
- Renal and liver function tests – Blood urea, serum creatinine, plasma albumin,
- globulin, serum total proteins, AST, ALT, Alkaline phosphatase.

- CXR, ECG, Echo, Stress ECG.
- On morning of surgery, after the last dialysis: Hb / Hct , electrolytes, PT, APTT , ECG,
- CXR, ABG , weight of the patient.

Pre-operative preparation

- Optimization of the patient-Control of hypertension, diabetes, anemia, coagulopathy, fluid and electrolyte imbalances, infections.
- Preoperative dialysis- Patients on hemodialysis usually require preoperative dialysis within 24 hours before surgery to reduce the risk of volume overload, hyperkalemia, and excessive bleeding.
- Informed consent
- Premedication-Anxiolysis with shorter acting agents; Anti aspiration prophylaxis: antacids, H-2 blockers, prokinetics eg. Metoclopromide;Immunosupressants: Cyclosporine, Azathioprine, Prednisolone; Antihypertensives; Antibiotics

Effect of anesthesia in persons with CRF - The administration of general anesthesia may induce a reduction in renal blood flow in up to 50% of patients, resulting in the impaired excretion of nephrotoxic drugs. In addition, the function of cholinesterase, an enzyme responsible for breaking down certain anesthetic agents, may be impaired, resulting in prolonged respiratory muscle paralysis if neuromuscular blocking agents are used. Fluorinated compounds such as methoxyflurane and enflurane

are nephrotoxic and should be avoided in patients with CRF. Succinylcholine, a depolarizing blocker, causes hyperkalemia but is not contraindicated.

Effect of surgery in persons with CRF - Hyperkalemia may be precipitated by tissue breakdown, blood transfusions, acidosis, ACE inhibitors, â-blockers, heparin, rhabdomyolysis, and the use of Ringer lactate solution as a replacement fluid. Ringer lactate solution contains potassium, which is often disregarded but can cause fatal hyperkalemia.

Most patients with CRF have chronic acidosis; surgical disease can further complicate the acidemia. Such patients are at a higher risk for hyperkalemia, myocardial depression, and cardiac arrhythmia. Hypocalcemia and hyperphosphatemia may be caused by rhabdomyolysis. Hyponatremia may occur from hypotonic fluids or inappropriate secretion of antidiuretic hormone.

Anaesthetic techniques for renal transplantation- Although spinal anaesthesia was used exclusively for the initial reported cases of renal transplantation[7], and various centers have reported successful cases exclusively under regional anaesthesia[8], the most widely used technique nowadays is general anaesthesia with endotracheal intubation to provide stable haemodynamics, excellent muscle relaxation and predictable depth of anaesthesia. No significant difference was found when this technique was compared with TIVA using opioids and propofol[9].Advantages of a regional technique would be that it avoids intubation, opioids and

relaxants, and provides good post-operative analgesia. But it also has a lot of disadvantages like awake anxious patient, duration of surgery is longer, uremic coagulopathy, postoperative peripheral neuropathy, unpredictable response to vasodilatation and difficulty in handling blood loss. Onset of action of block is faster due to metabolic acidosis and reduction in the volume of epidural space, and offset is also 20% faster, as increased cardiac output causes a faster washout. All doses of local anesthetics have to be reduced by 25% to avoid CVS and CNS toxic effects. Vasoconstrictors should be avoided as a rule (risk of arrhythmias in a potentially acidotic and hyperkalemic patient).

Intra-operative course

- Monitoring: 5 lead ECG, pulse oximeter, end tidal carbon dioxide, temperature, NIBP / IBP, CVP, PA catheter (indicated in poorly controlled hypertension, CAD with significant LV dysfunction, valvular heart disease, severe COPD), neuromuscular monitoring, TEE.

- Careful dose titration of drugs that are predominantly excreted by kidney. e.g. muscle relaxants, like vecuronium etc, anticholinergics, like atropine, glycopyrrolate etc, cholinergics, like neostigmine, CVS drugs, like phosphodiesterase inhibitors, and barbiturates. Pancuronium should be avoided, as it is excreted predominantly by the kidney.

- Drugs with active or toxic metabolites excreted through renal route should also be given carefully in titrated doses. Morphine, pethidine, diazepam, midazolam, sodium nitroprusside,enflurane, vecuronium, pancuronium should be used in titrated dose.

- Drugs with increased free fraction should be given in appropriately reduced doses, examples are barbiturates, benzodiazepines.

Induction and Maintenance

- Position of patient should be supine. It is important to take care of fistula (no IV line should be started or BP cuff tied on the hand with the A-V fistula).

- Rapid sequence induction technique should be practiced whenever renal transplant is done as an emergency procedure. To prevent rise in serum potassium, precurarizarion should be done before using succinylcholine. However it should be avoided if serum $K^+ > 5.5$ meq/l.

- Intravenous induction agents like thiopentone, etomidate and propofol can be used in titrated dosage.

- Muscle relaxants such as atracurium, cisatracurium, rocuronium or vecuronium are safer, and repeat doses given according to neuromuscular monitoring.

- For analgesia, shorter acting opioids such as fentanyl, alfentanil, sufentanil,remifentanil can be used, and the drug dosages should be reduced by 30-50%.

- Inhalational agents: Isoflurane is the anesthetic of choice. Sevoflurane and desflurane are also safe.

Intra-operative fluid management

- Adequate intravascular volume is the single most important measure that improves the likelihood of immediate graft function. Immediate graft function has been associated with a blood volume greater than 70 ml/kg and a plasma volume of greater than 45 ml/kg[10].

- Potassium-free fluids like 5% dextrose should be preferred, and adequate fluids should be administered to maintain a target CVP of 10 – 15 mm of Hg.

- Mannitol – 0.5-1.0 g /kg is usually given for intravascular expansion, free radical scavenging, increase in renal cortical flow, increase in the release of intrarenal prostaglandins, prevention of delay in graft function of cadaveric kidneys[11].

- Blood should be given to replace losses when they exceed the maximum allowable blood loss (MABL), to maintain brain oxygenation. Leukocyte depleted, irradiated plasma is preferred as these patients are on immunosuppressants.

- Frusemide counteracts the action of stress induced ADH release, inhibits Na-K ATPase to decrease oxygen consumption, can convert oliguric renal failure to non oliguric renal failure. But still it is widely used in 60 – 200 mg boluses.

- No conclusive data is available about the use of dopamine and dopexamine. Previous studies showed that renal doses were advantageous for improving renal blood flow and outcome of surgery[12], but recent studies failed to show any such advantage[13].
- Calcium channel antagonists such as verapamil can be used by renal artery injection followed by oral therapy. It preserves renal blood flow and reduces effects of cold ischemia.

Recovery and post-operative analgesia

- Extubation should be done when patient is completely awake, with satisfactorily recovered neuromuscular function.
- Care in High Dependency Unit or ICU.
- Post operative analgesia with intermittent doses of morphine titrated to pain, or with morphine or fentanyl by a PCA pump. The doses required are usually reduced in these patients.

Patients with CRF for other (non-transplant) surgeries

- **Patients with CRF treated conservatively -**The pre-operative orders should be given after a completely assessing the patient and establishing the duration of CRF; level of renal function impairment; and whether the elevation in BUN and creatinine is prerenal, intrarenal, postrenal, or a combination of these on a background of CRF. Patients who are euvolemic, responsive to diuretic therapy,

and/or have no significant electrolyte abnormalities or bleeding tendencies are uncomplicated and do not require dialysis before surgery. Patients with edema, CHF, or pulmonary congestion or those who are responsive to diuretic therapy require further cardiovascular evaluation. If the results of the cardiovascular evaluation are optimal, then fluid overload can be attributed to CRF. Combination diuretic therapy can help treat these patients to achieve euvolemia prior to surgery. Patients with diabetes have a greater tendency of having volume overload or cardiovascular disease. CRF may be so advanced that the patient develops diuretic resistance, with progressive edema. Preoperative dialysis may be considered in these patients. If postoperative dialysis is imminent, it is advisable to place a temporary catheter intraoperatively. This avoids the use of femoral cannulation, which carries a higher risk of infection. Permanent vascular access placement can then be arranged when the patient is more stable. Further deterioration in renal function can be avoided by identifying and avoiding potentially nephrotoxic agents. These include substitution or dosage adjustment for antibiotics (eg, aminoglycosides, acyclovir, amphotericin), sedatives, and muscle relaxants. NSAIDs and COX-2 inhibitors should be avoided, as should

radiocontrast material. Radiocontrast material can induce acute renal failure by causing vasoconstriction and direct renal tubular epithelial cell damage. If radiocontrast material must be used, prophylactic oral administration of the antioxidant acetylcysteine, along with hydration (0.45% saline), may reduce the risk of acute renal failure. As mentioned earlier, it would be best to use regional techniques wherever possible, provided the coagulation status is within normal limits. General anaesthesia should be administered carefully, after identifying all drug interactions and potential nephrotoxicity and either stopping or adjusting the dose of the drugs for the level of renal function. Electrolyte abnormalities must be detected early and corrected promptly in the perioperative period.No preoperative cardiac assessment is indicated for emergency surgery; however, postoperative cardiac assessment must be performed and continued for 3-5 days with daily ECGs and screening of cardiac enzyme levels to detect and treat possible perioperative MI. Perioperative MI occurs mostly within the first 72 hours. The incidence rate of perioperative MI is approximately 1% but carries a high mortality rate of almost 50%. Awareness of discordant blood testing results of total creatine kinase (CK), myocardial band enzymes of CK

(CK-MB), and troponin. Total CK levels are elevated in patients with CRF, but CK-MB levels are not; thus, elevation in CK-MB levels is due to myocardial injury. Elevation of troponin levels without a corresponding elevation in total CK levels has been shown to reflect enzyme elimination kinetics due to renal failure or cross-reactivity of the troponin I assay with noncardiac antigens. Therefore, any enzyme elevations are not diagnostic in and of themselves. The diagnosis of postoperative MI should be made based on a combination of clinical, laboratory, and ECG evidence. The preoperative use of beta-blocker therapy (eg, atenolol) may be beneficial, though at the risk of developing or worsening hyperkalemia.

- **Patients already on dialysis-**For patients already on dialysis, dialysis adequacy, preoperative dialysis needs, postoperative dialysis timing, and dosage requirements for all medications should be determined. Patients on hemodialysis usually require preoperative dialysis within 24 hours before surgery to reduce the risk of volume overload, hyperkalemia, and excessive bleeding. Patients with peritoneal dialysis who are undergoing abdominal surgery should be switched to hemodialysis until wound healing is complete. Peritoneal dialysis should be continued for those undergoing non-abdominal surgery.

- **Patients who already have a renal transplant -** Because of complicated drug interactions and immunosuppressive dosing, monitoring, and adjustment, a nephrologist with specialized knowledge of renal transplantation should be involved in the preoperative evaluation of patients with CRF who have received kidney transplantation. Cyclosporine or tacrolimus taken by renal transplant recipients for immunosuppression are metabolized by the cytochrome P-450 system in the liver and thus interact with a wide variety of agents. Diltiazem, hepatic 3-methylglutaryl coenzyme A reductase inhibitors, macrolides, and antifungal drugs inhibit the system, elevate drug levels, and can precipitate nephrotoxicity. Others, such a scarbamazepine, barbiturates, and theophylline, induce the hepatic enzyme system, reduce drug levels, and can precipitate rejection. Drug levels must be monitored in this setting. Intravenouscy closp-orine or tacrolimus should be given at one-third the oral dose until the patient is able to tolerate oral medications. A thorough pre-operative evaluation of the patient is mandatory to assess the functions of the different systems. Both general and regional anaesthetic techniques can be used, depending upon the functional status.

References

1. Wolfe RA, Ashby VB, Milford EL, et al: Comparison of mortality in all patients on dialysis, patients on dialysis waiting transplantation, and recipients of the first cadaveric transplant. N Engl J Med 341: 1725-1730, 1999.

2. Gaston RS, Alveranga DY, Becker BN, et al: Kidney and pancreas transplantation. Am J Transplant 3 (Supp 4): 64-77, 2003.

3. Legendre C, Saltiel C, Kries H, Grunfeld J-P. Hypertension in kidney transplantation. Klin Wochenschr 1989; 67: 919-22.

4. Gunnarsson R, Lofmark R, Norlander R, et al. Acute myocardial infarction in renal transplant recipients: incidence and prognosis. Eur Heart J 1984; 5: 218-21.

5. Hambley H, Mufti GH. Erythropoietin: an old friend revisited. Br Med J 1990; 300: 621-2.

6. Goldfarb S, Cox M, Suiger I, Goldbert M. Acute hyperkalaemia induced by hyperglycaemia; hormonal mechanisms. Ann Intern Med 1976; 84: 426-32.

7. Vandam LD, Harrison JH, Murray JE, et al: Anaesthetic aspects of renal homotransplantation in man. Anesthesiology 23: 783-92, 1962.

8. Linke CL, Merin RG: A regional anaesthetic approach

for renal transplantation. Anesth Analg 55: 69-73, 1976.

9. Kirvela M, Yli-Hankala A, Lindgren L: Comparison of propofol/alfentanil anaesthesia with isoflurane/N_2O/fentanyl anaesthesia for renal transplantation. Acta Anaesthesiol Scand 30: 574-580, 1986.

10. Dawidson I, Berglin E, Brynger H, et al: Intravascular volumes and colloid dynamics in relation to fluid management in living related kidney donors and recipients. Crit Care Med 15: 631-6, 1987.

11. Koning OH, Ploeg RJ, von Bockel JH, et al: Risk factors for delayed graft function in cadaveric organ transplantation: A prospective study of renal function and graft survival after preservation with University of Wisconsin solution in multi- organ donors. European Multicentre Study Group. Transplantation 63: 1620-8, 1997.

12. Grundmann R, Kindler J, Meider G, et al: Dopamine treatment of human cadaver kidney graft recipients: A prospectively randomized trial. Klin Wochenschr 60: 193-7, 1982.

13. Kadieva VS, Friedman L, Margolius LP, et al: The effect of dopamine on graft function in patients renal transplantation. Anesth Analg 76: 362-5, 1993.

The "Bomb" Ether Apparatus

Ether Apparatus, Wilson and Pinson's, steel, nickel-plated complete with rubber tubing, attachment for the mask, filling funnel, and spanner. (a) Ether in a closed space at a temperature of 100°C. is at a pressure of 97 lb. per square inch - its saturation vapour pressure at that temperature. With each fall of temperature there is a corresponding fall of pressure, until at its boiling point (35°C.) the effective pressure is nil. (b) Ether as a liquid expands as the temperature rises, and as liquids are very incompressible, room must be left in the closed space for this expansion. A special filler plug (A) is fitted which ensures that such room is left. A Safety Blow-off (C) is provided which prevents all possibility of the apparatus bursting.

It is intended for use with ether only. The ether keeps perfectly well inside the steel container. Always have the filler-plug (A) screwed up tightly (to prevent leakage when in use). See that the faces of the filler-plug and container are quite clean before tightening up. To Fill.- Unscrew and remove the filler-plug, and pour in ether until it begins to run over. If the container is hot, immerse the apparatus in cold water for a few seconds before un-screwing the filler-plug. See that the valve is turned off. Place in a large bowl of boiling water, which may cover it completely. The valve-top (B) is graduated like a clock dial, the largest red dot marking the zero or "off" position. The pointer is set to the zero dot when the valve is shut off, and is also adjustable, so that it can be reset to this position when the valve has worn a little. This resetting will be seldom needed. If. the valve gets very loose, tighten the gland-nut, i.e. the little nut in the middle of the valve. The spanner provided is for these adjustments. The small attachment (D) is for the administration of open warm ether, the method of giving which is described below.

Obesity and Anesthesia
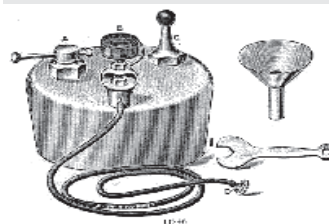
Review Article

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Obesity has been referred to as a new worldwide epidemic. Obesity is the nominal form of obese which comes from the Latin obçsus, which means "stout, fat, or plump." Çsus is the past participle of edere (to eat), with ob added to it. Its first attested usage in English was in 1651, in Noah Biggs's Matæotechnia Medicinæ Praxeos.

Definitions-Obesity is defined by BMI [body mass index]. The BMI is calculated according to the formula weight [kg] divided by height squared [m2]. Body mass index (BMI), also called the Quetelet number or Quetelet index, is the most widely accepted calculation of excess body fat. BMI was developed by the Belgian statistician and anthropometrist Adolphe Quetelet. It is calculated by dividing the subject's weight in kilograms by the square of his/her height in meters (BMI = W / h2). For example, a person who weighs 75 kilograms and stands 1.8 meters tall would have a BMI of 75/(1.82)=23.148. The number 23.148 is then compared to a table of definitions. The current definitions commonly in use establish the following values, agreed in 1997 and published in 2000 World Health Organization. Technical report series 894: "Obesity: preventing and managing the global epidemic" Geneva: World Health Organization, 2000.

- A BMI below 18.5 is characterized as underweight
- A BMI of 18.5 - 24.999 is characterized as normal weight
- A BMI of 25.0 - 29.999 is characterized as overweight or pre-obese
- A BMI of 30.0 - 34.999 is characterized as obese
- A BMI of 35.0 or higher is characterized as severely (or morbidly) obese

BMI is most accurate for people who live a sedentary lifestyle. It thus cannot distinguish between weight from body fat, muscle mass, or bone mass, so the table above is inaccurate for example in athletes, children or the elderly. Because muscle is more dense than fat, most amateur athletes would be classified as "overweight" and most professional athletes have enough muscle mass to be classified as "obese" or even "severely obese", when in fact their body fat percentage is very low and they are in no danger of developing any health problems correlative to carriage of excess fat. Children, meanwhile, have higher bone density in the years before puberty because of their smaller size, and that also results in skewed BMI values. In the case of elderly people, muscular atrophy and/or osteoporosis can also decrease the value of a BMI calculation.

Waist hip ratio >1.0 for males / >0.85 for females suggestive of android pattern of obesity

Other measures of measurement are biceps skin fold thickness/ subscapular thickness.

To be able to define obesity we should be able to calculate Ideal Body Weight [IBW]

IBW = Males - 50 + 2.3[ht in inches – 60]

Females - 45.5 + 2.3[ht in inches – 50]

Simplified IBW = ht in cm – X [X= 100 in males& 105 in females]

Pathophysiologic changes of Obesity - Obesity increases the risk of perioperative respiratory complications, difficulty in airway management and diminished cardiac function. Obesity has the potential to increase perioperative morbidity and a careful preoperative evaluation is indicated.

Table-1: Conditions associated with obesity

Organ system	Conditions
CVS	Venous stasis, CVA, pulmonary embolism, cardiomyopathy, hypertension, hyperlipidemia, IHD, peripheral vascular diseases
Respiratory	OSA, OHS, sleep disordered breathing, restrictive airway disease
Endocrine	Diabetes mellitus, hypothyroidism, Cushing's disease
Gastrointestinal	Cholelithiasis, gastrointestinal reflux disease, cirrhosis
Immunological	Impaired immune response
Musculoskeletal	Osteoarthritis, degenerative disc disease
Oncologic	Breast, colorectal, esophageal, kidney, endometrial cancers

Table 2: Symptoms of obstructive sleep apnea

Snoring
Excessive daytime sleepiness
Sudden arousals with choking
Unrefreshing sleep
Fatigue
Lethargy
depression
Morning dry throat
Morning headache
Impotence
Enuresis
Nocturnal sweating

Table 3: Co-morbid conditions associated with Obstructive Sleep Apnoea

Hypertension
Obesity
Diabetes Mellitus
Coronary artery disease
Cerebral vascular disease and stroke
Congestive heart failure
Cardiac dysrhythmias
Gastrointestinal reflux disease

Obstructive sleep apnea (OSA) - Approximately 5% of morbidly obese patients will have obstructive sleep apnea which is characterized by the following features [Table 2,3]

- Episodes of apnea or hypopnoea during sleep. An obstructive apnoeic episode is defined as 10 seconds or more of total cessation of airflow despite continuous respiratory effort against a closed airway. Hypopnea is defined as 50% reduction in airflow or a reduction sufficient to lead to a 4% drop in arterial oxygen saturation. Though the clinically significant numbers are quoted as 5 or more episodes per hour or > 30 per night but the clinical sequelae such as hypoxia, hypercapnia, systemic / pulmonary hypertension and cardiac dysrhythmias are more important.

- Snoring that gets louder as the airway obstructs, followed by silence and then gasping and choking as the patient rouses and airway patency is restored.

- Daytime symptoms – daytime sleepiness, morning headache, impaired concentration.

- Secondary polycythemia, ischaemic heart disease, cerebrovascular accidents, right ventricular failure.

Definitive diagnosis can be made by polysomnography[Fig 1] and its severity ascertained by the Apnea-Hypopnea Index (AHI).

	Episode/hr	Oxy Sat
Mild	5 – 15	80-89
Mod	16 – 30	70-79
Severe	> 30	60-69

Fig 1: Polysomnography
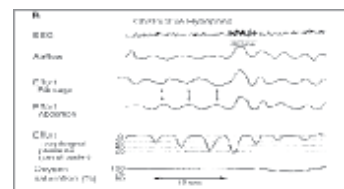
The ASA recommends risk stratification for patients with OSA. It may be useful to individualize the risk of perioperative complications. Table 4 below shows the scoring system. This scoring system has

yet to be validated and should be used as an adjunct to clinical judgment.

Table 4: Estimation of perioperative risk

A.   Severity of Sleep Apnoea based on sleep study

None   0

Mild   1

Moderate 2

Severe   3

B.   Invasiveness of surgery and anesthesia

Superficial surgery under local or peripheral

Nerve-block anesthesia without sedation   0

Superficial surgery with moderate sedation or

General anesthesia   ....…………………………….. 1

Peripheral surgery with spinal or epidural

Anesthesia (with not more than moderate

sedation) 1

Peripheral surgery with general anesthesia   2

Airway surgery with moderate sedation   2

Major surgery,general anesthesia   3

Airway surgery,general anesthesia   3

C.   Requirement for post-operative opioids

None   …………………………………. 3

Low dose oral opioids…………………………………. a

High dose oral opioids, parenteral, or

Neuraxial opioids…………………………………. 3

Estimation of perioperative risk

Overal score = Score of A plus the greater of   the score for either B or C

Score   = 4:   Increased perioperative risk

Score   > 4 :   Significantly increased perioperative risk

Airway changes-Obesity has been identified as an independent risk factor for difficult mask ventilation [Table 5]. The anatomical changes in the upper airway lead to increase an increase in incidence of problematic tracheal intubation.

- Impaired cervical and Atlanto-occipital movements

- Fat face, large tongue, large breasts, excessive palatal-pharyngeal tissue

- Restricted mouth opening

- Difficult laryngoscopy - Incidence of 'problematic' intubation is 5% when neck circumference >40cm and 35% when > 60 cm at the level of the thyroid cartilage[Fig 3].

- Awake intubation upto 8% [> 175% IBW awake intubation is recommended]

Fig 3: Neck circumference

Table5 : Obesity and airway management

Difficult mask ventilation	Difficult laryngoscopy	Difficult Intubation
Fleshy cheeks Large tongue Pharyngeal tissue folds Restricted neck movements	Double chin Cervical/ Upper thoracic pad of fat Submental fat Large breasts Large tongue Pharyngeal tissue folds	Excessive folds of Pharyngeal tissue folds Anterior larynx

Obesity and gas exchange-Mass loading of thoracic and abdominal components of the chest wall in supine, awake obese subjects causes abnormalities of both lung volumes and gas exchange. The well recognized harmful effects of anesthesia add significantly to the derangement of gas exchange. The table below summarizes the changes in lung fuction with obesity.

Table-6: Changes in lung functions.

Tidal volume	Normal or increased
Inspiratory reserve volume	Decreased
Expiratory reserve volume	Greatly reduced
Residual volume	Normal
Functional residual capacity	Greatly reduced
Vital capacity	Reduced
Total lung capacity	Reduced
Compliance	Reduced lung & chest wall compliance
Airway resistance	Increased
Work of Breathing	Increased

There changes in pulmonary mechanics with obesity can significantly affect the gas exchange.

- **Compliance** -Decrease in Ccw[chest wall] due to mechanical compression of thoracic cage.Decrease in C_L due to closure of dependent smaller airways and increased pulmonary blood volume
- **Resistance** -Increase due to decreased lung volume.
- **Lung volume changes** - ERV , FRC decreased more than any other lung volume. Mchanical compression of thoracic cage, abdominal wall and diaphragm causing decrease in diaphragm descent, elastic recoil and compliance.
- **Respiratory muscle strength, endurance** - PI max and PE max normal to decreased in eucapneic obese and definitely reduced in OHS; MVV decreased both

in simple obesity and OHS. Overstretched diaphragm and muscle fatigue due increased WOB and decreased muscle efficiency, increased oxygen consumption and CO_2 production

- **Work of breathing and energy cost of breathing-** WOB 70% higher than normal; Breathing efficiency ½ of normal. Elevated respiratory system resistance, compliance and inspiratory threshold load.
- **Gas exchange-** Impaired gas exchange due V/Q mismatch. Secondary to basal airway closure and atelectasis.

Implications for anesthesia- Preoperative evaluation in the morbid obese should include full blood count [to exclude polycythemia], chest X-ray, supine and upright blood gases, lung function tests and overnight oximetry. Patients with significant OSA should be considered for

polysomnography and may benefit from preoperative CPAP therapy.Induction of anesthesia is likely to a hazardous time with an increased risk for difficult mask ventilation or failed intubation. This mandates a careful planning of airway management with presence of a full range of airway aids and experienced backup.Historically, a morbid obese patient with suspected difficult airway was always approached with awake fibreoptic intubation technique. Recent studies have described 100% success in mask ventilation and 96% success in intubation on first attempt with an Intubating LMA, adding a very useful device to the armamentarium. Preoxygenation – The change in the pulmonary mechanics described above reduce the the nonhypoxemic apnea time available from >5mins in a normal patient to < 2-3 minutes despite preoxygenation. A new technique by which applying 5min of CPAP [10 cm of water]

prior to induction followed by PEEP with the face mask increased the PaO2 and apnea time.

Obesity and the cardiovascular system - The cardiovascular implications of obesity are enumerated in Table 1.

- **Hypertension-** There is 3-4 mm increase in systolic blood pressure and 2mm of Hg increase in diastolic blood pressure with every 10kg increase in weight. An expansion of extracellular volume resulting in hypervolemia and an increase in cardiac output are characteristic of obesity induced hypertension. Hypertension leads to concentric LVH and progressively non-compliant left ventricle which when added to increased blood volume increases the risk of cardiac failure [Fig 2].

- **Ischaemic heart disease -** Obesity is an independent risk factor for IHD and is more common in patients with central obesity.40% of obese patients with angina do not have coronary artery disease, implying that angina may be a direct symptom of obesity.

- **Cardiac function** – obese patients demonstrate an increase in cardiac output and left ventricular end diastolic pressure [LVEDP] and left ventricular hypertrophy [LVH]. Left ventricular systolic function is also deranged. An entity called 'obesity cardiomyopathy' is seen in morbidly obese patients which is associated with right sided failure, hypertension and ischaemic heart disease [Table 4].

Anaesthetic implications- Preoperative electrocardiogram may underestimate the severity of ventricular hypertrophy because of the low voltage complexes.Axis deviations and atrial tachyarrhytmias may be commonly present.Trans esophageal echocardiography may provide better images , especially of the left heart.These patients are prone to intraoperative ventricular failure [fluid imbalance, negative inotropy of anesthetic agents, pulmonary hypertension precipitated by hypoxia or hypercapnia]. Appropriate sized blood pressure cuffs may not be available , anesthetist should have a low threshold for invasive arterial blood pressure monitoring.

Obesity and gastrointestinal disorders-Recent studies have shown that obese patients without gastroesophageal reflux 75% greater volume than normal subjects but gastric emptying is faster. Residual volume may however be larger hence it is sensible to precautions against aspiration.

Anesthetic implications - Antiaspiration prophylaxis with H2 antagonists, prokinetics and antacids is adviced. Rapid sequence induction with use of succinylcholine and cricoid pressure is indicated.Awake extubation should be planned.

Drug pharmacokinetics in obesity-Obese patients have both an increase in lean body mass and increased fat mass, the increase in fat mass is greater than the lean body mass. Blood flow to the fat compartment is low [5%].Blood volume increases directly with body weight and obese individuals have increased blood volume and perfusion to vessel rich group. These changes lead to alteration in drug

Fig 4: Obesity caardiomyopathy
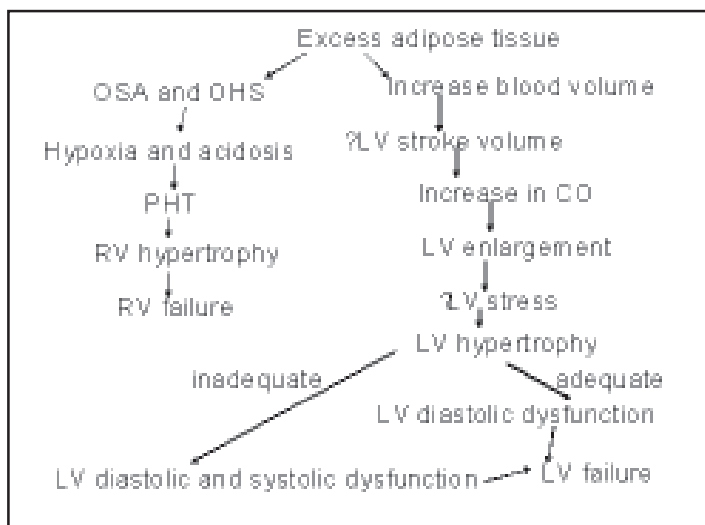
distribution, binding and elimination. Oral absorption remains unchanged. Volume of distribution $[V_D]$ – Increased in all lipophilic drugs and thereby reducing the elimination half life. The increased concentrations of triglycerides, lipoproteins, cholesterol and free fatty acids may inhibit protein binding and increase free fraction of the drugs. The increase in á$_1$ acid glycoprotein may increase degree of protein binding of local anesthetics and reduce the free fraction. Elimination – Hepatic clearance is not normally reduced in the obese. Phase I reactions[oxidation, reduction and hydrolysis] are normal or increased and metabolism by Phase II reactions is consistently increased. Increased reductive metabolism may be an important factor in development of halothane induced hepatotoxicity in obese patients at risk from hypoxemia and reduced liver blood flow. Renal clearance increases in obesity because of the increased renal blood flow and glomerular filtration rate. The table below highlights the effect of obesity on common anesthetic agents.

Table 7: Effect of obesity on anesthetic agents.

Drug	Altered pharmacokinetics	Implications
Thiopentone	V_D/ prolonged $T_{1/2}$	Increased absolute dose/ reduced dose by body wt/ prolonged action
Propofol	Little known	Dose calculated by Servin's formula for corrected body weight [IBW + 0.4 X excess body wight.
Midazolam/ diazepam	! V_D/ prolonged $T_{1/2}$	Increased absolute dose/ reduced dose by body wt/ prolonged action
Succinylcholine	! plasma cholinesterase activity	Increased absolute dose [Total body weight to calculate dose]
Atracurium	Unchanged	Dose based on TBW
Vecuronium	! V_D/ prolonged $T_{1/2}$	Dose based on lean body weight
Pancuronium	Low lipid solubility	Unchanged dose
Rocuronium	! V_D/ prolonged $T_{1/2}$	Dose based on Ideal body weight
Fentanyl	Unchanged	Doses based on TBW delayed recovery
Alfentanil	Elimination prolonged	Dose based on LBW
Remifentanil	Elimination prolonged	Dose based on LBW
Local anesthetics	Increased epidural fat content/ venous engorgement	75% of dose cal culated by TBW
Halothane	Deposition in adipose tissue Increased risk of reductive metabolism	Delayed recovery Increased risk of halothane hepatitis
Isoflurane	Unchanged	safe
Sevoflurane	Flouride concentration unchanged	Rapid recovery
Desflurane	Low solubilityblood and fat solubility	Faster recovery than Isoflurane and sevoflurane

Anesthetic Implications-The preferred method of treating postoperative pain in Morbid Obesity is with multimodal drug regimen with minimal opioids. NSAIDS and regional techniques are useful adjuncts to manage postoperative pain.

Desflurane and sevoflurane are volatile agents of choice.

Positioning the obese patient for Laryngoscopy and Intubation-Normal operation theatre tables may not accommodate an obese patient necessitating special arrang-ements. Patients should be positioned optimally for laryngoscopy. The patient is supported from behind the upper back and head to achieve the anatomical position whereby the is above the horizontal plane of the upper chest and a horizontal plane between the sternal notch and the external auditory meatus is established [Fig 5]. Careful padding of arms and pressure points are important precautionary measures to avoid neuropathy, skin necrosis and compartment syndromes.

Fig 5: Correct position for laryngoscopy

Post operative care-The obese patient presents additional challenges in the postoperative ward.Although routine ICU monitoring is not mandatory it would be wise to monitor them in an HDU setting where skilled personnel are available easily. They should be continually monitored for signs of airway compromise. Patients with OSA and history of difficult intubation need special attention.Postoperative use of opioids and sedative agents needs careful consideration as both these groups of drugs decrease upper pharyngeal tone and predispose to obstruction. Use of NSAIDS and regional blocks greatly reduce the opioid requirement and improve postoperative pain scores. Oxygenation should be continued in the postoperative period and nasal/oronasal CPAP should be considered. 30 degrees head up position should be maintained for all patients with OSA as it has proven efficacy in increasing the stability of the airway.

Summary - The anesthetic management of morbidly obese patient requires focus on preoperative airway evaluation and taking cognizance of coexisting disease to draw up a plan for peri operative management. Emphasis on preoxygenation, newer airway devices and newer volatile agents, short acting opioids and newer NSAIDS should be considered for safe conduct of anesthesia.

References

1. Adams JP, Murphy PG. Obesity in anaesthesia and intensive care. BJA 2000 85(1): 91-108.

2. Edbert TJ, Shankar H, Haake MR. Perioperative considerations for patients with morbid obesity. Anesthesiology Clin 2006 24, 621-636.

3. Obesity and sleep apnea. Anesthesiology clinics of North America, Ed : Fleisher LA, Pub: Saunders Philadelphia. September 2005, Vol 23[3].

4. Brodsky JB, LemmensHJM, Brock-Utne JG, et al. Anesthetic considerations for bariatric surgery: proper positioning is important for laryngoscopy.Anesth Analg 2003; 96:60-4.

5. Combes X, Sauvant S,Leroux B,et al . Intubating laryngeal mask aiway in morbidly obese and lean patients. Anesthesiology 2005;102: 1106-9.

6. Benumof JL. Obstructive sleep apnea in adult obese patients: implications for airway management.J Clin Anesth2001;13:144-56.

7. Gander S , Frascarolo P, Suter M et al. Positive end expiratory pressure during induction of general anesthesia increases duration of non hypoxic apnea in morbidly obese patients.Anesth Analg 2005;100:580-4.

Phaeochromocytoma and Anaesthetic Implications

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Phaeochromocytomas are rare catecholamine secreting tumours of chromaffin cells that may arise from any tissue of neuroectodermal origin. They form less than 0.1% of all cases of hypertension. The famous "Rule of 10" states that 10% are outside the adrenal glands, 10% are bilateral, 10% are malignant. However, 25-50% of hospital deaths in phaeochromocytomas occur under anaesthesia, hence it is important for the anaesthesiologist[1] . Mortality and morbidity have come down drastically, especially after the routine use of invasive monitoring for these cases besides adequately preparing them. These tumors may secrete mainly adrenaline or noradrenaline or both. However, the pharmacological effects of nordrenaline are predominant in most cases and the patient is in a chronic state of vasoconstriction and hypovolaemia. Cardiac dilatation and down regulation of receptors might occur in a number of patients. It is often associated with various syndromes like MEN I (Wermer's syndrome), MEN II (Sipple's syndrome), MEN III (Mucosal neuroma syndrome), Von Recklinghausen's disease and Von Hippel Lindau disease. The pathophysiology behind this disease process is an alteration in the normal synthesis of catecholamines.

History & Clinical Examination - The classic triad of phaeochromocytoma comprises of paroxysmal attacks of headache, sweating and palpitations, with a high blood pressure on examination. However, this classic presentation might not be present in all patients. The patient may complain of weight loss, anorexia and constipation, or even present with angina, myocardial infarction or cerebrovascular accident. Unexpected cardiovascular crises may occur spontaneously, due to stress or exercise, during surgery for an unrelated disorder, or during pregnancy or labour. Hypertension in a young patient; or resistant hypertension in any patient should lead to a suspicion of phaeochromocytoma. The differential diagnosis is thyrotoxicosis, carcinoid syndrome, pre-eclampsia and migraine. One more diagnostic aid is said to be the five 'P's - Pain in the chest & abdomen, Pallor, Perspiration, Polyuria (from glycosuria), HyPertension or Postural hypotension, Prostration. On examination, most of the findings are in the cardiovascular system: tachycardia, hypertension and signs of congestive cardiac failure. Blood pressure should be measured in both supine and upright positions to detect postural hypotension, and a blood pressure chart should be maintained to distinguish between paroxysmal and sustained hypertension. Apart from plasma and urinary catecholamine levels and abdominal imaging techniques, routine investigations may also reveal abnormalities, such as elevated blood sugar and elevated haematocrit. Urinalysis, blood urea, serum creatinine, blood glucose, serum electrolytes, calcium, ECG, CXR, haematocrit, blood grouping and cross matching, liver function tests, thyroid function tests and echocardiogram may be done according to patient requirements.

Diagnosis of phaeochromocytoma – It is by history; Urinary tests: metabolic products of adrenaline and noradrenaline – vannilyl mandelic acid (VMA), 4-hydroxy 3-methoxy mandelic acid (HMMA), urinary catecholamines, metanephrines & normetanephrines are increased; Blood tests: Plasma catecholamine levels are grossly raised.

Radiological tests- MRIs and CT scans will pick up 90% of tumours > 1cm. If not located on CT, but suspected (CT is poor for non adrenal tumours), then an MIBG scintiscan is indicated[2].

Excretion of catecholamines and their metabolites in a 24 hour sample of urine (moreàphaeochromocytoma)	
Epinephrine (Ep)	5 mg
Norepinephrine (Nep)	30 mg
Conjugated (Ep + Nep)	100 mg
Total metanephrines	65 mg
Total normetanephrines	100 mg
Vannilyl mandelic acid (VMA)	1 – 1.2 mg

Catecholamine/ metabolite	Plasma levels (pg/ml)
Epinephrine	40 - 100
Norepinephrine	200 - 400
Dopamine	< 1400
Metanephrine	< 2000
Normetanephrine	< 5000

Ultrasound may demonstrate large adrenal / intrabdominal tumours. Intravenous pyelography may also be done.

Other tests, of academic importance but negligible clinical significance include selective adrenal or renal venous sampling; adrenal provocation tests using glucagons and histamine, and suppression tests using clonidine; angiography; DSA etc.

Pre - operative management

a - adrenergic blockers

- Phenoxybenzamine - Non competitive á-blocker, with long half life.Dose is 10 mg bd orally, increasing by 10-20 mg/day, until postural hypotension and resolution of adrenergic symptoms occurs.

- Prazosin- 6-10 mg of this alpha-1 selective blocker.
- Doxazosin.

b- adrenergic blockers

- Propranolol is added at doses of 40-80 mg/day, can be increased to120-480 mg/day if required. b-blockers should never be started till adequate á-blockade has been obtained, otherwise they will precipitate hypertensive crisis.
- Esmolol is used mostly to control heart rate during acute crises in the operating room.

Labetalol - Combined á and b-blocker, with greater b than á effect. Care should be taken while using this drug that an adequate á-blockade has been obtained. This is used more in acute crises and in the operating room.

Others - Magnesium, Calcium Channel Blockers, Clonidine, Alpha Methyl Para Tyrosine – These are not very commonly used.

Pre-operative control of blood pressure is an essential component of preparing these patients. Preoperative alpha-adrenergic blockade is essential using phenoxybenzamine 10 mg twice a day increasing daily until blood pressure is controlled, i.e. till postural hypotension occurs or till adrenergic symptoms resolve[3,4,5]. If tachycardia develops, propranolol, a beta-blocker, is added (40-80 mg/day)[4]. Patients should be given plenty of fluids as a relative hypovolaemia is exposed. A minimal of 7 to 10 days treatment is required for most patients; longer for severe disease or if there is a cardiomyopathy. Beta blockage should never be commenced before alpha blockade, as this will precipitate a hypertensive crisis.

Roizen's Criteria (for adequate pre-operative control)[6]

- Blood pressure < 165 / 90 at all times
- Postural BP fall to not below 80 / 45
- ECG free of ST changes for 2 weeks
- < 1 VEB over 5 minutes

Anaesthetic goals:

- Optimum pre–operative preparation
- Alleviation of anxiety – drugs, good communication with anaesthesiologist & surgeon, informed consent

- Gentle induction of anaesthesia
- Reduction of sympathetic stimulation
- Avoidance of hypoxia, hypercarbia
- Coping with acute changes – HT, arrhythmias etc

The surgical procedure can be either open or laparoscopic. After shifting the patient into the operating room, at least two large bore venous cannulae sould be in place. ECG, SpO2, EtCO2, temperature and urine output should be monitored. Invasive arterial blood pressure and central venous pressure should be monitored. Optional monitors include pulmonary capillary wedge pressure and neuromuscular blockade monitoring. A number of drugs should be kept ready for use in acute hypertensive and hypotensive crises, such as sodium nitroprusside, phentolamine, magnesium sulphate, propranolol, esmolol, phenylephrine, dopamine, adrenaline and noradrenaline. Drugs that cause arrhythmias and tachycardia should be avoided, such as atropine, ketamine, succinyncholine, halothane, desflurane, pancuronium, atracurium etc. The anaesthetic technique can be either controlled general anaesthesia with muscle relaxation or general anaesthesia combined with epidural anaesthesia[7]. Though it has also been done with a regional anaesthetic technique alone, it is not recommended as control of acute fluctuations of blood pressure is better with general anaesthesia. Any combination of drugs can be used for induction and maintenance, avoiding the ones specified before. Episodes of tachycardia should be treated with esmolol or propranolol. Hypertension can occur, especially during laryngoscopy and tumor handling, and should be controlled with sodium nitroprusside, nitroglycerine and labetolol. It has been found that the peak total catecholamine level found during surgery correlated quite well with more operative instability suggesting that patients with phaeochromocytomas with high production of catecholamines are more likely to show cardiovascular instability[8]. Adequate volume loading is necessary. Following ligation of the venous drainage of the tumor, there is usually a sudden fall in blood pressure due to sudden fall in catecholamine levels in the body, combination of residual alpha and beta blockade, receptor downgrading, and diminished blood volume. This should be treated with i.v. fluids, and which may require noradrenaline or adrenaline infusions.

Post-operatively, intensive care with invasive monitoring is recommended for all patients. In most cases, cardiovascular stability returns within a few hours of completion of surgery and vasoactive agents are withdrawn at this stage. About 50% of patients might remain hypertensive for 1 – 3 days. Adequate fluids should be given post-operatively, titrated to CVP, and analgesia should be maintained via epidural top-ups or intravenous narcotics. The patient should be extubated when considered appropriate. The mortality as well as difficulty in management of phaeochromocytoma increases manifold when it complicates other conditions such as pregnancy[9], when magnesium sulphate is one of the preferred vasodilators[10], or in paediatric[11] patients. Other conditions resembling phaeochromocytoma include neuroblastoma and ganglione-uroma.It is essential to remember that not all cases of phaeochromocytoma will be well-controlled with medication, two other situations are possible- when abdominal manipulation during incidental surgery leads to uncontrollable rises in blood pressure, leading to a diagnosis of phaeochromocytoma in the operating room, and when a known case of phaeochromocytoma, still not well-controlled with drugs, presents for an emergency surgery. In both these cases, invasive monitoring should be started, and the intra-operative fluctuations of blood pressure controlled with appropriate inotropes, dilators and fluids.Post-operative ICU care with elective ventilation is a must for these patients till blood pressure is satisfactorily controlled.

References

1. St John Sutton MG, Sheps SG, Lie JT. Prevalence of clinically unsuspected phaeoch-romocytoma: Review of a 50-year autopsy series.Mayo Clin Proc 56:354, 1981.

2. Geoghegan JG, Emberton M, Bloom SR, Lynn JA. Changing trends in the management of phaeochromocytoma. Br J Surg. 1998 Jan;85(1):117-20.

3. Tsioufis CP, Stefanadis CI, Toutouzas PK. Images in cardiology: Preoperative treatment with phenoxybenzamine restores ECG to normal in a woman with pheochromocytoma. Heart. 2002 Aug;88(2):186.

4. Desmonts JM, le Houelleur J, Remond P, et al. Anaesthetic management of patients with phaeochromocytoma: A review of 102 cases. Br J Anaesth 49:991, 1977.

5. Boutros AR, Bravo EL, Zanettin G, Straffon RA. Perioperative management of 63 patients with pheochromocytoma. Cleve Clin J Med. 1990 Oct;57(7):613-7.

6. Witteles RM, Kaplan EL, Roizen MF. Safe and cost–effective preparation of patients with phaeochromocytoma. Anesth Analg 91:302-4,2000.

7. Oberoi GS, Yaubihi N, Clezy JK. Anaesthesia for phaeochromocytoma resection: role of thoracic epidural blockade. P N G Med J. 1993 Dec;36(4):301-5.

8. Russell WJ, Metcalfe IR, Tonkin AL, Frewin DB. The preoperative management of phaeochromocytoma. Anaesth Intensive Care. 1998 Apr;26(2):196-200.

9. Hamilton A, Sirrs S, Schmidt N, Onrot J. Anaesthesia for phaeochromocytoma in pregnancy. Can J Anaesth. 1997 Jun;44(6):654-7.

10. James MF, Huddle KR, Owen AD, van der Veen BW. Use of magnesium sulphate in the anaesthetic management of phaeochromocytoma in pregnancy. Can J Anaesth. 1988 Mar;35(2):178-82.

11. Hack HA, Brown TC. Preoperative management of phaeochromocytoma—a paediatric perspective. Anaesth Intensive Care. 1999 Feb;27(1):112-3.

Side Effects of Nitrous Oxide

Nitrous oxide has no smell and is not unpleasant to breathe. The mask may smell a little rubbery but this is not usually unpleasant. Some people have a 'phobia' for face masks and feel as though they are suffocating. (Such fears often go back to a previous unpleasant experience; for example, in the dentist's chair!) If so, many people prefer to breathe through the mouth piece instead

Not everyone likes the effects of nitrous oxide. Some people feel that is makes them feels nauseated (although this occurs commonly in labour anyway). Others feel confused or disoriented, floating, or a bit drunk. These feelings are pleasant for some, but unpleasant for others. The important thing to remember is that all of these effects will quickly disappear once you stop using it. If they don't - then something else must be to blame, such as stress or fatigue

There is absolutely no risk of becoming dependent or addicted to nitrous oxide when using it during childbirth. If it is used in high concentrations for a very long time, nitrous oxide can depress the bone marrow and lead to temporary anaemia. For this to occur, the exposure period needs to be at least eight hours (and at concentrations sufficient to produce anaesthesia). There is no evidence that this complication has ever occurred -or even could occur - using nitrous oxide during childbirth.

Effects on the Baby

Nitrous oxide does not cause any abnormalities or malformations. Nor does it interfere with the contractions or have any effect on the duration of labour. Although it passes easily to the baby, as we have already seen, it is very rapidly eliminated as soon as the baby cries and starts to breathe. It does not have any effect on the fetal heart rate or circulation and does not depress the baby's respiration at birth. In other words, nitrous oxide is perfectly safe for the baby.

Studies on the neurobehaviour of infants who have been exposed to nitrous oxide during labour have detected no influence of the gas whatsoever - even in the first few hours of life. Similarly, other studies have confirmed that nitrous oxide has no effects on the infant's ability to suckle.

Myasthenia Gravis and Anaesthetic Implications

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Myasthenia gravis is an autoimmune disease, with an incidence of 0.25 to 2.0 per 100,000 people, resulting from the production of antibodies against the alpha subunit of nicotinic acetylcholine receptors of the endplate[1, 2, 3, 4]. These antibodies reduce the number of active receptors, brought about either by functional block of the receptors, by increased rate of receptor degradation, or by complement-mediated lysis. Repetitive nerve stimulation results in a decremental response. The disease is frequently associated with morphologic alabnormalities of the thymus[5]. In young patients, thymic hyperplasia is common while thymoma is more frequent in elderly patients. Myasthenia gravis may be associated with other disorders of autoimmune origin such as thyroid hypofunction, rheumatoid arthritis, and systemic lupus erythematosus.

Clinical presentations

- Transient neonatal myasthenia - It is present in 20% of neonates born to myasthenic mothers, with difficulty in sucking and swallowing, difficulty with breathing, ptosis and facial weakness. The condition has a tendency to spontaneous remission, usually within two to four weeks.

- Congenital or infantile myasthenia-These children have variable muscle weakness from birth due to congenital endplate acetylcholine-receptor-deficiency. The condition is not autoimmune in nature, and hence therapy primarily depends on anticholinesterase therapy.

- Juvenile myasthenia-This is similar in pathogenesis and treatment to the adult variety, except that thymoma is not a feature in these cases.

- Adult Myasthenia Gravis (MG)-The incidence is about 1 in every 20,000 adults. There is a preponderance of women, Hyperplasia of the thymus gland is present in over 70% of patients, and 10-15% have thymomas. The clinical course of MG is marked by periods of exacerbations and remissions.

History & Clinical examination - The extraocular muscles are involved at some time in the course of the disease in almost every patient during the first year. Weakness of pharyngeal and laryngeal muscles (bulbar muscles) results in dysphagia and dysarthria. Arm, leg, or truncal weakness can occur in any combination and is usually asymmetrical in distribution. After the disease reaches its maximum severity, most patients who survive continue with a chronic form of the disease with fewer and less severe episodes of exacerbation.A detailed central nervous system examination should be performed. This will show normal higher mental functions and unaltered sensory system function. A motor system examination enables the anaesthesiologist to gauge the severity of the disease process, and this shows involvement of the lower cranial nerves and an asymmetrical muscle involvement in the rest of the body.

Classification Of Myasthenia Gravis(Ossermann and Genkins)	
I	Ocular signs and symptoms only
II	A Generalized mild muscle weakness
IIB	Generalized moderate weakness, and/or bulbar dysfunction
III	Acute fulminating presentation, and/or respiratory dysfunction
IV	Late severe generalized myasthenia gravis

The distribution, severity, and outcome of the disease are determined during the first one to three years after the onset. In 14%, the disease remains clinically localized to extraocular muscles and in the remaining 86%, becomes generalized.

Diagnosis

- Edrophonium (Tensilon test)- Improvement in muscle strength after an intravenous injection of edrophonium helps to confirm the diagnosis of MG. After a test dose of 1 to 2 mg, a total dose of 10 mg is administered intravenously or a small dose of 2-5 mg, after which, a positive response is expected within 5 minutes.

- Electromyography-A motor nerve is stimulated three times per second, and the electrical activity of the muscle is recorded. A decrement of response of at least 10% (fade) by the fifth stimulation is usually present in the myasthenic.

- Regional curare test- A fore-arm tourniquet is applied and inflated. Curare 0.2 – 0.5mg is injected intravenously into the isolated forearm (distal to the tourniquet), and electromyography is performed on that limb. The myasthenic will show marked decrement in response to repeated stimuli, whereas no change should occur in the normal individual. The test is employed when the edrophonium test and simple electromyography are equivocal.

- Acetylcholine receptor antibodies - These antibodies are detectable in 85 – 90 % of myasthenics and are diagnostic for MG. The titer of antibodies does not correlate with the severity of the disease.

- Computed Tomograph scan (CT) or magnetic resonance imaging (MRI)- These radiologic tests may be used to confirm the presence of an abnormal thymus gland.

Myasthenia gravis should be distinguished from an acquired disorder called Lambert - Eaton's myasthenic syndrome, seen in association with small cell carcinoma of the lung in which the quantal release of acetylcholine vesicles is reduced due to antibodies against calcium channels, often associated with dysautonomia. A main distinguishing feature is that it improves with tetanic stimulation or exercise. The skeletal muscle weakness in Lambert – Eaton's syndrome is not reliably reversed with anticholinesterase, while 3,4-diaminopyridine has been shown to cause an increase of transmitter release and improve the symptoms. They are sensitive to both depolarizing and nondepolarizing relaxants.

Pre-operative medical treatment

- Symptomatic treatment with anticholinesterases, non-specific immuno-suppression with steroids and immuno-suppressants can be tried for optimization before thymectomy. Anticholinesterase therapy is aimed at increasing the amount of acetylcholine available to the reduced number of active receptors, thus increasing the likelihood of agonist-receptor interaction and therefore neuromuscular transmission. Neostigmine, edrophonium, pyridostigmine, and

ambenonium are all effective acetylcholinesterase inhibitors. Physostigmine crosses the blood-brain barrier, producing central nervous system symptoms, and is not used in myasthenics for this reason. Pyridostigmine is the most common acetylcholinesterase inhibitor employed because it has the fewest muscuranic side-effects and a 3-6 hour duration of action. Pyridostigmine is administered either intravenously 2 mg or 60 mg orally. A sustained-release preparation is often that is active over several hours. This preparation is often used at night to ensure strength on awakening in the morning. Dose requirement vary from day to day. Patients usually learn to adjust appropriately.

- Other medical treatments of MG are directed at decreasing the production of antibodies. Corticosteroids promote clinical improvement in up to 80% of patients but prolonged treatment gives rise to side effects like cataract, osteoporosis, hypertension, and peptic ulcer. Initiation of steroid therapy leads to neuromuscular weakness that is due to direct inhibitory effect on neuromuscular transmission.Immuno-supressants like azathioprine and cyclosporine have also been used.

- Plasmapheresis has been used to remove circulating antibodies and temporarily improve symptoms in 40% of cases. Several treatments are

required, and improvement may last only 4 days or as long as 12 weeks. Plasmapheresis also decreases pseudocholinestrase levels, which results in prolonged duration of action of succinylcholine.

- Thymectomy has provided long term improvement by decreasing production, or the stimulus for production of antibodies directed at nicotine acetylcholine receptors. Thymus may be responsible for the pathogenesis of MG because the thymus contains myoid cells with nicotinic receptors and a number of myasthenics have thymic abnormalities. It may also be source of autoreactive helper T-cells. It is the preferred treatment under 55 years of age, but can be done if patient is medically fit.

Approaches of thymectomy

- Transcervical - Less interference with respiratory mechanics, complete removal is doubtful.
- Transsternal -Complete removal possible.
- Thoracoscopic removal- Needs one lung ventilation, supposed to cause less pain.
- When thymoma is present, removal of thymus gland via sternotomy may be required.

Anaesthetic management

The anaesthetic management of the myasthenic patient must be individualized to the severity of the disease and to the type of surgery. The use of regional or local anaesthesia is warranted whenever possible, General anaesthesia can be performed safely, provided the patient is optimally prepared and neuromuscular transmission is adequately monitored during and after surgery[6].

Preoperative preparation-Adequate preoperative evaluation of the myasthenic patient must be carried out carefully. Specific history and examination should include:

- Age, sex, onset and duration of the disease – These as well as the presence of thymoma may determine the response to thymectomy.
- The severity of myasthenia and the involvement of bulbar or respiratory muscles must be evaluated.
- Preoperative respiratory function tests must be performed since chronic respiratory disease and/or a preoperative vital capacity <2.9 L are two of the predictive criteria for postoperative respiratory support.
- Optimization of the condition of the myasthenic patients can markedly decrease the risk of surgery and improve the outcome. Ideally surgery should be performed during the period of remission when all other medical problems are optimized. Many regimens have been recommended for preoperative treatment. It is controversial whether anticholinesterase therapy should be maintained or discontinued before and after surgery.

- Withhold anticholinestrase if one is procedure requires use of muscle relaxant. The patient's baseline weakness facilitates muscle relaxation, requiring little or no muscle relaxant. It also decreases the risks of drug interactions later like partial antagonism of non-depolarizing muscle relaxants and prolongation of the action of succinylcholine.
- Additionally withholding of muscle relaxants eliminates cholinergic crises as a cause of respiratory failure. But for physically or psychologically dependent individual, this approach is not suitable. Some anaesthesiologist continue the normal schedule. But, if the surgery is non-emergent, the dosage can be tapered as the activity of patient is decreased, while in the hospital. The continuation may be advocated if patient is taking the drug every 2-4 hourly.
- Anticholinesterases potentiate the vagal responses and hence adequate atropinization must be ensured. Also, anticholinesterases can inhibit plasma cholinesterase activity with a subsequent decrease in the metabolism of ester local anaesthetics, and the hydrolysis of succinylcholine will be decreased. As in non myasthenic patients, the duration of succinylcholine block in myasthenic patients is inversely related to the plasma cholinesterase activity. In contrast with succinylcholine, the inhibition of acetylcholinesterase by anticholinest-

erases may increase the need for nondepolarizing muscle relaxants in the myasthenic patient, although this has not been documented. Recently, plasmapheresis alone without immunosuppression has been used to optimize the medical status of the myasthenic patient prior to surgery

- Careful preoperative evaluation of respiratory parameters and bulbar strength are necessary before prescribing premedication Depressant drugs for preoperative premedication should be used with caution as myasthenic patients may have little respiratory reserve, and sedatives are completely avoided in patients with bulbar symptoms. The patient and his relatives should be informed during the pre-anaesthetic check-up that postoperative tracheal intubation and respiratory support may be required, and an informed consent should be obtained.

Intra - operative management- Two techniques have been recommended for general anaesthesia in the myasthenic patient. Because of the unpredictable response to succinylcholine and the marked sensitivity t onondepolarizing muscle relaxants, some anaesthesiologists avoid muscle relaxants and depend on deep inhalational anaesthesia, such as halothane, for tracheal intubation and maintenance of anaesthesia. However, others utilize a balanced technique which includes the use of muscle relaxants, without the need for deep inhalational anaesthesia with its concomitant respiratory and cardiovascular side effects. When possible, many anaesthesiologists prefer to combine GA with a regional anaesthetic technique, keeping within the dosage limitations of local anaesthetics.

Response to muscle relaxants- The response of the myasthenic patient to both depolarizing and nondepolarizing relaxants is different from that in normal individuals, and a thorough understanding is necessary for their safe administration. There is a decrease in the number of functional AChRs available in MG, with a decrease in the response to the chemical transmitter, as well as to other depolarizing agents such as succinylcholine[7]. On the other hand, there is a marked sensitivity to nondepolarizing relaxants. The abnormal response of the myasthenic patients to muscle relaxants is independent of the extent of involvement of body musculature in the disease process, that is, even patients with localized ocular myasthenia and during remission who may have circulating antibodies and decreased receptor population sufficient to maintain neuromuscular transmission, show an abnormal response to neuromuscular blocking agents. Because of the decreased number of AChR or their functional blockade by AChR antibodies, succinylcholine may not effectively depolarize the endplate resulting in high doses of succinylcholine may be required for rapid sequence tracheal intubation in a patient with MG. The endplate potential may not reach the threshold required for inducing depolarizing phase 1 block, and hence succinylcholine may readily induce phase 2 block. Anticholinesterases can decrease the plasma cholinesterase activity, with a subsequent delayed hydrolysis of succinylcholine and potentiation of neuromuscular block. The reduction of the number of ACh receptors at the neuromuscular junction makes myasthenic patients extremely sensitive to nondepolarizing muscle relaxants. There is a large spectrum in the muscle relaxant requirements in these patients. Intermediate acting neuromuscular blockers, like atracurium and vecuronium can be safely given in titrated doses with neuromuscular monitoring[8], and they can be completely reversed at the termination of the surgical procedure. It is mandatory to monitor neuromuscular transmission carefully during surgery by peripheral nerve stimulation to titrate the necessary dose of muscle relaxants, and to ensure complete reversal of neuromuscular block at the termination of surgery, as the abnormal response to muscle relaxants occurs even in patients with localized ocular myasthenia[9], and in those in remission. Monitoring should be continued postoperatively for early detection of neuromuscular dysfunction.

Postoperative course- It is essential to closely monitor the patient's ventilatory function in the immediate post-operative period clinically, as it has been shown recently in normal patients that many of the recommended tests such as maintained response to tetanic stimulation of a periph-

eral nerve can return to normal, while the pharyngeal and neck muscles necessary to protect the airway can still be partially paralysed, and this difference might be exaggerated in patients of MG who already have some degree of bulbar and/or respiratory muscle weakness. Patients should be considered partially paralysed until they wake up and can lift their head for five seconds or generate an inspiratory force exceeding - 25 cm H_2O. Myasthenic patients may be at increased risk of developing postoperative respiratory failure, and following trans sternal thymectomy, up to 50% of patients require prolonged postoperative ventilation. Risk factors predicting requirement of prolonged post-operative ventilation include[10]:

- Duration of myasthenia gravis for longer than six years.

- A history of chronic respiratory disease other than respiratory dysfunction directly due to MG.

- A dose of pyridostigmine greater than 750 mg per day, 48 hr before operation.

- A pre-operative vital capacity < 2.9 L.

- Clinical classification of MG (Ossermann classes 3 and 4).

- A previous history of respiratory failure due to MG, and associated steroid therapy.

Thymectomy benefits nearly 96% of patients regardless of preoperative characteristics. Following thymectomy, different therapeutic regimens have been recommended depending on the out-come of surgery. Most early-onset myasthenics can be treated with thymectomy alone, while late-onset myasthenia as well as myasthenia associated with thymoma needs additional post-operative immunosuppression. Some patients of myasthenia gravis may come for emergency surgeries before adequate medical control has been achieved, in which case, titrated doses of muscle relaxants should be used with neuromuscular monitoring, and arrangements for post-operative ventilation should be made before taking up such a patient for surgery

Myasthenic crisis and Cholinergic crisis - Myasthenic crisis is a medical emergency characterized by respiratory failure from diaphragmatic weakness or severe oropharyngeal weakness leading to aspiration. Crisis can occur in the setting of surgery (postoperative), acute infection, or following rapid withdrawal of corticosteroids (though some patients have no precipitating factors). Patients should be placed in an ICU setting and have forced vital capacity (FVC) checked every 2 hours. Changes in ABG occur late in neuromuscular respiratory failure. Criteria for intubation include a drop in FVC below 15 ml/kg, severe oropharyngeal weakness leading to aspiration or laboured breathing regardless of spirometric measurements. It can be extremely difficult to distinguish too much from too little anticholinergic medication when a patient with known myasthenia gravis presents with rapidly increasing muscular weakness, with or without respiratory difficulty. Features suggestive of a cholinergic crisis (too much medication) include muscle fasciculation, pallor, sweating, hypersalivation and small pupils. If the diagnosis is not clear-cut, it is advisable to temporarily discontinue cholinesterase medication and to secure the airway with intubation, stabilize ventilation and then address the question of the underlying diagnosis. Cholinergic crisis results from an excess of cholinesterase inhibitors (ie, neostigmine, pyridostigmine, physostigmine) and resembles organophosphate poisoning. In this case, excessive ACh stimulation of striated muscle at nicotinic junctions produces flaccid muscle paralysis that is clinically indistinguishable from weakness due to MG. It may cause bronchospasm with wheezing, bronchorrhea, respiratory failure, diaphoresis, and cyanosis. Miosis and the SLUDGE syndrome (ie salivation, lacrimation, urinary incontinence, diarrhea, GI upset and hypermotility, emesis) also may mark cholinergic crisis. However, these findings are not inevitably present. If in doubt, an edrophonium test can be performed. Improvement suggests too little medication i.e. myasthenic crisis and aggravation suggests too much medication. This test should only be performed with the necessary skills and equipment ready for intubation and ventilation.

References

1. Vincent A, Palace J, Hilton-Jones D: Myasthenia gravis. Lancet 2001; 357: 2122-8.

2. Drachman DB. Myasthenia gravis. N Engl J Med 1978; 298: 136-42.

3. Drachman DB, De Silva S, Ramsay D, Pestronk A. Humoral pathogenesis of myasthenia gravis. Ann N Y Acad Sci 1987; 505: 90-105.

4. Lindstrom JM, Seybold ME, Lenon VA, et al. Antibody to acetylcholine receptor in myasthenia gravis. Prevalence, clinical correlates, and diagnostic value. Neurology 1976; 26: 1054-9.

5. Berrih-Aknin S, Morel E, Raimond F, et al. The role of the thymus in myasthenia gravis: immunohistological and immunological studies in 115 cases. Ann N Y Acad Sci 1987; 505: 50-70.

6. Stoelting RK, Dierdorf SF, McCommon RL. Myasthenia Gravis. In: Anesthesia and Co-Existing Disease, 2nd ed, New York: Churchill Livingstone, 1988; 626-30.

7. Churchill-Davidson HC, Richardson AT. Neuromuscular transmission in myasthenia gravis. J Physiol 1953; 122: 252-63.

8. Hunter JM, Bell CF, Florence AM, Jones RS, Utting JE. Vecuronium in the myasthenic patient. Anaesthesia 1985; 40: 848-53.

9. Baraka A, Afifi A, Muallem M, Kachachi R, Frayha F. Neuromuscular effects of halothane, suxamethonium and tubocurarine in a myasthenic undergoing thymectomy. Br J Anaesth 1971; 43: 91-5.

10. Leventhal SR, Orkin FK, Hirsh RA. Prediction of the need for postoperative mechanical ventilation in myasthenia gravis. Anesthesiology 1980; 53: 26-30.

Childbirth techniques

Childbirth has been associated with pain since the beginning of time, and throughout history measures have been introduced to help relieve it. Various exorcisms can be found in the records from the ancient civilisations of Babylon, Egypt, China and Palestine. Primitive attempts to help relieve pain were based mainly on suggestion and distraction. The former embraced the use of rings, necklaces, amulets and other magical charms; while the latter included counter-stimulation i.e. the infliction of a painful stimulus sufficient to detract from a natural one. In the Middle Ages various herbal concoctions based on extract of poppy, mandragora, henbane and hemp were introduced. There is evidence that alcohol was also used in labour. At the beginning of the nineteenth century other 'remedies' were introduced. In 1806 a thesis by Miller, entitled "Means of Lessening Pain of Parturition", recommended vigorous exercise, bloodletting and a variety of medications designed to induce vomiting. One can imagine that treatments such as these would have been quite effective in distracting women from their pain!

Medical history abounds with episodes where new treatments have been embraced with well-intended but misplaced enthusiasm. The introduction of anaesthesia and pain relief in childbirth in the nineteenth and early twentieth centuries was no exception. Some practitioners were so seduced with the powerful effects of the new drugs available to them (chloroform, opioids, 'Twilight Sleep'), that they used them indiscriminately. However, when revolutionary new remedies are promoted uncritically, they invariably lead to counter-revolution. The excessive use of sedative and analgesic drugs used during labour at the beginning of this century was a prelude to the so-called Natural Childbirth Movement. The origins of this movement go back to 1914 when Behan wrote: "Like menstruation, childbirth should be a painless process. It is only as culture advances that the labour becomes painful, for in women of primitive races pain is absent.".Dr Grantly Dick-Read proposed the same argument in 1933. Later, various modifications of the Dick-Read philosophy were introduced in other countries. Psychoprophylaxis was first described in 1947 by a Russian psychiatrist, Velvovski, and was modified by Lamaze and Vellay in Paris in 1952. Antenatal education, breathing patterns and relaxation also play a prominent role with this technique. More recently, Le Boyer has introduced a somewhat different approach - but based on similar concepts. Like the Twilight Sleep movement, most of the above approaches to childbirth have been consumer led.

Correspondence

FAHR Disease

A 56 year old female presented with complaint of headache and abnormal behaviour. A non-contrast CT scan head (Fig 1-3) was done.
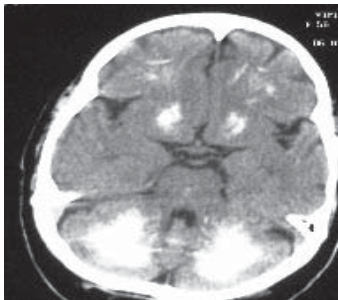

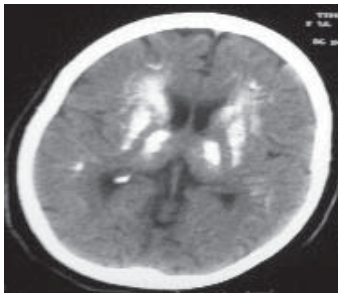Figure-1, CT axial images show calcifications dentatenucleus and basal ganglia.

Figure-2, CT axial images show diffuse calcifications semiovale center and subcortical region

Fahr disease is a rare degenerative neurological disease characterized by the presence of abnormal calcium deposits and associated cell loss in certain areas of the brain. The most common site of calcification is the globus
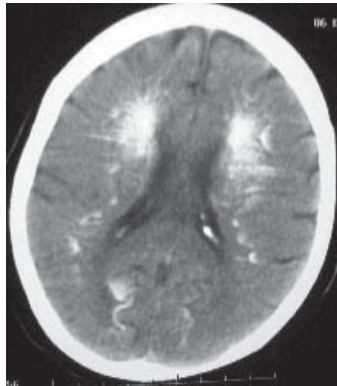
Figure-3, CT axial images show calcifications basal ganglia and subcortical region

pallidus. Additional areas of calcification are putamen , caudate nucleus , internal capsule , dentate nucleus , thalamus , cerebellum and cerebral white matter. Fahr disease is often referred to as idiopathic basal ganglia calcification because there is no apparent explanation for such calcification in these brain regions. This condition was first described by Fahr in 1930. Fahr syndrome gene location is said to be 14q , situated on the long arm (called q) of chromosome 14. Fahr disease is often familial. Familial Fahr disease may be transmitted as an autosomal recessive trait or in other affected females , may have autosomal dominant inheritance. In other instances , the condition appears to occur randomly for unknown reasons. Fahr disease affects men and women equally and can appear at any stage of life. In people with

dominantly inherited Fahr disease , symptoms usually appear anywhere between the ages of 30 and 60. The recessive form of Fahr disease emerges at a younger age , between infancy and young adulthood. Associated symptoms in Fahr syndrome include progressive deterioration of cognitive abilities (dementia) and loss of acquired motor skills. As the condition progresses paralysis may develop that is associated with increased muscle stiffness (rigidity) and restricted movement (spastic paralysis). Additional abnormalities may include relatively slow , involuntary , continual writhing movements (athetosis) or chorea , a related condition characterized by irregular , rapid , jerky movements. In some affected individuals , there may also be gradual deterioration of the nerve fibres that transmit impulses from the retinas to the brain (optic atrophy) , a condition associated with partial or near complete visual impairment. The term Fahr triad consists of symmetrical calcification of the basal ganglia, neuropsychiatric symptoms and hypofunction of the parathyroid gland. There is no cure for Fahr disease , which worsens over time. The process of calcification cannot be stopped or reversed. When possible , clinicians focus on alleviating its various mental and physical effects. Lithium carbonate , for example , may be

recommended to control psychotic symptoms , while antidepressant medications are often used to combat depression.

References

1. Geschwind DH , et al. Identification of a locus on chromosome 14q for Idiopathic Basal Ganglia Calcification (FAHR disease). American Journal of Human Genetics. 1999; 65: 764-772.

2. Lauterbach EC , et al. Neuropsychiatric correlates and treatment of lenticulostriatal diseases : A review of literature and overview of research opportunities in Huntington's , Wilson's and Fahr's disease. A report of the ANPA committee in research. American Neuropsychiatric Association. Journal of Neuropsychiatry and Clinical Neurosciences. 1998; 10: 249-266.

3. Harrington MG , et al. The significance of the incidental finding of basal ganglia calcification on Computed Tomography. J Neurol. Neurosurg. Psychiat. 1981; 44: 1168-1170.

4. Rosenblatt A, Leroi I. Neuropsychiatry of Hutington's disease and other Basal Ganglia disorders. Psychosomatics. 2000; 41: 24-30.

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N-acetylcysteine an effective method of tracheobronchial clearance in spinal cord injury patients - a case report

N-acetylcysteine is an N-acetyl derivative of amino acid cysteine. It is a clear liquid with a sulfur odor which is more stable than its parent compound. In addition to its use as an antioxidant, N-acetylcysteine has also been found to be very useful as a mucolytic agent. Tenacious bronchial secretions occur frequently in respiratory disease. The viscous nature of tracheobronchial secretions is due to the constituents mucoprotein and deoxyribonucleoproteins[1]. In the absence of acute infection, these secretions owe their viscidity mainly to the mucoprotein moiety. Deoxyribonucleoproteins occur in significant quantities only in purulent secretions. When the obstructing secretions are thick and tenacious or the cough is weak and ineffective, an agent which will liquefy the secretions will be extremely valuable. Various enzymatic agents and detergents have been used to liquefy the sputum and aid in its removal[2]. N-acetylcysteine was found to markedly reduce in vitro the viscosity of human sputum and tracheobronchial secretions[1].

Case 1

A 34 year old man presented to the orthopedics department with fracture and dislocation of sixth and seventh cervical vertebrae with quadriplegia following road traffic accident. Muscle power in the upper limbs were 4/5 and in the lower limbs 0/5 and sensory level was till C7 dermatome. He underwent operative reduction and internal fixation with bone grafting and anterior instrumentation of the cervical spine. The course of surgery was uneventful. At the end of surgery, trachea was extubated and patient shifted to postoperative ward. During his course in the ward he developed lower respiratory tract infection which later on led to severe respiratory distress. On eight postoperative day he required respiratory assistance for which endotracheal intubation was done. Later on he was shifted to intensive care unit for ventilation and further management. Though his ventilatory support was stepped down considerably it was not possible to withdraw it completely. A strict regime of chest physiotherapy with tracheal suctioning was followed. He produced copious mucopurulent expectoration requiring frequent tracheal suctioning and leading to intermittent decrease in oxygen saturation (91-93%) Tracheostomy was done on the sixteenth postoperative day to facilitate weaning from the ventilator and for tracheal toilet. Within 24 hours his ventilatory support was stepped down. He maintained on pressure support ventilation with pressure support of 5 mm of Hg and continuous positive airway pressure of 5 mm Hg on FiO_2 of 0.4. A day later he developed sudden decrease in oxygen saturation (100% to 85%). His hemodynamic parameters were unal-

tered. The patient felt distressed communicating difficulty in breathing. Chest physiotherapy and tracheal suctioning yielded minimal secretions. Examination of chest showed diminished movement on the left side and on auscultation no air entry was present. Nebulisation with 5 ml of normal saline was carried out for 5 minutes followed by chest physiotherapy and tracheal suctioning but produced no significant improvement. Subsequently his ventilatory supports were stepped up to synchronized intermittent mandatory ventilation mode with a rate of 15 breaths per minute on FiO_2 of 1.0. The oxygen saturation improved from 85% to 92%. It was suspected that the fall in saturation could be due to the presence of tenacious secretions leading to blockade of air entry into left lung. The patient was nebulised with 3 ml of 20% N-acetylcysteine for 10 minutes followed by intratracheal instillation of 2 ml via tracheostomy. Chest physiotherapy was done for two minutes and tracheal suctioning repeated which yielded about 20 ml of purulent secretions. Subsequently the air entry to the left side improved and oxygen saturation increased to 100%. Ventilatory support was decreased within next 4 hours to previous supports (pressure support ventilation with pressure support of 5 mm of Hg and continuous positive airway pressure of 5 mm Hg on FiO_2 of 0.4).

Case 2

A 75 year old man presented to orthopedics department with dislocation of fifth and sixth cervical vertebrae after fall from bed. Muscle power in the upper limb was 4/5 and in the lower limb 0/5 and sensory level was till C6 dermatome. He underwent anterior and posterior decompression and fixation of cervical spine. The intraoperative course was uneventful. In view of inadequate respiratory efforts following reversal of neuromuscular blockade and long duration of surgery (7 hours) he was shifted to the intensive care unit for ventilatory support and further management. He was weaned from ventilatory support within 24 hours and was extubated. Regular chest physiotherapy was performed and the patient was encouraged to cough out sputum. Due to the absence of effective cough reflex he was unable to clear his tracheobronchial secretions adequately. Within 24 hours after extubation he developed respiratory distress and oxygen saturation decreased (88%). Saline nebulisation was carried out and patient encouraged to cough. On examination of chest, the left side was not expanding with respiration and air entry on left was markedly decreased on auscultation. Chest roentogram revealed collapsed left upper lobe (figure 1). His oxygen saturation further deteriorated to 85%. Trachea was reintubated with aid of flexible fibreoptic bronchoscope and patient was placed on full ventilatory support. Fibreoptic bronch-oscopy revealed pooled tracheal secretions which where taken out by suction. Though the oxygen saturation marginally improved to 92% the findings on chest examination did not improve. Three ml of saline was instilled into trachea followed by chest physiotherapy. Endotracheal suction produced minimal secretions. Nebulisation followed by instillation of 3 ml of 20% N-acetylcysteine intratrachealy was done via the endotracheal tube. Endotracheal suction was done after 5 minutes which yielded about 20 – 30 ml of pooled purulent secretions.Subsequ-ently, the air entry on left side improved gradually. Chest roentogram repeated within an hour showed considerable improvement (figure 2).

Discussion-Spinal trauma can cause severe impairment of pulmonary function depending on level of injury to the spinal cord. Normal respiration involves active use of the intercostals muscles, the diaphragm and the abdominal muscles. Patients with level of injury above C4 vertebrae suffer permanent respiratory paralysis leading to complete ventilatory dependence. Injuries between C4 and T6 will leave the person able to breath on their own. However, because the intercostal muscles may be weakened or paralyzed depending on the level of injury, breathing may be solely carried out by the diaphragm. In general, the higher the level of injury the greater the respiratory compromise. The reported incidence of respiratory complications in cervical spinal cord injury patients vary with as high as 86% reported in a series[3]. As a consequence of paralysis of respiratory and other muscles, severely affected spinal cord injury patients are predisposed to

respiratory complications due to the presence of restrictive lung disease, ineffective or absent cough, atelectasis and chronic aspiration. Cough is a complex physiological reflex which protects the lung from inhalation of irritants and clears the airways of excess secretions and particulate matter. An effective cough consists of an inspiratory gasp, a compressive phase and an expulsive phase. The production of cough involves coordinated activity of all the groups of respiratory muscles. The intercostal muscles are actively involved in all the three phases. Spinal cord injury patients, especially those with higher level cord injury and paralysis of the intercostal and abdominal muscles, lack the ability to generate an effective cough[4]. Though the cough reflex sensitivity is preserved in these patients, the ineffective cough results primarily from the loss of innervation of respiratory muscles[5]. Impaired cough leads to inability to clear tracheobronchial secretions which become thick and purulent leading to atelectasis. Experimental atelectasis has been created in animals by artificial instillation of bronchial secretions and by pharmacological blunting of the cough reflex[6]. It has been shown that an adequate and effective cough can prevent atelectasis in these circumstances.

Case 1 was not able to create an adequate blast of air via tracheostomy. Cough was severely impaired in case 2 leading to pooling of secretions in the trachea. Effective cough or an adequate air blast via the tracheostomy is essential for expectorating out the tracheobronchial secretions. The absence of adequate cough in these two patients lead to mucus impaction and atelectasis. Rarely is this due to a central intraluminal bronchial plug that can be visualized bronchoscopically, rather, more typical is obstruction of multiple small bronchi and bronchioles due to impaired clearance of mucus[7]. Mortality among spinal cord injury patients most frequently follow repeated episodes of pneumonia, bronchial mucus plugging, atelectasis and respiratory failure[8]. Health and survival in these patients are strongly associated with meticulous and vigorous pulmonary hygiene. This can be brought about by routine secretion clearance with a strict regimen of chest physiotherapy and regular tracheal suctioning. Chest physiotherapy involves percussion and positioning for postural drainage. It cannot be performed in unstabilized spinal cord injury patients. In post operative patients following thoracotomy nebulised N-acetylcysteine has shown to reduce sputum viscosity, reduce difficulty in expectoration, increase weight of sputum expectorated and improved oxygen saturation compared to nebulised normal saline[9]. Our experience in these two patients shows that N-acetylcysteine can be extremely effective in these situations.

It acts by opening the disulfide bonds in mucoprotein through a specific sulfhydryl- disulfide interchange reaction, thereby effectively lowering the viscosity[10]. It has been shown that a vigorous regimen of tracheobroncheal toilet along with routine administration of mucolytic agent N-acetylcysteine helps in significant decrease in post operative atelectasis[7]. N-acetylcysteine effects a marked liquefaction within one minute, although the maximum effect is not gained for 5 to 10 minutes. The duration of action after a single endotracheal instillation is approximately 45 minutes[10]. Liquefied secretions are more easily removed by ciliary action or by cough. For this purpose it can be administered by various routes[2] – directly into tracheostomy, via intratracheal catheter or can be nebulised with air as oxygen inactivates N-acetylcysteine[11] or into endotracheal tube. Complications with endotracheal instillation or nebulisation of N-acetylcysteine has been minimal[2, 7]. It can produce bronchospasm in patients with previous history of bronchial hyperreactivity. Nausea has also been reported which has been attributed to its unpleasant sulfurous odor. No literature exists on the use of N-acetylcysteine for the treatment of pulmonary atelectasis produced in spinal cord injury patients due to inability to cough out secretions. These patients require life long assistance in tracheobronchial clearance of secretions. Although there are no specific recommendations regarding the frequency of use of N-acetylcysteine, it has been used as frequently as 2 ml intratrachealy every 2 hours with minimal complications[7]. N-acetylcysteine can provide these patients with a simple applied, reliable, safe and practical method for effective clearance of accumulated tracheobronchial secretions and

thus decreasing pulmonary morbidity and mortality.

Figure 1: During period of respiratory distress

Figure 2: After treatment with N-acetyl cysteine

References

1. Sheffner AL, Medler EM, Jacobs LW, Sarett HP. The in vitro reduction in viscosity of secretions by acetylcysteine. Am Rev Respir Dis 1964;90:721–729.

2. Webb WR. New mucolytic agents for sputum liquefaction. Postgrad Med 1964; 36: 449-53.

3. VanBuren RL, Wagner, FC Jr. Respiratory complications after cervical. spinal cord injury. Spine 1994; 19 (20): 2315-2320.

4. Wang AY, Jaeger JR, Yarkony GM, Turba RM: Cough in spinal cord injured patients: the relationship between motor level and peak expiratory flow. Spinal Cord 1997; 35: 299–302.

5. Dicpinigaitis PV, Grimm DR, Lesser M: Cough Reflex Sensitivity in Subjects with Cervical Spinal Cord Injury. Am. J. Respir. Crit. Care Med., 1999; 159(5):1660-1662.

6. Lee WE, Tucker G, Ravdin IS, Pendergrass EP.: Experimental. Atelectasis. Arch. Surg. 18:242.

7. Thomas PA, Lynch RE, Merrigan EH : Prevention of. postoperative pulmonary atelectasis. Review of 215 cases and. evaluation of acetylcysteine. Am Surg. 1966 May;32(5):301-7.

8. Jackson AB, Groomes TE. Incidence of respiratory complications following spinal cord injury. Arch Phys Med Rehabil 1994; 75: 270-275.

9. Gallon AM. Evaluation of nebulised acetylcysteine and normal saline in the treatment of sputum. retention following thoracotomy. Thorax 1996; 51(4):429-32.

10. Hurst GA, Shaw PB, LeMaistre CA. Laboratory and clinical evaluation of the mucolytic properties of acetylcysteine. Am. Rev Respir Dis 96:962-970.

11. Lawson D, Saggers BA: NAC and antibiotics in cystic fibrosis (letter). Br Med J 1965; 1:317.

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Gastrointestinal stromal tumor (GIST)

Gastrointestinal stromal tumor (GIST) are a rare tumor of the gastrointestinal tract (1-3 % of all gastrointestinal malignancies). The present case refers to a 70 years old female presenting with complaint of abdominal pain and sensation of fullness in the epigastric region. Imaging and histopathological diagnosis suggested gastric GIST with invasion into liver, pancreas and inferior vena cava.GIST are one of the most common mesenchymal tumors of the gastrointestinal tract, but they are rare in occurrence. They represent 3 % of all GI Tumors. Currently, GISTs are defined as GI tract mesenchymal tumors containing spindle or epitheloid cells that mark positive for Rf protein (CD 117)[1]. Recently some GISTs without the KIT mutation have been found to express a mutation in another tyrosine kinase receptor gene, the PDGFRa gene[2]. It is now believed that GISTs are from precursor GI cells that differentiate into the interstitial cells of Cajal[3]. We present a rare case of malignant gastric GIST with invasion into liver, pancreas and IVC.

A 70 years old female presented with complaint of abdominal

pain and a sensation of fullness in the epigastric region for last two months. The patient also reported a weight loss of 8 kg during previous 3 months. Upon examination, her vital signs were normal and upon examination, a questionable mass was felt is the abdomen because of dullness in epigastric region.Frontal supine radiograph of the abdomen was obtained which revealed diffuse soft tissue haze in central abdomen with displacement of bowel loops inferiorly (Figure 1). Utrasound abdomen revealed the presence of a 12 x 15 cm mass with solid and cystic components in retroperitoneum (posterior to stomach and involving liver, pancreas and inferior vena cava along with aortic encasement) causing gall bladder compression. Barium study revealed widened C-loop along with smooth extrinsic impression on greater curvature of stomach (Figure 2). CT scan of the abdomen with intravenous contrast showed a large solid and cystic mass that was suspected to originate in the antropyloric region along greater curvature of stomach with invasion into liver, pancreas and inferior vena cava (Figure 3-4). Patient underwent surgery, during which 15 cm gastric mass was removed. Histopathological examination of the mass was reported as follows 'plump to ovoid spindle cells are seen in loose clusters and scattered cells have a blunt ended nuclei with vascular chromatin and inconspicuous nucleoli. Few bizarre cells are seen. Stromal fragments with necrosis noted in smears with infrequent mitoses'

suggestive of gastrointestinal stromal tumor. Cells are positive for CD 117 and CD 34 and are negative for SMA and S100.
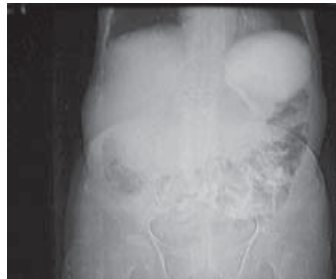

Fig 1 : Frontal supine radiograph of the abdomen showing diffuse soft tissue haze in central abdomen with displacement of bowel loops inferiorly
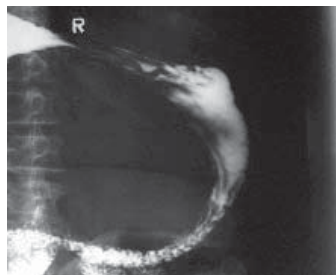

Fig 2 : Barium study showing widened C-loop along with smooth extrinsic impression on greater curvature of stomach

Fig 3 : CT scan of the abdomen showing a large solid and cystic mass along greater curvature of stomach
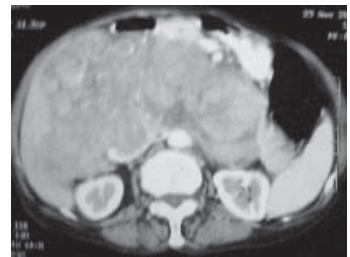

Fig 4: CT scan of the abdomen showing a large solid and cystic mass with invasion into liver, pancreas and inferior vena cava

Discussion

Mazur and clark first introduced the term GIST in 1983[4]. GIST are rare but nevertheless the most common mesenchymal neoplasms of the gastrointestinal tract. Majority of patients present in the fifth to seventh decade of life with male predominance (2:1). GIST are most common in stomach (60-70%) followed by the small intestine (20-30%), the colorectum (10%) and the oesophagus (< 5%). Cytologically , GISTs can be classified into two broad categories: Spindle Cell GISTs and Epitheloid GISTs. Although GISTs can differentiate along either of both cell types, some show no significant differentiation at all[5]. The number of mitotic figures present can be used to histologically grade GISTs. In general , GISTs with less than 1 mitotic figure per 50 high-power fields (HPFs) are correlated with benign behavior. A finding of 1-5 mitoses per 10 HPFs suggests potential malignancy. A finding of more than 5 per 10 HPFs indicates malignancy. Finding of more than 10 per 10 HPFs denotes high grade malignancy[6].Kit protein is the product of the c-kit proto-

oncogene located on chromosome 4 q 11-21. This protein is a tyrosine-kinase growth factor receptor present in 90% of GIST cells. The CD 117 protein is located in the cell membrane of all cells expressing the kit proto-oncogene[7]. Mutation of the kit proto-oncogene results in a CD117 receptor that is constantly stimulated without the presence of the stem cell growth factor. Some of the GISTs that lock the kit mutation appear to have mutations in another class III protein kinase gene that encodes the platelet derived growth factor[8]. Interstitial cells of Cajal are GI pacemaker cells that regulates intestinal motility and peristalsis. A relationship between GISTs and cajal cells have been proposed, because these are the only 2 intestinal entities to express both CD 34 and CD 117[3].GISTs may range in size from few millimeters to over 30 cm, however, size alone does not predict biological behavior with certainty. Most patients with malignant stromal tumors are symptomatic, the most common being abdominal mass closely followed by GI bleeding as a result of overlying mucosal ulceration and pain. The remainder of symptoms may include anorexia, dysphagia, obstruction, perforation or fever. The aim of imaging is to locate GIST lesion, evaluate local invasion, and detect distant metastasis. GISTs rarely spread to regional lymph nodes (<10 %). Rather malignancy is manifest by local invasion; distant metastasis most commonly involve liver (50-60 %) and peritoneum (21-43 %). Only 10 % of metastatic lesions occur in the lungs or bones[9].The

malignant potential of these tumors are best estimated by the simultaneous estimation of several clinical parameters such as size, location in the gut, invasion of the adjacent organ, mucosal invasion, degree of cellularity, cellular architecture, mitotic count, nuclear polymorphism, necrosis and proliferation rate[10]. Since within a tumor, there may be considerable hetrogeneity with respect to those features that separate benign tumors from malignant ones, thorough sampling for microscopic evaluation is essential, for precise diagnosis. A minimum of one tissue section per centimeters of tumor diameter is required. Most small GISTs (<5cms) with a low rate of mitoses (<5 during cells per 50 high-power fields) are benign and after surgery do not require adjuvant therapy. Larger GISTs (>5cms) and especially when the cell division rate is high (>6 mitoses per 50 HPF) may disseminate and / or recur. Recently, the c-kit tyrosine kinase inhibitor imatinib, a drug initially marketed for chronic myelogeneous leukemia, was found to be useful in treating GISTs, leading to a 40-70 % response rate in metastatic or inoperable cases. Patients who became refractory on imatnib may respond to the multiple tyrosine kinase inhibitor sunitnib[11].

References

1   Mieptnen M, Sarlome-Rikala M, Lasota J. Gastrointestinal Stromal tumors : Recent advances in understanding of their biology. Human Pathol. 1999; 30:1213- 1220.

2   Tamborini E, Bonodiman L, Greco a, et al. A new muta-

tion in the KIT ATP pocket causes acquired resistance to imatinib in a Gastrointestinal Stromal Tumor patient. Gastroenterology. 2004 July; 127(1): 294-9.

3   Sircor K, Hewlett BR, Huiringa JD, et al. Intestinal cells of Cajal as precursors of Gastrointestinal Stromal Tumors. Am J Surg Pathol. 1999 Apr; 23(4): 377-89.

4   Licht J, Weissmann L, Antman K. Gastrointestinal Sarcomas. Surg Oncol. 1988;15: 181-188.

5   Pidhorecky I, Cheney RT, Kraybill WG, Gibbs JF. Gastrointestinal Stromal Tumors: Current diagnosis, biologic behavior, and management. Am Surg Oncol. 2000 oct; 7(9): 705-12.

6   Pierie JP, Choudhary U, Muzipansky A. The effect of surgery and grade on outcome of Gastrointestinal Stromal tumors. Arch Surg 2001. Apr; 136(4): 383-9.

7   Miettinen M, Lasota J. Gastrointestinal Stromal Tumor- Definition, clinical, histological, immunohistochemical and molecular genetic features and differential diagnosis. Virchows Arch. 2001; 438(1): 1-12.

8   Heinrich MC, Blanke CD, Druker BJ, Corless CL. Inhibition of KIT tyrosine kinase activity: A novel molecular approach to the treatment of KIT-positive malignancies. J Clin oncol. 2002; 20: 1692-1703.

9   De Matteo RP, Lewis JJ, Lewg D, et al. Two hundred

gastrointestinal stromal tumors: recurrence patterns and prognostic factors for survival. Am Surg. 2000 (Jan); 231(1): 51-8.

10 Croonn KF, Perry CM. Imatinib Mesylate in the Treatment of Gastrointestinal Stromal Tumors. Drugs. 2003; 63(5): 513-22 discussion 523-4.

11 Demetri GD, Van ooosterom AT, et al. Efficacy and safety of sunitinib in patients with advanced gastrointestinal Stromal Tumor after failure of imatinib: a randomized controlled Trial. Lancet. 2006 Oct 14; 368(9544): 1329-38.

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Pain relief during labor

Music -Historical records reveal that the ancient Greeks played soothing instrumental music to women in labour. Music can have a relaxing effect in labour due to its ability to alter mood, reduce stress and promote positive thoughts. It can be used as a trigger for a breathing response or as a cue for relaxation. It may also be used as a distraction although this is a less effective use for music in labour. Music can be comforting not only for you, but also for your supporters

Heat and cold-Two further simple ways of easing pain and assisting relaxation during labour are through the application of heat and cold. They provide a source of counter-stimulation.Heat can be applied in several ways:

- by taking a hot shower or bath
- via a hot water bottle or hot wet towel over the abdomen
- by applying a hot compress over the perineum

Instead of applying heat to the skin, some women find that cold is more soothing. A cool, damp face-cloth is always refreshing, while an ice pack can easily be applied to the lower back.

Imagery -Creative mental activity, known as imagery, can also be used to encourage relaxation and help women manage their pain during labour. Many people use imagery in everyday situations. For example, when we feel hungry we can often 'see' (visual imagery) and 'taste' (taste imagery) an imagined meal in front of us - even to the extent of making our mouths water. The word imagery (or visualisation) implies that only the visual sense is used. However, all senses (vision, touch, hearing, taste and smell) can be included in this mental activity.

Rhythmical movements-Many women find that rhythmical movement helps to ease pain during labour. This is not surprising because the movement is a common response in other painful circumstances. Likewise, during labour, many women instinctively have a strong urge to be active. Movement provides a source of counter-stimulation and may stimulate the release of endorphins within the nervous system. For example, rocking the pelvis backwards and forwards during contractions is often found to be soothing. This can be performed while standing, sitting, kneeling, lying down or on hands and knees.Other rhythmical movements include tapping your fingers, rubbing your abdomen, breathing rhythmically and stamping your feet. Some women find it helps to count, sing, shout or howl at the same time!. Whichever manoeuvre appeals to you, the action should be rhythmical and repetitive, and make you feel better.

TENS-Transcutaneous Electrical Nerve Stimulation (TENS) provides yet another form of counter-stimulation and has been used for several years in the management of postoperative and cancer pain. It has been postulated that TENS helps to relieve pain by stimulating the release of endorphins. The TENS equipment consists of a small, battery driven pulse generator, connected to one or two pairs of electrodes which are attached to the skin with adhesive tape. When it is turned on, the TENS machine causes a tingling sensation underneath the electrodes - the strength of which can be adjusted at the generator controls. TENS is most useful during labour in helping to relieve pain. Conse-

quently, the electrodes are usually placed on each side of the lower spine. A back-ground stimulation is set and the hand control unit is used to increase the intensity of the current during a contraction. In order to be of benefit, it is necessary to turn the control to a setting which is 'almost painful'. The most effective time to begin using TENS is early in labour before the pain becomes too intense. TENS is non-invasive and simple to use. It does not have any side effects (apart from irritating the skin) and is controlled by the mother herself. TENS is also portable and does not interfere with the mother's ability to move around. (Sometimes, TENS can interfere with the signal from an electronic fetal monitor. In this event, TENS may have to be abandoned). Women differ considerably in their opinions about the effectiveness of TENS in labour. In practice, additional analgesia is often needed - although it is possible that drug dose requirements may be less with the aid of TENS. Not everyone finds TENS effective and some dislike the tingling sensation.

Massage-Touch has been associated with the power of healing since the beginning of civilisation. During labour, many women find comfort through being touched, stroked and massaged. touch reinforces the fact that someone cares for you and that you are not alone. Moreover, by providing a source of counter-stimulation touch and massage can sooth pain. Therapeutic massage (eg: shiatsu) has been recommended as a means of preventing and treating many of the ailments associated with pregnancy and as a means of easing the pain of labour. Perineal massage (the area between the vagina and anus) during the last six weeks of pregnancy may reduces tearing or the need for an episiotomy during delivery. Touch and massage can be provided in several ways:

• lightly stroking the abdomen;

• vigorously firm stroking where it hurts most;

• firm circular massage using the palm of the hand over the centre of the back or sacrum. This is most useful when the pain is being felt mainly in the back;

• rhythmical squeezing and letting go of the shoulder muscle;

• a long stroke down the length of the back, buttocks and down the back of the legs; stroking across the forehead, down the neck and down the arms;

• simply holding hands!

Shiatsu- Shiatsu is a Japanese form of therapeutic massage. Shiatsu means 'finger pressure'. The basis and application of Shiatsu is similar to that of acupuncture. For example, when using shiatsu to relieve labour pain, pain-relieving pressure points ('tsubo') are stimulated which are similar to pressure points used in acupuncture *but without the use of needles.*

Uses of LMA in Present Day Anaesthesia

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Recent Advances

Many new supraglottic airway devices have been introduced and include airways with and without sealing characteristics. These can be further subdivided into two main groupsnamely single-use versus reusable and whether the device offers protection from aspiration of gastric contents. [1] The first supraglottic airway device - the laryngeal mask airway (LMA)[2] was conceived and designed in 1981 by Dr. Archie Brain of the United Kingdom. The important steps in the development of the LMA and its variants are:

- First made commercially available in 1988 and was approved by the FDA for use in USA in 1991

- Flexible LMA released in 1992

- Approved for resuscitation by Japanese ministry in 1992 and by European Resuscitation Council in 1996

- Included in the difficult airway algorithm in 1993 and its role modified by Benumof in 1996

- Intubating LMA released in 1997

- Disposable LMA released in 1998

- American Heart Association approval for its role in resuscitation in 2000

- ProSeal LMA introduced by Archie Brain in 2000

- LMA CTrach introduced in April 2005

- ProSeal LMA Supreme introduce recently

The LMA family-This includes the classic LMA (cLMA), the flexible LMA, the intubating LMA (ILMA), the disposable LMA (LMA Unique), the ProSeal LMA (PLMA) and the LMA CTrach. Successful use of the LMA does not need the many prerequisites necessary for direct laryngoscopy and tracheal intubation. These supraglottic devices have become increasingly popular as more and more anaesthesiologists favour their use for airway management during elective anaesthetics and difficult airway situations as well as in emergency situations for the following reasons[3]:

- There is decreased resistance in the patient's upper airway in comparison with the endotracheal tube

- There is minimal haemodynamic instability during placement as infraglottic structures are not

- stimulated

- No translocation of oral/nasal bacterial colonies and secretions into the lower respiratory tract as is

- possible while performing endotracheal intubation

- Inadvertent bronchial intubation is totally avoided

- Ease of insertion and smooth awakening

Fig 1. LMA Family

Classic LMA (cLMA)- The first member of the LMA family, earlier known as the standard LMA fills a niche between the face mask (FM) and tracheal tube (TT) in terms of both anatomical position and degree of invasiveness. It is manufactured from medical grade silicone rubber and is reusable. The cLMA represents the salient features of the LMA family. It consists of three main components: an airway tube, inflatable mask and mask inflation line. The airway tube is slightly curved to match the oropharyngeal anatomy, semi rigid to facilitate atraumatic insertion and semitransparent so that condensation and regurgitated material is visible. A black line runs longitudinally along its posterior curvature to aid in orientation. The distal aperture of the airway tube opens into the lumen of an inflatable mask and is protected by

two flexible vertical rubber bars, called mask aperture bars (MAB), to prevent the epiglottis from entering and obstructing the airway. The inner aspect of the mask is called the bowl, which is comprised of the distal aperture, mask aperture bars, back plate and the inner aspect of the inflatable cuff. The mask inflation line, which is attached to the most proximal portion of the cuff in the midline consists of four parts, the long narrow inflation line itself, the inflation indicator balloon (pilot balloon), a metallic valve and the syringe port. The valve, which has a white coloured core is made from polypropylene and has a stainless steel spring valve. The safety record is good for elective surgery. Positive pressure ventilation is readily accomplished with the cLMA.[2] In the cLMA the glottic seal is usually lost at peak airway pressures above 20 cm H2O. Though the correctly positioned cLMA offers some protection against aspiration, the incidence of aspiration with the LMA in fasted patients is 0.012%.[4,5] It is available in eight sizes, neonates to large adults (1, 1.5, 2, 2.5, 3, 4, 5, 6).
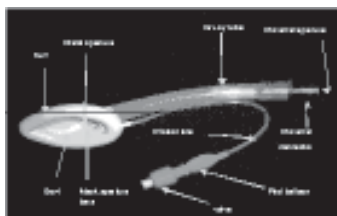
Flexible Laryngeal mask airway (LMA-Flexible)[4] -The Flexible (reinforced) LMA was released in1992 following reports of kinking of LMA tube in Anaesthesia in 1990. It is made from medical grade silicone and rubber and is reusable. It consists of a classic LMA cuff connected to a flexible wire reinforced tube which is longer and narrower than the airway tube of the cLMA. Though the diameter of the oral tube of the Flexible LMA is narrower than that of the cLMA, it is comparable to a tracheal tube thus making it practical for intraoral surgeries especially adenotonsillectomy. The extra length ensures that the anaesthesiologist can be away from the surgical field. It is available in six sizes (2, 2.5, 3, 4, 5, 6).
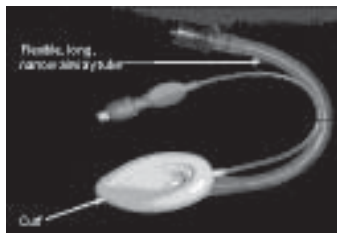

Fig 3. LMA-Flexible

LMA Unique [4]- The disposable LMA or the LMA-Unique was released in 1998 for cardiopulmonary resuscitation because the silicone based cLMA was costly and needed proper sterilization to prevent cross infection. The disposable LMA is constructed from clear medical-grade polyvinyl chloride, other than the stainless steel spring valve. It is supplied sterile, and cannot withstand autoclaving without losing structural integrity. It is meant for single use in the field or out of box situations. The dimensions, shape, and intersize scaling are identical to the cLMA, but the tube is more rigid and the cuff thicker. The disposable LMA is currently available in size 3-5. In August 2000, the design was altered to make the backplate and airway tube softer, but the cuff was unchanged.

Fig 4. LMA Unique

The Intubating LMA (ILMA) [4,6,7]-The intubating LMA-Fastrach is especially designed to aid blind tracheal intubation and it consists of three parts-the ILMA itself, the tracheal tube and a stabilizing rod. The ILMA is a rigid, anatomically curved airway tube made of stainless steel with a standard 15 mm connector. The tube is wide enough to accommodate an 8.0 ETT and short enough to ensure passage of the ETT beyond the vocal cords. A rigid handle attached to the tube facilitates one-handed insertion, removal, and most importantly, adjustment of the device's position so that the aperture directly opposes the larynx. The mask aperture bars of the cLMA are replaced here by a single flap, the epiglottic elevating bar of the ILMA. It has been used for routine intubation, rescue intubation, and intubation of the difficult airway patient after the induction of anesthesia or in the awake state.[5] The ILMA is available in adult sizes only (3,4,5) that correspond

to the cuff size of the original LMA. The disposable versions will also be available in future. A dedicated tracheal tube was developed with the following features:

- a soft hemispherical bevel with a leading edge in the midline and providing it with appropriate markings.
- a pilot balloon inflation line that is housed within the wall of the tube
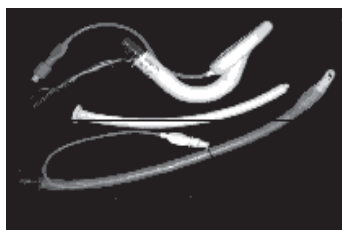- a detachable proximal connector

Fig 5. Intubating LMA

The ProSeal LMA (PLMA)[4,8,9]- The ProSeal LMA is the most complex of the specialized masks of the LMA family. It is made from medical grade silicone and has the following new features. It has two cuffs; dorsal and ventral and two tubes; an airway and a drain tube. The drain tube provides a bypass channel for regurgitated gastric contents and helps in detecting malpositions of the mask. The flat dorsal component of the cuff of PLMA is designed to press the ventral elliptical cuff more firmly into the periglottic tissues and a wedge shaped proximal component designed to plug gaps in the proximal pharynx. The laryngeal cuff of the PLMA is made of softer silicone than that of the cLMA. It covers the

posterior aspect of the bowl of the mask and presses the bowl forwards when inflated. Increased depth of the bowl is designed to improve the seal with the larynx. It is available in paediatric as well as adult sizes (1.5, 2, 2.5,3,4, 5). Recently PLMA Supreme, a disposable version has been introduce.
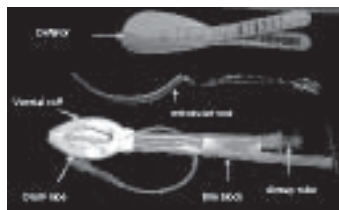

Fig 6. ProSeal LMA

LMA CTrach [10]-The LMA CTrach is a modified LMA Fastrach with integrated fibreoptics. It is designed to increase the success rate of ventilation and tracheal intubation with the ILMA and is the most recent addition to the LMA family. It allows real time visualization of the cord structures as the tracheal tube enters the trachea. It has a lens behind the epiglottic elevator which captures the image from in front of the mask aperture which is transmitted to a detachable digital screen with a light source and a digital camera. Technical alterations have been made in the model released in Dec 2005.

Fig 7. LMA CTrach

Uses of the LMA-The LMA has been used for a wide range of procedures and is now used in more than 23% of all general anesthetics administered in the United States.[11] It is mostly used for short cases, making it especially valuable for outpatient surgery. It has proved useful in patients requiring multiple anaesthetics over a short period of time. The maximum duration for which the LMA can be safely used is not yet known. It has been used for surgical procedures lasting up to 8 hours. It has been used in the ICU to provide respiratory support for 10-24 hours with no apparent problems. Contraindications [4, 12,13]- Mouth opening less than 1.5 cm for the cLMA and Flexible LMA; and 2 cm for ILMA and PLMA; Non fasting patients and patients at increased risk of aspiration (previous gastric surgery, gastroesophageal reflux, obesity, diabetic gastroparesis)[2]. Patients with poor lung compliance requiring airway pressures of more than 20 cm H_2O.

Routine & Emergency anaesthesia

In the operating room & Outside the Box-Indications for use include routine, elective cases where tracheal intubation is not required or is required only because the surgery interferes with maintenance of the airway with a face mask. Different types of LMAs are available for different situations. The Flexible LMA with a reinforced airway tube is used for ENT/ophthalmic/head and neck/dental procedures. The PLMA has been especially designed for

PPV and to protect against aspiration. It is being used for elective procedures of long duration in varying positions including lateral, lithotomy and prone positions and also for gynecological laparoscopy and laparoscopic cholecystectomies in increasing number.

The LMA has been used for following surgeries

Ear nose & throat surgery-The use of the laryngeal mask airway in otolaryngologic surgery has been extended to procedures such as adenotonsillectomy, uvulopalatopharyngoplasty, middle ear surgery and laser pharyngoplasty. The flexible LMA is a valuable tool for otolaryngologic and maxillofacial surgery. Cautious use increases patient safety, reduces intra and postoperative morbidity and helps to avoid problems accompanying tracheal intubation and sedation.[14]

General Surgery-The cLMA is very popular for short general surgical procedures apart from anorectal, pilonidal, breast and abdominal surgeries which pose special problems of their own. The patients might be placed in lithotomy or prone positions, the airway might be too close to the surgical field or positive pressure ventilation will be required in addition to the danger of regurgitation and aspiration. Specialised LMAs viz. flexible LMA or PLMA may be more apt in these circumstances. The LMA has a special role in thyroid/parathyroid/thymic surgeries. The LMA has been used for surgery on the thyroid as its cuff displaces the gland anteriorly,

facilitating surgical access.[4] Because damage to the recurrent laryngeal nerve is a complication of thyroid surgery, it may be desirable to stimulate that nerve during surgery and observe the motion of the vocal cords by inserting a fiberscope through the LMA.[4] Tracheal deviation and narrowing should be considered relative contraindications to use of the LMA in thyroid surgery. Majority of us feel that tracheal intubation is essential in all these procedures but the exchange of the tracheal tube for an LMA at a deeper plane of anaesthesia can be of help in assessing the vocal cord movements or ruling out tracheomalacia in a patient with a large goiter with the help of a fibreoptic scope at the end of surgery.[4]

Laparoscopy [4]-Use of the LMA for laparoscopic procedures is controversial. Studies suggest that the LMA is safe for gynecologic laparoscopy. However, there have been reports of aspiration in patients undergoing laparoscopy and upper abdominal surgery with the LMA. The PLMA has a special role here. The author (unpublished data) has successfully conducted more than thousand cases of laparoscopic procedures with this device.

Special situations

Transportation-Restricted access, constant movement and noise make airway management during transportation potentially difficult. There is sufficient literature support where the LMA was used for transportation especially in the emergency scenario. It has been used during

helicopter transfer of patients with cervical spine injury and those trapped in positions which do not lend themselves to tracheal intubation. Paramedics and respiratory therapist acquire skill more rapidly and have a higher rate of successful placement with the LMA than a tracheal tube.

Microgravity-Microgravity means small or reduced gravity. It is a term commonly applied to a condition of free-fall within a gravitational field in which the weight of an object is reduced compared to its weight at rest on earth. There may be increased risk of hypoxic cardiorespiratory arrest, aspiration of foreign bodies, and burns during spaceflight or at microgravity. There is great difficulty in performing simple acts without the use of restraints. In such a scenario, laryngoscopy would be difficult without body restraints. Success rate of LMA placement even without body restraints is higher as compared to laryngoscope guided tracheal intubation.[15]

Remote Anesthesia Provider-The anaesthesiologist is away from the patient undergoing diagnostic imaging and radiotherapy procedures. This patient can often be managed using a LMA. The reinforced LMA or the PLMA may be useful in situations that require the patient to be placed in an awkward position. The ferromagnetic material present in LMA well can reduce image quality and even cause heating and movement when used in MRI, thus posing special problem. Therefore, it may be necessary to remove the valve and knot the pilot tube. Special

LMAs with valves that do not contain ferrous material are available.

Difficult airway & role of the LMA in ASA Difficult Airway Algorithm[16,17]

The LMA devices have been successfully used in patients with difficult airway due to fixed neck, limited mouth opening, obesity, laryngeal stenosis, acromegaly, obesity, pneumocephalus and patients with airway distortion secondary to tumour, facial injuries, congenital problems, upper airway obstruction secondary to residual neuromuscular blockade, poor mobility of the neck or cervical instability. A cLMA can usually be inserted successfully with mouth opening to an interdental distance of at least 15 mm in an adult patient. Its use should be considered prior to using transtracheal ventilation or establishing a surgical airway. The LMA found a place in the emergency airway management limb of the ASA difficult airway algorithm in 1993. However its role was revised by Professor Jonathan Benumof in 1996, and included the LMA at five places. As a ventilatory device at two points; As an airway intubator at three points. Three new LMAs (ILMA, PLMA and the LMA CTrach) have been added since then and it is time that we have a fresh look at the role of LMA in difficult airway algorithm especially in the emergent obstetric scenario.

Failed intubation[17-22] -Problems with tracheal intubation were the most frequent cause of anaesthetic death in the published analyses of records of the UK medical defence societies.[18,19] The laryngeal mask airway is included in the algorithms for unexpected failed intubation published and promoted by the airway societies of the US and Canada.[17,20] The PLMA has been reported as a rescue device after failed intubation during rapid-sequence induction.[23,24]

Coexisting disease-The ProSeal LMA is suitable for patients with a similar range of coexisting disease which can be managed with a cLMA, but the improved seal allows its use in patients with diseases that cause a reduction in pulmonary compliance, and the drain tube allows its use in patients with some increased risk of regurgitation. The PLMA has been successfully used in obese patients as a temporary airway prior to tracheal intubation, for gynecological laparoscopy and for laparoscopic cholecystectomy.

Intensive Care Unit (ICU)-The routine use of the cLMA in the ICU is restricted because high airway pressures cannot be reliably generated and the lungs cannot be unfailingly protected from regurgitated gastric contents. These devices have been used as airway rescue and for providing short term ventilation in percutaneous tracheostomy, percutaneous Cricothyrotomy and laryngotracheobronchoscopy.[25,26] The ProSeal LMA has been used for postoperative respiratory support in a patient with HELLP syndrome after its use in failed obstetric intubation. [24]

Monitoring [27-31] -The LMA provides valuable information about respiratory, cardiovascular and upper gastrointestinal tract physiology. Monitoring equipment can be attached to different parts of the LMA and its variants as shown in the following table1:

measurement of EtC_{O2} and various respiratory parameters such as tidal volume, minute volume, recuperative rate, compliance and resistance of the lungs with the

Table 1	
Possible monitoring with an LMA	
Airway tube	Capnography end-tidal CO2
	Respiratory mechanics
	Laryngeal muscle activity
	Oesophageal function
Dorsal and ventral surfaces of the cuff	Pharyngeal SpO2
	pH of secretions
Pilot balloon	Intracuff pressure
Drain tube	Gastric pH, volume
	Cardiac output
	Core temperature

help of capnometer or respiratory module attached to it. A fiberoptic scope through the airway tube allows laryngeal muscle activity and oesophageal function to be assessed. The dorsal and ventral surfaces of cuff allow pharyngeal pulse oximetry and pH of the secretion to be evaluated. The pilot balloon allows measurement of intracuff pressure which may vary during course of anaesthesia. The drain

tube allows insertion of a gastric tube, temperature probe, a Doppler and fiberscope thereby facilitating measurement of gastric volume, pH, core temperature, cardiac output and oesophageal function.

Cardiopulmonary resuscitation (CPR)-The LMA offers the advantages of an easier and quicker access to the airway in comparison to tracheal intubation by the doctors as well as the paramedics and has been used for paediatric as well as adult population. Almost all published data about the use of the LMA for resuscitation in children concern the neonatal subpopulation. Therefore, the LMA. may be utilized depending on the situation at the time of the cardiac arrest. In Neonatal Resuscitation, the LMA. airway is an alternative in the .cannot intubate, cannot ventilate. situation.[32] In adult Basic Life Support (BLS), the LMA. (Classic, Unique) is recommended as an alternative airway device to the bag-mask.

Cost effectiveness-Though the initial cost of an LMA may be higher than a face mask or a tracheal tube its use has been found to be cost effective in and outside the operating room. The main economic benefits are: the increased case turnover, decreased requirement of anaesthetic agent for the maintenance of anaesthesia and indirect cost saving by reducing the risk of an adverse outcome in the .failed intubation, failed face mask ventilation. scenario.

Educational considerations-A survey of American anesthesia residency programs in 2003 about difficult airway rotation training programs found that 33% had a difficult airway rotation, and of these 100% were provided training with the classic LMA, and 72% with the intubating LMA.[33] Because the development of skills requires practice, many anaesthesiology residency training programs, both national and international have developed an airway rotation to maximize exposure to different devices and techniques.[34]

Complications-With appropriate selection of patients, proper anaesthetic technique, training and periodic examination of equipment, problems arising from LMA use are rare. Reported problems include aspiration of gastric or pharyngeal contents, stimulation of pharyngolaryngeal reflexes, trauma to pharyngeal structures, compression of neurovascular elements in the neck and fragmentation or herniation of the LMA itself.[35-37] To date very few deaths directly attributable to the use of LMA have been reported.[38,39]

Conclusion -This family of airway devices has proven to be safe for patients not requiring endotracheal intubation but who are not at increased risk of gastric regurgitation. Their use can be occasionally life-saving in the management of airways of patients who are unexpectedly difficult to ventilate and/or intubate. Therefore these devices have a role in airway management during anaesthesia as well as airway rescue for prehospital emergency airway management.

References:

1. Miller DM. A Proposed Classification and Scoring System for Supraglottic Sealing Airways: A Brief Review. *Anesth Analg* 2004; **99:** 1553-9

2. Brain AIJ. The laryngeal mask.a new concept in airway management. Br J Anaesth 1983; 55: 801.5.

3. Brimacombe J. The advantages of the LMA over the tracheal tube or face mask: a meta-analysis. Can J Anaesth 1995; 42: 1017-23.

4. Brimacombe J. Laryngeal Mask Anesthesia. Principle and Practice. London: WB Saunders, 2005.

5. Brimacombe J, Berry A. The incidence of aspiration associated with the laryngeal mask airway . a metaanalysis of published literature. J Clin Anesth 1995; 7: 297-305.

6. Brain Al, Verghese C, Addy EV, Kapila A. The intubating laryngeal mask. I. Development of a new device for intubation of the trachea. Br J Anaesth 1997; 79:699-703.

7. Moller F,Andres AH, Langenstein H. Intubating laryngeal mask airway (ILMA) seems to be an ideal device for blind intubation in case of immobile spine. Br J Anaesth 2000; 85: 493-5.

8. Brimacombe J, Keller C. The ProSeal laryngeal mask airway. A randomized, crossover study with the standard laryn-

geal mask airway in paralyzed, anesthetized patients. Anesthesiology 2000; 93:104-9.

9. Keller C, Brimacombe J, Kleinsasser A, Loeckinger A. Does the ProSeal laryngeal mask airway prevent aspiration of regurgitated fluid? Anesth Analg 2000; 91: 1017-20.

10. Timmermann A. Russo S. and Graf B.M. Evaluation of the CTrach- an intubating LMA with integrated fibreoptic system. Br J Anaesth 2006;96: 516-21.

11. Rosenblatt WH, Ovassapian A, Eige S, et al: Use of the laryngeal mask airway in the United States: a randomized survey of ASA members. ASA annual meeting, Orlando, Florida, October 1998.

12. Rasanen J. The Laryngeal Mask Airway . First Class on Difficult Airways. Finnanest 2000; 33: 302-5.

13. Rosenblatt WH. Airway Management. In: Barash PG, Cullen BF, Stoelting RK.(eds) Clinical Anesthesia (4th Edn) 2001; 23: 599 . 605.

14. Williams PJ, Bailey PM: Comparison of the reinforced laryngeal mask airway and the tracheal intubation for adenotonsillectomy. Br J Anaesth 1993;70:30.3.

15. Keller C, Brimacombe J, Giampalmo M, et al. Airway management during spaceflight: a comparison of four airway devices in simulated microgravity.Anesthesiology 2000;92: 1237- 41.

16. Practice Guidelines for Management of the Difficult Airway: A report by the American Society of Anesthesiologist Task Force on Management of Difficult Airway. Anesthesiology 1993;78:597-602.

17. Benumof J L. The laryngeal mask airway and the ASA difficult airway algorithm. Anesthesiology 1996; 84:686-99.

18. Utting JE. Pitfalls in anaesthetic practice. Anaesthesia 1987; 59: 877- 90.

19. Gannon K. Mortality associated with anaesthesia. A case review study. Anaesthesia 1991; 46: 962-6.

20. Crosby ET, Cooper RM, Douglas MJ, et al. The unanticipated difficult airway with recommendations for management. Can J Anaesth 1998; 45: 757.76.

21. Morris J, Cook TM. National survey of rapid sequence induction. Anaesthesia 2001; 56: 1090.7.

22. Gataure PS, and Hughes JA. The laryngeal mask airway in obstetrical anaesthesia. Can J Anaesth 1995;42(2): 130-3.

23. Awan R, Nolan J, Cook TM. Use of the ProSeal LMA for airway maintenance during emergency Caesarean section after failed intubation. Br J Anaesth 2004;92: 144-6.

24. Keller C, Brimacombe J, Lirk P, Puhringer F. Failed Obstetric Tracheal Intubation and Postoperative Respiratory Support with the ProSealTM Laryngeal Mask Airway. Anesth Analg 2004; 98: 1467-70.

25. Nixon T, Brimacombe J, P.Goldrick P, McManus S.Airway Rescue with the ProSeal TM Laryngeal Mask Airway in the Intensive Care Unit. Anaesth Intensive Care 2003; 31:475-6.

26. Verghese C, Rangassami, J, Kapila A, Parke T. Airway control during percutaneous dilatational tracheostomy: pilot study with the intubating laryngeal mask airway.Br J Anaesth 1998; 81: 608-9.

27. Brimacombe J, Keller C. Successful pharyngeal pulse oximetry in low perfusion states. Can J Anesth 2000;47: 907-9.

28. Ozlu O, Ocal T. Comparison of endtidal CO2 and arterial blood gas analysis in paediatric patients undergoing controlled ventilation with a laryngeal mask airway or a face mask. Paed Anaesth 1999; 9:409-13.

29. Matsukawa T, Goto T, Ozaki M, Sessler DI, and Kumazawa T. Core temperature monitoring with new ventilatory devices. Anesth Analg 2003; 96: 1688-91.

30. Girling KJ, Spendlove JL, Quarishi MS, Mahajan RP. Video imaging to assess neuromuscular blockade at the larynx. Anesth Analg 2001; 92: 149-53.

31. Bapat P, Verghese C. Laryngeal mask airway and the incidence of regurgitation dur-

ing gynecologi callaparo-scopies. Anesth Analg 1997; 85: 139-43.

32. Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular care. Part 11: neonatal resuscitation. The American Heart Association in collaboration with the International Liaison Committee on Resuscitation. Circulation 2000; 102:1343-57.

33. Hagberg CA, Greger J, Chelly JE, Saad-Eddin HE.Instruction of airway management skills during anesthesiology residency training. J Clin Anesth 2003;15: 149-53.

34. American Society of Anesthesiologists Task Force on management of the Difficult Airway. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on management of the Difficult airway. Anesthesiology 2003; 98: 1269-77.

35. Sideras G, Hunter JM. Is it safe to artificially ventilate a paralysed patient through the laryngeal mask? The jury is still out. Br J Anaesth 2001; 86: 749.53.

36. Brimacombe J, Clarke G, Keller C. Lingual nerve injury associated with the ProSeal laryngeal mask airway: a case report and review of literature. Br. J.Anaesth.2005; 95: 420-3.

37. Colbert SA, O.Hanlon DM, Page R, Moriarty DC. The laryngeal mask airway reduces blood flow in the common carotid artery bulb. Can J Anaesth 1998; 45:23-7.

38. Keller C, Brimacombe J, Bittersohl J, Lirk P and Goedecke A V. Aspiration and the laryngeal mask airway: three cases and a review of the literature. Br J Anaesthesia 2004; 93: 579-82.

39. Cook and Gande. Aspiration and death associated with the use of the laryngeal mask airway. *Br J Anaesth* 2005; 95: 425-6.

Anaesthetic machine

An anaesthetic machine
The anaesthetic machine is used by anaesthetists to support the administration of anaesthesia. The most common type of anaesthetic machine in use in the developed world is the continuous-flow anaesthetic machine, which is designed to provide an accurate and continuous supply of medical gases (such as oxygen and nitrous oxide), mixed with an accurate concentration of anaesthetic vapour (such as isoflurane), and deliver this to the patient at a safe pressure and flow. Modern machines incorporate a ventilator, suction unit, and patient-monitoring devices. The original concept was invented by the British anaesthetist H.E.G. Boyle in 1917. Prior to this time, anaesthetists often carried all their equipment with them, but the development of heavy, bulky cylinder storage and increasingly elaborate airway equipment meant that this was no longer practical for most circumstances. The anaesthetic machine is usually mounted on wheels for convenient transportation.Simpler anaesthetic apparatus may be used in special circumstances, such as the TriService Apparatus, a simplified anaesthesia delivery system invented for the British armed forces, which is light, portable and may be used effectively even when no medical gases are available. Many of the early innovations in U.S. anaesthetic equipment, including the closed circuit carbon-dioxide absorber (aka: the Guedel-

Foregger Midget) and diffusion of such equipment to anaesthetists within the United States can be attributed to Dr. Richard von Foregger and The Foregger Company.

Components of a typical machine

A modern machine typically includes the following components:

- connections to piped hospital oxygen, medical air, and nitrous oxide. Pipeline pressure from the hospital medical gas system (wall outlet) should be around 400 kPa (60 psi; 4 atmospheres).

- reserve gas cylinders of oxygen, air, and nitrous oxide attached via a specific yoke with a Bodok seal. Older machines may have cylinder yokes and flow meters for carbon dioxide and cyclopropane. Many newer machines only have oxygen reserve cylinders. The regulators for the cylinders are set at 300 kPa (45 psi; 3 atmospheres). If the cylinders are left on and the machine is plugged into the wall outlet, gas from the wall supply will be used preferentially, since it is at a higher pressure. In situations where pipeline gases are not available, machines may safely be used from cylinders alone, provided fresh cylinders are available.

- a high-flow oxygen flush which provides pure oxygen at 30 litres/minute

- pressure gauges and regulators to protect the machine components and patient from high-pressure gases

- flow meters (rotameters) for oxygen, air, and nitrous oxide, which are used by the anaesthetist to provide accurate mixtures of medical gases to the patient. Flow meters are typically pneumatic, but increasingly electromagnetic digital flow meters are being used.

- one or more anaesthetic vaporisers to accurately add volatile anaesthetics to the fresh gas flow

- a ventilator

- physiological monitors to monitor the patient's heart rate, ECG, blood pressure and oxygen saturation (additional monitors are generally available to monitor temperature, arterial blood pressure central venous pressure, etc.). In addition, the composition of the gases delivered to the patient (and breathed out) is monitored continuously.

- breathing circuits, most commonly a circle attachment

- a heat and moisture exchanger (HME)

- scavenging system to remove expired anaesthetic gases from the operating room. Scavenged gases are usually vented to the atmosphere.

- suction apparatus

There is generally a small work bench built into the machine where airway management equipment is kept within ready reach of the anaesthetist.

Anesthesia for Robotic Surgery

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Use of robots in surgery is an exciting recent technology that has certainly influenced the anaesthesiologists. Accomplish-ment of a number of surgeries with help of robots has made medical fraternity aware of some of the associated possible benefits. However, whether this promising technology goes for in getting regarded as a routine in operation theatres, still remains to be seen. 'Robot' term was coined by Czech playright Korel Capek in his play Rossom's Universal Robots[1]. Robot is taken from the Czech 'Robota', meaning forced labor. At present, these robots have been evolved to a great extent and are providing help to mankind in various disciplines including medicine. The history of robotics in surgery begins with PUMA 560, a robot used in 1985 by Kwah et al to perform neurosurgical biopsies with greater precision[2]. Davies et al in 1988 performed transuretheral resection of prostate using same robot[3]. While Probot, a robot specifically designed for TURP, was being developed, Integrated Surgical Supplies Ltd. of Sacra Monto,CA,USA, was developing ROBODOC, a system designed to machine femur with greater precision in the hip replacement surgeries[1]. ROBODOC was first surgical Robot approved by FDA. Robots were then developed by army soldiers with goal of decreasing war time mortality by allowing surgeon to reach wounded soldiers through teleconferencing. AESOP (Automated Endoscopic System for Optimal Positioning) employs a robotic arm guided camera controlled by the surgeon voice commands.

This was followed by development of SRI (Stanford Research Institute) Green Telepresence Surgery System, that underwent extensive redesign and reintroduction as Da Vinci system (Intuitive Surgical System of Mount View, CA). Da Vinci System is a telemanipulator system that offers a 3 dimensional image and 7 degrees of freedom allowing surgeons improved visualization and better control. It has 3 components - a vision cart that holds a dual light source and dual 3 chip cameras, a master console, where operating surgeon acts and a moveable cart, where 2 instrument arms and camera arms are mounted (Figure1). One year later, Zeus System was put into production by Computer Motion[1,4]. Zues System is composed of a surgeon control console and 3 table mounted Robotic arms. The right and left arms simulate arms of surgeons and the third arm is an AESOP voice controlled Robotic endoscope for visualization. Robotic surgery offers added advantage over conventional techniques, of improved 3D (three dimensional) visualization and better control and precision because of seven degrees of freedom[5]. Moreover, fulcrum effect (movement of instrument in opposite direction from desired target on monitor to interact with site of interest), observed in conventional laparoscopy is avoided[6]. This offers better hand eye coordination. Other technical advantages include elimination of effect of physiologic tremor and motion scaling ability. Minimal access surgeries done with robotic help are associated with less tissue trauma, pain, stress response, better cosmetic results, quicker recovery, early ambulation, shorter hospital stay and related costs[7]. Voice controlled robot make tele-surgery possible with surgeons sitting at a distance from patient. This new technology with unknown territories is not without drawback. The need for a larger operating room to accommodate a bulky robot, extra staff and higher infrastructure costs are a big disadvantage especially in developing countries with a limited budget for medical facilities. There is requirement of general anaesthesia with profound muscle relaxation as any movement of patient may disturb robot's visual perception resulting in surgical inaccuracies and complications. It is difficult to reposition and access airway without disengaging the equipments completely. In emergency situations, this can

cause serious problems. Longer surgeries are probably a time related factor that would improve with surgeons practice and familiarity with nature of equipment. Though, controversial at times, there is an increasingly felt need of continuous arterial blood pressure (BP) and central venous pressure (CVP) monitoring in some such surgeries . Other disadvantages could be position related like compromised lung capacities, high central venous pressures in trendelenberg and lithotomy position or procedure related like pneumo-peritoneum related complications such as CO_2 embolism. It may be difficult to adjust cardiac filling pressures quickly as a result of severely restricted posturing of patient. There is loss of touch sensation of the experienced surgeons hand as in conventional surgeries.

Clinical applications of Robot in Surgery

- Abdominal surgeries- Nissen fundoplication, Cholecystectomy, Gastric bypass, Esophagectomy, Heller's myotomy, Bowel resection

- Cardiothoracis surgeries-Internal Mammary artery harvesting, Atrial Septal Defect repair, Coronary Artery Bypass Graft, Mitral valvuloplasty, Lung surgeries

- Urologic Gynaecologic surgeries-Tubal re-canalization, Hysterectomies, Ovary resection

- Orthopedic surgeries-Total Hip Replacement, Total Knee Replacement, Spine surgeries

- Neurosurgeries-Complement image guided surgery, Radiosurgery

- Others-Adrenalectomy, Laser Surgeries (Retinal), Airway Surgeries

Anaesthetic concerns

Nissen Fundoplication is the commonest procedure being done with robotic help [8] . Abdominal robotic surgeries are done under minimum mandatory monitoring. . General anaesthesia with entotracheal intubation remains the standard approach in these patients. Bilateral intravenous access with broad 16 gauge cannula, connected with extension tubing, is useful as arms which are usually tucked by the side, may not be available to anaesthesiologist during the procedure. Fluids are guided by CVP and urine output. It is useful to follow trends in CVP after noting baseline CVP when final positioning has been achieved , especially when high CVP values are recorded in steep trendelenberg position . Placement of an arterial line in all patients is controversial and should be individualized. Good muscle relaxation is required as a small patient movement can be dangerous. Any movement of patient may disturb robot's visual perception resulting in surgical inaccuracies and complications. Neuromuscular monitor, though not mandatory , may be used for assessing need for muscle relaxants intraoperatively. Head needs to be protected with guards. Other specific procedure related concerns like Rapid Sequence Induction for gastro-

esophageal reflex requiring Nissen fundoplication apply as in conventional surgery.

Pneumo-peritoneum using CO_2 is required and abdominal pressure should be limited to 14 mmHg. The combination of pneumo-peritoneum with trendelenberg position causes reduction in vital capacity, functional residual capacity , total lung volume and pulmonary compliance . An increase in airway pressure is observed due to decreased lung compliance , impairment of diaphragmatic excursion and transmitted high intra-abdominal pressures secondary to intraperitoneal insufflation of CO2 . A decrease in venous return due to compressive effect on inferior vena cava and indirectly because of high intrathoracic pressures together with increase in systemic vascular resistance are responsible for a possible decrease in cardiac output. Trendelenberg position , however negates the effect of pneumo-peritoneum on cardiovascular system, by increasing central pooling of blood and offering increased preload to heart . However , this may have deleterious effects on myocardial oxygen demand and contractility , particularly in patients with known coronary artery disease and already compromised ejection fraction . Intracranial and intraocular pressures may also increase . Venous congestion in head and neck may lead to swelling of face , eyelids , conjuctiva , tongue and upper airway. Laryngeal edema occurring as a consequence to venous congestion due to steep trendelenberg position in robotic

surgery has been reported recently [9]. Administration of corticosteroids prophylactically does not appear to reduce risk of post extubation stridor [10,11]. A cuff leak test done prior to extubation may be useful in identifying patients at risk of post operative stridor because of laryngeal edema [12]. Visualizing glottis and vocal cords by doing a gentle laryngoscopy at the end of surgical procedure and "extubation under vision", as is practiced conventionally in thyroid surgeries in many centres for cord palsy detection may give further idea about laryngeal edema . In patients with substantial swelling , it may be prudent to delay removal of the endotracheal tube until situation improves. Anaesthesiologists need to be aware that that robotic equipments can interfere with patient access and prepare accordingly[13]. The operating room team must practice crisis situations of removing the robotic equipment and gaining access to the patient rapidly should the need arise . Excellent communication and co-ordination between the team members is the key to success in such critical scenarios .

PUMA robot is a safe device used for TURP. Restriction of robot to precise arc of resection prevents resection of tissue outside frame. Transurethral Ultrasonography done intraoperatively provides a 3D image of prostatic tissue, based on which surgery is done. Radical prostatectomy requires lithotomy with 30° - 45° trendelenberg position. Thighs are kept apart to allow robot to approach surgical field . Such position may restrict lung capacities, increase cerebral and central pooling of blood and is contraindicated in patients with history of stroke and cerebral aneurysm. Arms are usually tucked by side and may not be available intra-operatively for intravenous access. Presure points are padded adequately . Shoulder braces used to prevent cephalad slipping in trendelen-berg position may sometimes be associated with brachial plexus neuropraxia [9].

Robotic cardiac surgeries avoid sternotomy and associated inflammatory response. One lung ventilation is mandatory and patient must be preoperatively assessed by pulmonary function tests (PFT) to know the suitability of one lung ventilation. Robotic cardiac surgeries should be deferred if PFT's are indicative of poor functional state[7]. One lung ventilation requires isolation of one lung with either double lumen tube , single lumen endobronchial tube or endotracheal tube with endobronchial blocker . One lung ventilation strategy rests upon standard principles . Tidal volume of approximately 10 ml /kg should be used for ventilation of single lung . A low tidal volume may cause atelectasis while a larger volume may cause excessive airway pressures . Respiratory rate should be set so that $PaCO_2$ remains at 40 mmHg . FiO2 of 1 and application of PEEP to ventilated lung play important role in ensuring adequate tissue oxygenation . Transesophageal echocardiography has become standard of care for cardiac robotic surgeries. It helps in assessing heart/valvular function and also guiding central line and pulmonary artery catheter placement. Robotic assisted esophagectomy avoids thoracotomy and lateral decubitus position as required in conventional esophageotomy. Knee replacement and Hip replacement surgeries done by robotic systems offer better control , effective drilling and better fitting/ articulation of joints. The precision of robots offers an added advantage in laser retinal surgeries, neurosurgeries and airway surgeries with small fields of focus.

Conclusion

To summarize, newly developed robotic system have an enormous potential in advancing surgical treatment modalities beyond human ability. Undoubtedly, they have brought in revolution in surgical disciplines. With this advancement, the need to understand new specific anaesthetic concerns has also come up. It is important to recognize and if possible, rectify the associated drawbacks and implicated dangers to patient's safety.

References

1. Satava RM, Surgical Robotics : the early chronicles : a personal historical perspective, Surg Laparosc Endosc Percutan Tech, 2002; 12: 6-16.

2. Kwoh YS, Hou J, Jonckkheere EA et al, A robot with improved absolute

positioning accuracy for CT guided stereotactic brain surgery, IEEE Trans Biomed Eng 1988; 35: 153-161.

3. Davis B,A review of robotics in surgery, Proc Inst Mech Eng 2002 ; 214 : 129-140.

4. Czibik G, D'Ancona G , Donais H et al, Robotic cardiac surgery : present and future applications, J Cardio-thorac Vasc Anesth, 2002; 16:502-507.

5. Kim VB, Chapman WH, Albrecht RJ et al, Early experience with telemanipulative robot – assisted laparoscopic cholecystectomy using Da Vinci, Surg Laparosc Endosc Percutan Tech,2002; 12:34-40.

6. Satava RM, Bowersox JC, Mack M et al, Robotic Surgery-state of art and future trends Contemp Surg, 2001;57: 489-499 .

7. Nishanian E V , Mets B, Anesthesia for Robotic Surgery, In : Ronald D. Miller ed. Anesthesia , 6th ed (Indian) .Philadelphia , Pennsylvania: Churchill Livingstone , 2005: 2557-2572 .

8. Lanfranco A.R, Castellanos AE, Desai JP et al, Robotic Surgery - A current perspective, Annals of surgery 2004 ; 239(1): 14-21.

9. Phong S.V.N, Koh L.K.D, Anaesthesia for robotic –assisted radical prostatectomy considerations for laparoscopy in the Trendelenberg position, Anaesth Intensive Care 2007; 35 : 281-285 .

10. Darmon JY, Rauss A, Dreyfuss D et al, Evaluation of risk factors for laryngeal edema after tracheal extubation in adults and its prevention by dexamethasone, A placebo – controlled ,double blind, multi-centre study, Anesthesiology 1992 ; 77 : 245-251.

11. Ho L I , Harn H J , Lien TC et al, Post extubation laryngeal edema in adults, Risk factor evaluation and prevention by hydrocortisone, Intensive Care Med 1996 ; 22 : 933-936.

12. De Bast Y , De Backer D ,Moraine J J et al, The cuff leak test to predict failure of tracheal extubation for laryngeal edema, Intensive Care Med 2002 ; 28 : 1267-1272 .

13. Mariano E.R., Furukawa L, Woo R K et al, Anesthetic concerns for Robot- Assisted Laparoscopy in an Infant, Anesth Analg 2004 ; 99 : 1665-1667.

Figure 1.: Showing DaVinci Robot Assembly

Safety features of modern Anesthetic machines

Based on experience gained from analysis of mishaps, the modern anaesthetic machine incorporates several safety devices, including:

- an oxygen failure alarm. In older machines this was a pneumatic device called a Ritchie whistle. Newer machines have an electronic sensor.

- hypoxic-mixture alarms to prevent gas mixtures which contain less than 21% oxygen being delivered to the patient. In modern machines it is impossible to deliver 100% nitrous oxide (or any hypoxic mixture) to the patient to breathe. Oxygen is automatically added to the fresh gas flow even if the anaesthetist should attempt to deliver 100% nitrous oxide.

- ventilator alarms, which warn of disconnection or high airway pressures

- interlocks between the vaporisers preventing inadvertent administration of more than one volatile agent concurrently

- alarms on all the above physiological monitors

- the Pin Index Safety System prevents cylinders being accidentally connected to the wrong yoke

- the NIST (Non-Interchangeable Screw Thread) system for pipeline gases, which prevents piped gases from the wall being accidentally connected to the wrong inlet on the machine

- pipeline gas hoses have non-interchangeable Schrader valve connectors, which prevents hoses being accidentally plugged into the wrong wall socket

Advances in Neuroanaesthesia Monitoring

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Monitoring in the perioperative period plays an important part in the satisfactory outcome of a surgical patients. It assumes paramount significance when the patients belong to neurosurgery specialty because, their condition may change rapidly within a matter of few minutes, leading to poor outcome. Newer advanced monitoring techniques are introduced into clinical practice for the satisfactory outcome of neurosurgical patients. The following advanced monitoring (except SJO_2) technique have still a long way to go before they become routine in clinical practice.

Near Infrared Spectroscopy (NIRS)

NIRS is an application of a technology that has been available for a number of years. It can be used to provide information about changes in regional cerebral oxygenation, cerebral blood flow and volume and oxygen utilization in the brain.

Principles

The principle behind NIRS is based on the fact that light in the near infrared (700-1000nm) can pass through skin, bone, and other tissues relatively easily. When a beam of light is passed through brain tissue, it is both scattered and absorbed. The absorption of near infrared light

is proportional to the concentration of certain chromophores, notably iron in haemoglobin, copper in cytochrome aa_3. Oxygenated (HbO_2) and deoxygenated haemoglobin (Hb) and cytochrome aa_3 have different absorption spectra, depending on the substances' oxygenation status. The isobestic point of oxygenated and deoxygenated haemoglobin is at about 810 nm. HbO_2 has greater light absorption above this wavelength and Hb has greater light absorption below 810 nm. The maximum oxidation/reduction proportion for cytochrome oxidase or cytochrome aa_3, which is the terminal member of the mitochondrial respiratory chain, is at 830 mm. This allows for the measurement of oxidation status. NIRS interrogates arterial, Venous and capillary blood and therefore the delivered oxygen saturation is an average value for these compartments. However, most of the NIRS signal is from the venous blood because it contributes to approximately 70% of the intracranial blood volume. This technique indirectly assesses flow by detecting changes in venous saturation and can provide information about tissue several centimeters below the probe. NIRS has greater tissue penetration than pulse oximetery and does not need

pulsatility. Near infrared instrument generally consists of small optical probes connected to a monitoring device by a wire bundle. This enables the monitor to be placed at a distance from the patient which will facilitate its use in ICU and during surgery. The rubber optical probes contain light source consisting of small tungsten light filament of less than 3 watts and two photo diodes filtered at 760 nm and 850 nm The light sources are recessed so as to prevent direct skin contact. A photodiode detector converts the reflected light to a current and then to a voltage for amplification and signal detection. The probes illuminate upto a volume of 10 ml of hemispherical tissue. The radial depth will depend on the interoptode distance. The optodes are placed on one side of the forehead with an interrupted spacing of 4-7 cm. Normal values of the HbO_2 are reported to be 60-80% and the ischaemic threshold is estimated to be 47% saturation (1).

Clinical application

One of the major problems with NIRS is the inability to reliable distinguish between extracranial and intracranial changes in blood flow and oxygenation which affect its reliability as a monitor of brain oxygenation in clinical practice. The amount of extracranial contamination

decreases with increased optode separation, but is still noticeable at 7 cm separation . It is now accepted that optodes separation less then 4 cm predominately reflects extracranial tissue changes (2) .Kirkpatrick et al (3) in 1995 used NIRS to monitor cerebral oxygen saturation in patients undergoing carotid endarteractomy (CEA) under GA. The NIRS was able to detect rapid changes in brain oxygen saturation without significant contamination from extracranial vessels. The authors were able to identify three categories of NIRS response during CEA.

- No change in HbO_2 on internal Carotid Clamping.

- Decrease in HbO_2 that recovers during clamping

- Decrease in HbO_2 that only recovered with the release of clamp

In those patients in whom spontaneous recovery of the signal did not occur, a hyperaemic response with an increase in HbO_2 and middle cerebral artery flow velocity above baseline was observed. By using bilateral cerebral oximetry, Samra et al(4) in 1996 were able to demonstrate a significant but variable drop in cerebral oxygenation without neurologic dysfunction in patients undergoing CEA under regional anaesthesia However, they were unable to identify the critical cerebral oxygenation or change in cerebral oxygenation that required the shunt insertion.By using a modification of Fick principle, NIRS can detect changes in CBF and cerebral blood volume (5) . However, this technique considerably underestimates CBF because of optical effects of extracranial tissue . Trends values of NIRS may help to detect ischaemic events and the technique is being used during interventional procedures. Regardless of these problems, NIRS is able to monitor trends in oxygenation in the individual patient and may be useful as an adjunct to the multimodel monitoring system.

Brain Tissue Oxygen Tension

The exact level of cerebral perfusion pressure (CPP) following traumatic brain injury has been subject to much debate; the latest definitive guidelines being the downward revision of the Brain trauma Foundations guidelines on CPP targets in 2003 suggesting a CPP target of 60, rather than 70mmHg. The provision is, however, that in selected patients, where there is evidence of regional or global ischaemia the CPP target may need to be higher. Individualized CPP optimization, therefore, becomes dependent on, amongst other things, the monitored levels of brain oxygenation.

Brain tissue oxygen partial pressure (PbO_2) is partial pressure of oxygen in the extracellular fluid of brain and reflects availability of oxygen for ATP production. It represents the balance between oxygen delivery and consumption, and is influenced by changes in capillary perfusion. Distance from the supplying capillaries and possible barriers to oxygen diffusion may be particularly important after Injury.

The two most commonly used systems to date are the Licox and the Neurotrend.

Measurement principles:

The Licox system provides PbO_2 with or without brain temperature, in an estimated 7.1-15 mm^2 area The probe utilizes a closed polarographic (Clark type) cell. In addition to PbO_2, Neurotrend also offers $PbCO_2$ pH and temperature. Monitoring PbO_2 is being increasingly used whenever ICP monitoring is indicated. This technique may be used for patients with head injury, subarachnoid haemorrhage or intraoperatively during aneurysm and tumour surgery. Purpose designed triple lumen cranial access devices allow simultaneous ICP, intracerebral microdialysis and PbO_2 monitoring. Post insertion CT confirmation of probe position in the brain parenchyma is important for interpretation of readings. Transiently increasing the F_iO_2 and observing the corresponding PbO_2 increase, is advisable to exclude the presence of surrounding microhaemorrhages or sensor damage at insertion. A 'run in' or equilibration time of upto half hour is required before readings are stable.

Normal values: Human recordings have varied from a PbO_2 37(+12) mmHg, $PbCO_2$ of 49(+5) mmHg, brain pH of 7.16 (+0.08) to a pbO_2 value of 48mmHg (6) in uncompromised patients undergoing cerebrovascular surgery.

Safety : Initial concerns regarding the invasiveness of these intraparenchymal sensors and the risk of haemorrhage and infection have proved unfounded.

Drawbacks:

1. Trauma while insertion

2. Inability to adequately position and secure

3. PbO_2 sensors are extremely localized, only and sampling approximately $15mm^2$ of tissue around the tip

PbO_2 reactivity :

The increase in PbO_2 relative to an increase in arterial PO_2 is termed brain tissue oxygen reactivity. It is believed that this reactivity is controlled by an oxygen regulatory mechanism (cf. CBF autoregulation), and this mechanism may be disturbed following head injury.

PbO_2 autoregulation :

Soehle et al (7) in 2003 introduced the concept of PbO_2 autoregulation, defined as the ability of the brain to maintain PbO_2 despite changes in CPP, thereby identifying appropriate individual CPP targets.

Applications of brain tissue oxygen monitoring

Aneurysm surgery : Intraoperative use of PbO_2 monitoring is a sensitive indicator of cerebral tissues at risk. Severe bleeds (Fisher grade 3) also significantly decreases PbO_2. Correctly positioned PbO_2 monitoring allows not only assessment of the effect and reversibility of temporary aneurysm clipping, but can also be indicative of the correct positioning of the subsequent permanent clip (7). Hypoxic PbO_2 levels confirmed compromised perfusion detected on preoperative SPECT and cerebral angiography . In a study of 46 patients undergoing craniotomy for aneurysm clipping, (8) the majority of 31 patients who required temporary clipping of the parent vessel, showed decrease in PbO_2 with a level of PbO_2 <8 mmHg for 30 min being predictive of cerebral infarction. Another study (9) found that PbO2 monitoring during aneurysm clipping supplemented somatosensory evoked potentials (SSEP) monitoring in identifying ischaemia, especially in those patients where the baseline SEP was absent.

Arterio venous malformation Surgery:

PbO_2 measurement has been used to investigate the oxygenation of cerebral tissue supplied by vessels with AVM . Thirteen patients undergoing resection of AVM_s were compared with 8 non ischaemic patients undergoing aneurysm surgery (control). Low PbO_2 but normal $PbCO_2$ and pH (in contrast with raised $PbCO_2$ and acidosis were seen in acute occlusive disease with ischaemia) (10) before AVM resection suggested low perfusion and chronic hypoxia with possible metabolic adaptation and subsequent hypometabolism, while the marked PbO_2 increases post resection indicate hyperperfusion with its attendant problems. Apart from enhancing the understanding of AVM pathophysiology, this study reaffirms the feasibility of intraoperative PbO_2 monitoring.

Head injury patients:

Gupta and colleagues in 1996, studying brain oxygenation in these patients found that jugular venous oxygen saturation was not as reliable as PbO_2 as an indicator of regional oxygenation (11). Valadka and group (12) analysed the PbO_2 and suggested the likelihood of death increased with increasing duration of time at or below PbO_2 of 15 mm Hg or with occurrence of any PbO_2 values below 6 mm Hg.

Monitoring PbO_2 in human several authors have reported intraoperative data from craniotomies on non trauma patients. Using surface Licox probe in 26 elective craniotomies mostly for tumours. PbO2 averaged 47.9 torr in normal cortex and 33.7 in swollen cortex. Potential concerns about surface probes include potential movement of probes because of inability to secure them properly and also possibility of contamination of PO2 reading from room air. Using paratrend probes Hoffman et al in 1997 obtained mean PbO_2 values of 30-35 torr in their control group of aneurysm patients and approx. 15 torr in tissues around AVM.

Maas et al (13) in 1998 noted four of five head injured patients with a PbO_2 of about 5 torr during the first 24 hrs. after trauma died, as compared with death in only one of 16 patients with PbO_2 of more than 5 during the first 24 hrs. Kiening (14) proposed that a PbO_2 of 10 torr be used as a critical value, below which aggressive attempts should be made to increase O_2 delivery to the brain. The author also

observed that SJO_2 of 50% in general correlates with a PbO_2 of 8.5 torr.

The future

The invasiveness of the Pbo_2 technique will always be an issue and may limit its usefulness in patients with coagulopathy, for instance. Combining parameters such as ICP and PbO_2 into a single probe may reduce the number of probes inserted, but the ideal remains a non invasive monitor. Better integration of the collected data with continuous online derived indices at the bedside may also facilitate patient optimization. Routine use of dynamic challenges (e.g. increases in CPP or FIo_2 when cerebral hypoxia presents), may identify individualized therapeutic targets.

Cerebral Blood Flow Monitoring

Why monitoring/measuring CBF is important?

Autopsy data have repeatedly shown that brain ischaemia is common in non survivors of traumatic head injury and it is likely that inadequate CBF significantly contributes to the occurrence of post-traumatic secondary brain insult and therefore, increases the probability of a poor outcome after brain injury. Using PET in humans suffering from ischaemic stroke the threshold for brain infarction was established at CBF of 8 ml/100gm/min and that for the penumbra at 20 ml/100 gm/min. Therefore, CBF or adequacy of CBF monitoring offers a rational approach to detect and prevent secondary insults and improve the outcome of these patients.

Measuring CBF continues to be difficult, especially intraoperatively in the clinical setting. The most reliable methods are used in research laboratory and are technically complex and non continuous, monitoring CBF changes is still much more accessible for the anaesthesiologist than assessment of the absolute CBF values.

1. Xenon[133] Regional CBF (rCBF) can be studied by the intravenous, intraarterial (carotid) or by inhalation method. Ostapkovich and colleagues used this technique (15) to compare the effects of remifentanil and N_20 on CBF and CO_2 reactivity with fentanyl, N_20 anaesthesia during craniotomy. After dural exposure and a minimum of 15 min at a stable drug dose, 15-20 mci of ^{133}Xe in saline was injected into a saphenous vein, followed by a saline flush. Xe^{133} gas was sampled from the expiratory circuit of monitor to construct the arterial input function. Tracer washout was recorded over the MCA distribution contralateral to the operative site with sodium scintillation detector for 11 min; CBF was calculated using initial slope index. Both regimens had similar effects on absolute CBF and cerebrovascular CO_2R maintained. This technique is routinely available for surgical procedures. Xe has low soulubility in blood and hence is rapidly cleared from it ,further studies can be performed within approximately 30 min. The accuracy and specificity of theis method depends upon the number of externally placed detectors.

Drawbacks with Xenon[133]

1. It is difficult to obtain precise information according to anatomical correlation

2. Comparisons of the same region from one study to another are difficult

3. It measures mainly cortical and subcortical blood flow within the territory of the MCA

4. Look through phenomenon : where the detectors pick up highly perfused brain tissue but not ischaemic areas. It is an artifact.

5. The equipment is bulky

6. Patients are exposed to radiations

7. Neccesity for carotid artery pucture

8. Potential inaccuracies from variations in partition coefficient of Xe in normal or abnormal brain tissues

Double indicator dilution technique : Wietasch et al (16) in 2000 have recently described a bedside method for assessment of CBF. The investigation was performed in 14 **anaesthetized** patients before coronary artery bypass grafting during which CBF was altered by hypocapnia, normocapnia and hypercapnia. Measurements were made simultaneously by the Kety Schmidt inert gas technique with Argon and a newly developed transcerebral double indicator dilution technique (TCID). For TCID measurements to be made boluses of ice cold indocyanine green were injected through a central venous line, and the resulting Thermodye dilution

Curves were recorded simultaneously in aorta and the jugular bulb using combined fibreoptic thermistor catheters. The values of CBF was calculated from the mean transit times of the indicators through the brain. The authors concluded that TCID is an alternative method to measure global CBF at the bed side and it offers a new opportunity to monitor cerebral perfusion of patients. However, its use is far from being applied in the operation theatre.

3. Positron emission tomography (PET)

PET is being used both as a diagnostic and a clinical research tool. It allows examination of the CBF and brain O_2 consumption. Alkire and colleagues (17) in 1999 published a study evaluating regional cerebral metabolic activity in human brain using functional brain imaging with the F-18 fluoradeoxyglucose PET. He found halothane caused a metabolic reduction in the whole brain with significant shifts in regional metabolism. Propofol compared with halothane or isoflurane was associated with greater absolute metabolic reduction and a suppression of relative cortical metabolism and caused significantly less suppression of relative metabolism in the basal ganglia and mid brain regions. However, this method is very expensive and complicated.

4. Transcranial Doppler (TCD)

Routine TCD ultrasonic examination of the intracranial arteries was shown to be possible in 1982. It is used with ease at the bedside or during surgery. The waveform resembles that of arterial pulse and is easily quantified into systolic, mean and diastolic flow velocities and pulsatility index. One fact that has to be kept in mind when using TCD is that the value obtained for a particular artery is the velocity of blood flow through that vessel. Unless some means or other can establish the diameter of that vessel, it is impossible to determine the actual blood flow. The linear relationship between CBF and mean flow velocity (CBF=mean flow velocity x area of the insonated vessel x cosine of the angle of insonation) is only present if neither the diameter of the insonated vessel nor the angle of insonation changes during the examination. Thus, TCD is primarily a technique for measuring relative changes in flow but does not facilitate quantitative measurement of CBF. For instance in patient with SAH and vasospasm, an increase of blood velocity paradoxically indicates a decrease rather than an increase of CBF Examination of the ratio of extracranial internal carotid artery blood flow velocity to MCA blood flow velocity helps differentiating vasospasm from increased CBF (Lindegaard index)

TCD has been used to assess the cerebrovascular reactivity. Gupta and colleagues in 1996 suggested that hypoxemic cerebral vasodilation may be measured non invasively using TCD (18). They studied normal human volunteers and found that the threshold for hypoxaemic cerebral vasodilation was a SpO_2 of 90% which is higher than previously reported.

TCD is being used intraoperatively in anaesthetic research and has shown that inhalational agents produce a dose dependent increase in CBF. The magnitude of this increase is dependent on the balance between the intrinsic vasodilatory action of the agent and the vasoconstriction secondary to flow metabolism coupling.

TCD may be a good monitoring device during carotid endarterectomy (CEA) and continuous measurement of blood flow velocity in the distribution of MCA may be helpful in differentiating intraoperative haemodynamic versus embolic neurologic episodes. Embolization detected by TCD occurs in > 90% of patients during CEA. It has been suggested that surgical intervention such as more careful dissection of the artery and more meticulous attention to back bleeding and flushing to avoid embolization can be guided by acoustic evidence for embolism. TCD may also indicate which patient should have aggressive haemodynamic interventions and /or anti coagulant after cerebral embolic epidode; decreased CBF velocity can be differentiated.

Oscillating flow or systolic spikes are typical Doppler ultrasonic flow signals in the presence of cerebral circulatory arrest, which if irreversible, results in brain death. Similar wave forms could be seen during some neuroendoscopic procedures with raised ICP during surgery (19). TCD is a useful confirmatory method to establish irrevers-

ibility of cerebral circulatory arrest as an optional part of the protocol to confirm brain death and it is of special value when the use of sedative drugs render EEG unreliable. Reasonable correlations have been reported between TCD and Xe computed tomography and PET CBF(20) measurements.

5. Laser Doppler Flowmetery

A craniotomy or burr hole is needed to insert a laser Doppler flowmeter to detect cortical blood flow. The depth and area of the tissue involved limit the technique. Moreover, it is possible that areas that are beyond the monitor could be subjected to deleterious flow reduction without being detected. The technique requires the Cortex to be exposed and so can not be used to follow changes in physiological variables during the earlier or later phases of neurosurgical operations. For these reasons, reliance on such measurements alone to predict the risk of ischaemic injury may be unwise.

Cerebral Microdialysis

Cerebral MD is a well established laboratory tool and is being increasingly used as a bed side monitor to provide on line analysis of brain tissue biochemistry during neurointensive care.

Principles of MD

A MD catheter consists of a fine double lumen probe, lined at its tip with a semipermeable dialysis membrane. The probe tip is placed into biological tissue and perfused via an inlet tube with fluid isotonic to the interstitium. The perfusate passes along with membrane before exiting via outlet tubing into a collecting chamber. Diffusion drives the passage of molecules across the membrane along their concentration gradient. Molecules at high concentration in the brain ECF pass into the perfusate with minimum passage of water and, as the perfusate flows and is removed at a constant rate, the concentraton gradient is maintained. The MD catheter, therefore, acts as an artificial blood capillary and the concentraton of substrate in the collected fluid (microdialysate) will depend in part on the balance between substrate delivery to, and uptake/excretion from the ECF.

It is instantly apparent that the concentration of a given molecule in the dialysate will be lower than its concentration in the brain ECF unless there is total equilibration across the dialysis membrane. The proportion of the true ECF concentration collected in the dialysate is termed the relative recovery and is dependent on membrane pore size, membrane area, rate of flow of perfusate and diffusion speed of the substance.

In clinical practice most commonly used system comprises a catheter that is 10 mm in length with a 20 kDa or 100 kDa molecular weight cut off, perfused with commercially available perfusate solution at a rate of 0.3il/min. The advantage of a 100 kDa molecular weight cut off catheter is the ability to investigate higher molecular weight biomarkers, but such catheters have equivalent recovery to 20 kDa cutt off catheter for the more conventional and clinically relevant, MD variables such as glucose, lactate, pyruvate, glutamate and lactate ratio (LPR).

Treatment of acute brain injury (TBI) during neurointensive care is aimed at preventing or minimizing the burden of secondary injury. Monitoring brain tissue biochemistry has the potential of identifying impending or early onset secondary injury and allow timely implementation of neuroprotective strategies. Cerebral MD may allow assessment of the adequacy of treatment in an individual patient at a particular moment in time and therefore ,has the potential to guide individualized and targeted therapy after TBI.

Catheter placement

Placement of the MD catheter in 'at risk' tissue such as the area surrounding a mass lesion after TBI or the vascular territory most likely to be affected by vasospasm after SAH, allows biochemical changes be measured in the area of brain most vulnerable to secondary damage. In the case of diffuse axonal injury, catheter placement in the non dominant frontal lobe is recommended.

MD Markers

The most common commercially available assays for bed side use are those for glucose, lactate glycerol and glutamate.

Markers of glucose metabolism

Glucose is the main source of energy to the brain.

Microdialysate glucose levels are reduced in patients after TBI and a concentration consistently less than 0.66 ìmol/litre in the first 50 hour post TBI is associated with poor prognosis (21) . The causes of this low glucose concentration is likely to be multifactorial. In the acute period after TBI, there is typically a reduction in oxidative metabolism and an increase in glucose metabolism (22) . Extremely low cerebral MD glucose are observed during periods of severe hypoxia/ischaemia after TBI and SAH, and are associated with a brain tissue PbO_2 of less than 1.3kPa . However, a poor correlation has been shown between ischaemia defined by PET imaging and low MD glucose concentration suggesting that, in some cases at least low MD glucose concentration may be associated with hyperglycolysis rather than critical supply of glucose and oxygen because of reduced cerebral perfusion (21)..Lactate pyruvate ratio is a more robust and reliable biomarker of tissue ischaemia than lactate concentration alone. LPR is the most widely monitored MD variable after TBI .

In human brain, severe hypoxia is typically associated with marked increase in LPR which correlates with PET

measured oxygen extraction fraction (23). An increase in LPR above established threshold of 20-25 is associated with poor outcome following TBI and SAH and has traditionally been thought to indicate tissue ischaemia. However, it has been proved to be difficult to establish the tissue hypoxia threshold for a raised LPR and it is increas-ingly apparent that anaerobic glycolysis may occur because of failure of effective utilization of delivered oxygen because of mitochondrial failure as well as hypoxia/ischaemia.

Clinical applications of microdialysis

Clinical microdialysis has been applied in the ward, in ICU, in OT and to ambulatory patients. In addition to cerebral monitoring the technique has been used in other sites including skin, subcutaneous adipose tissue, myocardium and skeletal muscle. Peripheral MD has been used to measure subcutaneous glucose concentrations in diabetic patients and to monitor the metabolism of flaps in plastic surgery.

Glucose, lactate, LPR, glutamate and glycerol have been identified as useful markers of disturbance in brain energy metabolism. The level of glucose indicates the amount of glucose available to cells, the lactate and LPR indicate the amount of oxygen and glucose used by the cells, the level of glutamate indicates the extent of possible cytotoxic damage to the cells and the level of glycerol indicates the extent of cell membrane disintegration.

The first report of human cerebral MD investigated biochemical changes during thalamotomy for Parkinson's disease way back in 1990.

Ischaemic/Trauma

The application of MD for monitoring patients on neuro ICU was pioneered in Sweden. Changes in the MD concentration of lactate, pyruvate and glutamate in four patients corresponded with clinical events such as periods of raise ICP (24) . Further studies by the same group demonstrated correlation between levels of excitatory amino acids and outcome in SAH and increased level in energy related metabolites in areas of ischaemia as defined by PET.

It has been demonstrated that release of excitatory amino acids is transient in absence of secondary injury in head injured patients. However, in patients with secondary insult and particularly patients with contusions, very high levels of glutamate are detected. Glutamate release has also been shown to relate to intracranial hypertension, seizure activity and outcome Other investigators have shown a relationship between lactate levels and outcome following head injury and increased lactate levels in response periods of physiological deterioration. There is also some evidence that MD may assist clinical decision making such as management of cerebral perfusion , guidance of hyperventilation and appropriateness of extensive surgical procedures . MD has the potential not only to assist in the diagnosis of significant vasospasm but also to guide triple H therapy. This may be particular useful in the unconscious patient in whom clinical examination is not possible. In a recent study, tight glycemic conrol (defined as 5.0-6.7 mmol/dl) did not improve functional outcome after head injury and was associated with increased incidence of MD markers of cellular distress (25) . This finding merits further

investigation and suggests that established targets for glucose control after head injury might not be universally applicable and measurement of cerebral MD glucose concentration has the potential to guide individualized glucose management.

In addition to monitoring patients on the ICU, preoperative MD has been applied to monitor metabolism during cerebrovascular surgery. The effect of ischaemic during aneurysm surgery have been related to low levels of glucose and raised levels of ascorbic acid, glutatheoine, lactate, glutamate and glial fibrillary acidic protein . There is increase in LPR and decreases in glucose in association with reduced brain tissue oxygen during and following aneurysm surgery.

Epilepsy

Evidence that glutamate is implicated in the pathogenesis of epileptic seizures has prompted studies of MD during epilepsy surgery. Bilateral hippocampal MD has been performed to test the hypothesis that an increase in extra cellular glutamate may trigger spontaneous seizures.

Tumours

In comparision to the investigation of patients with head injury SAH and epilepsy tumour chemistry has not been extensively investigated. However, MD has been used to administer exogenous substances to the brain. L-2,4 diaminobutyric acid, an amino acid with potent anti tumour activity delivered using MD into gliomas, has demonstrated tumour necrosis

Jugular venous Oximetry(SJO_2)

SJO_2 is an index of cerebral oxygen uptake. Its usefulness is in large part due to availability and ease of obtaining information. The normal SJO_2 is 55-75% This value assumes a normal oxygen delivery (cerebral blood flow (CBF) x arterial oxygen content) and a normal haemoglobin level when the SaO_2 is 100%. Changes in SJO_2 provide indirect information on the state of cerebral metabolic rate of oxygen ($CMRO_2$), and because CBF is normally linked to $CMRO_2$, SJO_2 provides indirect information on CBF as well. An increase in SJO_2 indicates a lower $CMRO_2$, increase in CBF or both. A decrease in SJO_2 indicates an increase in $CMRO_2$, inadequate delivery of oxygen to the brain or both. Monitoring SJO_2 provides different data to the anaesthesiologist but can not be used as a single source of information, although we can determine the dominant venous drainage of the head, only a fraction of blood passing through the brain is sampled when SJO_2 is measured in one or both internal jugular veins. The jugular sample is more representative of the forebrain than of the venous blood drainage from the posterior fossa.

Cerebral Venous Oxygen desaturation may occur when hyperventilation is deliberately used during neurosurgical procedures to decrease cerebral blood volume. Matta et al (26) in 1994 concluded that hyperoxia during acute hyperventilation in the an-aesthetized patient improves oxygen delivery to the cerebral circulation, as measured by a higher cerebral venous oxygen content and saturation. An increased PaO_2 should be considered for those patients in whom aggressive hyperventilation is contemplated.

Monitoring of SJO_2 is useful during aneurysm surgery to control ischaemic periods. Temporary vascular clipping of the proximal parent artery is an integral part of aneurysm dissection and clipping. The safe limits for arterial occlusion and the benefit or detrimental effect of intermittent reperfusion are yet to be determined, SJO_2 can be a useful sign of impending ischaemia. Jugular bulb catheters are regularly placed in some centres to detect brain desaturaton during surgery of large tumours, or repair of aneurysm Moreover, its usefulness in the management of head injury is accepted world wide.

It is impossible to predict which side in a specific patient will give more important data and there is no consensus on which side should be cannulated. Generally, the right IJV is preferred because it often is the dominant vessel. Alternatively, the side with the larger jugular foramen can be used or the side on which a compression of the jugular vein causes a greater increase in ICP. The catheter tip should lie at the level of the first or second vertebral body, that is, above the point at which the jugular vein receives its first extracranial tributary, the facial vein. The extracranial contamination at this

level is considered to be about 3%.

Continuous SJO_2 monitoring by fiberoptic device is prone to a high percentage of reading errors and it is expensive. Intermittent SJO_2 measurement is easier, samples can be drawn easily, analysed using widely available co-oximeters. This method obviously reduces the number of critical detectable episodes depending on the frequency of sampling, furthermore, great care must be taken while withdrawing blood, to avoid extracranial blood contamination (do not withdraw more than 2 ml/min.) Lastly, importantly SJO_2 differences seem to exist in blood samples simultaneously taken from both jugualr veins, so it remains unclear which side should be cannulated. Such discrepancy can be predicted on the basis of anatomic variations of cerebral venous drainage and alterations in normal coupling between cerebral oxygen demand and oxygen delivery. The discrepancy in SJO_2 may be as high as 17-22%.

Desaturation is significant if SJO2 falls below 50% and lasts more than 15 min. A significant association between SJO_2 desaturation and poor neurological outcome exists (27) with poor outcome in 55% of patients with no episode of desaturaton, 74% with one episode and 90% with multiple episodes. A major shortcoming, however, is the inability of SJO_2 to detect regional ischaemia with PET evidence of approximately 13% of the brain being ischaemic before SJO_2 levels decrease below 50% (28).

References

1. Levy WJ, Levin S, Chance B. Near infrared measurement of cerebral oxygenation. Correlation withe lectroencephalographic ischemia during ventricular fibrillation. Anesthesiology 1995;83:738.

2. Duncan A, Meek JH, Clemence M. Optical pathlength – measurements on adult head, calf and forearm and the head of the new born infant using phase resolved optical spectroscopy. Phys Med Biol 1995;40:295.

3. Kirkpatrick PJ, Smielewski P, Whitfield PC et al. An observational study of near infrared spectroscopy during carotid endarterectomy. J Neurosurg 1995;82:756.

4. Samra SK, Dorje P, Zelenock GB, et al. Cerebral oximetry in patients undergoing carotid endarterectomy under regional anesthesia. Stroke 1996;27:49.

5. Gupta AK, Menon DK, Czosnyka M, et al. Non invasive measurement of cerebral blood volume in volunteers Br J Anaesth 1997;78:39.

6. Hoffman WE, Charbel FT, Edelman G. Brain tissue oxygen, carbon dioxide, and pH in neurosurgical patients at risk for ischemia. Anesth Analg 1996;82:582.

7. Soehle M, Jaeger M, Meixensberger J. Online assessment of brain tissue oxygen autoregulation in traumatic brain injury and subarachnoid hemorrhage. Neurol Res. 2003;25:411.

8. Kett-White R, Hutchinson J, Al-Rawi PG et al. Cerebral oxygen and microdialysis monitoring during aneurysm surgery: effects of blood pressure, cerebrospinal fluid drainage and temporary clipping on infarction. J Neurosurg 2002;96:1013.

9. Szelenyi A, Jung CS, Schon H et al. Brain tissue oxygenation monitoring supplementary to somatosensory evoked potential monitoring for aneurysm surgery. Initial clinical experience. Neurol Res. 2002;24:555.

10. Hoffman WE, Charbel FT, Edelman G et al. Brain tissue oxygenation in patients with cerebral occlusive disease and arteriovenous malformation. Br J Anaesth 1997;78:169.

11. Gupta AK, Hutchinson PJ, Al-Rawi P et al. Measuring brain tissue oxygenation compared with jugular venous oxygen saturation for monitoring cerebral oxygenation after traumatic brain injury. Anesth Analg 1999;88:549.

12. Valadka AB, Gopinath SP, Contant CF et al. Relationship of brain tissue PO_2 to outcome after severe head injury.
Crit Care Med 1998;26:1576.

13. Maas AIR, Fleckenstein WD, De Jong DA et al. Monitoring cerebral oxygenation: experimental studies and preliminary clinical results of continuous monitoring of cerebrospinal fluid and brain tissue oxygen tension. Acta Neurochir 1993;59(Suppl.) :50.

14. Kiening ML, Unterberg AW, Bard TF et al. Monitoring of cerebral oxygenation in patients with severe head injury : brain tissue PO_2 versus jugular vein oxygen saturation. J Neurosurg1996; 85:751.

15. Ostapkovich ND, Baker K Z, Fogarty-Mach P, et al. Cerebral blood flow and CO_2 reactivity is similar during remifentanil/ N_2O and fentanyl / N_2O anesthesia. Anesthesiology 1998;89:358.

16. Wietasch GJ, Mielck F, Scholz M et al. A bedside assessment of cerebral blood flow by double-indicator dilution technique Anesthesiology 2000;92:367.

17. Alkire MT, Pomfrett CJ, Haier RJ et al. Functional brain imaging during anesthesia in humans: effects of halothane on global and regional cerebral glucose metabolism.Anesthesiology 1999;90:701.

18. Gupta AK, Menon DK, Czosnyka M et al. Threshold for hypoxic cerebral vasodilation in volunteers. Anesth Analg 1997; 85:817.

19. Brauer P, Kochs E, Werner C et al. Correlation of transcranial Doppler sonography mean flow velocity with cerebral blood flow in patients with intracranial pathology. J Neurosurg Anesthesiol 1998;10:80.

20. Steiner LA, Coles JP, Johnston AJ et al. Assessment of cerebrovascular autoregulation in head injured patients: a validation study. Stroke 2003;34:2404.

21. Vespa P, Bergsneider M, Hattori N et al. Metabolic crisis without brain ischemia is common after traumatic brain injury: a combined microdialysis and positron emission tomography study. J Cereb Blood Flow Metab. 2005;25:763.

22. Bergsneider M, Hovda DA, Shalmon E, et al. Cerebral hyperglycolysis following severe human traumatic brain injury: a positron emission tomography study. J Neurosurg 1997;86:241.

23. Hutchinson PJ, Gupta AK, Frywee TF et al. Correlation between cerebral blood flow, substrate delivery and metabolism in head injury: a combined microdialysis and triple oxygen positron emission tomography study. J Cereb Blood Flow Metab 2002;22:735.

24. Persson L, Hillered L. Chemical monitoring of neurosurgical intensive care patients using intracerebral microdialysis. J Neurosurg 1992;76:72.

25. Vespa PM, Boonyaputtikul R, McArthur D et al. Intensive insulin therapy reduces microdialysis glucose values without altering glucose utilization or improving the lactate/pyruvate ratio after traumatic brain injury. Crit Care Med 2006;34:850.

26. Matta BF, Lam AM, Mayberg TS. The influence of arterial oxygenation on cerebral venous oxygen saturation during hyperventilation. Can J Anaesth 1994;41:1041.

27. Gopinath SP, Valadka AB, Uzura M. Comparison of jugular venous oxygen saturation and brain tissue PO_2 as monitors of cerebral ischemia after head injury. Crit Care Med 1999;27:2337.

28. Cole JP, Fryer TD, Smielewski P et al. Incidence and mechanisms of cerebral ischemia in early clinical head injury. J Cereb Blood flow Metab. 2004;24:202.