ENDOSCOPIC SURGERY – ANAESTHETIC CHALLENGES – A HISTORICAL REVIEW

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SUMMARY

A few years ago endoscopic surgery was not in the vocabulary of majority of surgeons and anaesthesiologists. As with any breakthrough, the incorporation of laparoscopy into surgical practice sparked its own set of modifications in general surgery and the concept – "Big surgeon-Big incision" faded gradually until complete disappearance. The "in thing" in the surgical armamentarium is "endoscopic surgery" and the minimally invasive intervention now impacts most surgical practice. Laparoscopic procedures include endoscopic visualization and manipulations of all organs, neuro and spine endoscopy, thoracoscopy, minimally invasive cardiac bypass procedures (MIDCAB), endocrinological surgeries and gynaecological procedures. Although pregnancy was considered a contraindication for laparoscopic cholecystectomy less than a decade ago, it has now become the most commonly performed laparoscopic procedure during pregnancy. In children also, the laparoscopic surgery has found its applications thus enhancing the responsibility of an anaesthesiologist. The story of anaesthesia has always been rich and has varied depending upon the changing needs.

Ancient history

The history of the laparoscopic "revolution" is in fact intriguing.

The importance of performing an internal examination of the many compartments of the human body has been recognized for several centuries.

The Arabian physician Abulkasim[1] (936-1013) is often credited with being the first to use reflected light to inspect an internal organ, the cervix.

Modern history

At the turn of the 20th Century, George Kelling[1] of Dresden used a cystoscope to observe the abdominal organs of dogs. He also realized that pneumoperitoneum was very important for exposure, using room air for insufflation of the peritoneal cavity. He then coined the term "celioscopy" to describe this technique.

The first report of using this procedure in man was by the Swedish physician Hans Christian Jacobaeus[1] in 1910 who coined it the term "laparoscopy".

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The early procedures were however entirely diagnostic, because the exposure obtained and the instruments available did not allow operative intervention.

Over several years various individuals have contributed serially to make laparoscopic surgery a safe procedure.

In 1924, Richard Zollikofer of Switzerland promoted the use of CO_2 as the insufflating gas for pneumoperitoneum rather than filtered air or nitrogen.

Later Janos Veress of Hungary developed a spring loaded insufflation needle for the safe introduction of gas into the abdomen, which is used till today.

It was Raoul Palmer[1] in Paris in 1944 who stressed the importance of monitoring intra-abdominal pressure.

It was another 20 years, however, before Kurt Semm[1] in Kiel, Germany, developed an automatic insufflation device that monitored intra-abdominal pressure and gas flow.

However, since laparoscopy was considered a "blind" procedure with an inherent risk of injury to intraperitoneal structures, acceptance was slow throughout Europe and North America.

Well, it was the widespread introduction of videoscopic technologies in the 1980s that changed the face of surgery.

Although in 1985, Erich Muhe[1] of Germany described his technique of laparoscopic cholecystectomy using the galloscope, it was in 1986 that a computer chip TV camera was developed and attached to the laparoscope. This began the era of video guided surgery in which laparoscopic surgical techniques could be viewed on the surgical screen and could

be used for more complicated procedures. This advance in technology proved to be the critical factor that allowed the widespread acceptance of laparoscopy in the surgical armamentarium. It was in 1987 that the complete removal of a diseased gall bladder in a patient was performed by Mouret in Lyon, France.[1] Interest in these procedures grew almost exponentially, largely fueled by patient demands.

Public awareness that endoscopic surgery is associated with diminished pain and cosmetic disfigurement as well as quicker resumption of normal activities accelerated its acceptance, so much that all wanted the 'pin hole' surgery. However, new surgical procedures translate to new anaesthetic challenges demanding changes in anaesthesia techniques.

Applications

Initially laparoscopic surgery was confined to short diagnostic gynaecological procedures and old and high risk patients were contraindications to laparoscopic surgery. The umbrella is still spreading with almost every procedure being conducted endoscopically. "The inclusion criteria for these procedures have increased".

It has become the standard surgical approach for gastroesophageal reflux disease (GERD), donor nephrectomy, adrenal tumors and morbid obesity. Nowadays, there is hardly any absolute contraindication for a procedure to be performed laparoscopically, since the postoperative benefits far exceed the stress of intraoperative pathophysiological changes.

However, although visually minimally invasive to the patient, the procedure in fact can be quite invasive, and the term "minimal access surgery" is appropriate.

Thus during laparoscopy there are several trespasses to normal homeostasis which are very important for the anaesthesiologist; patient positioning, insufflation of exogenous gas and increased intra-abdominal pressure (IAP). [2-5]

These trespasses are not present in traditional laparotomies. Because intracorporeal organ retraction is limited in laparoscopic procedures, it was quickly realized that exposure was the key to the success of laparoscopy and patient position was critical, to produce gravitational displacement of the viscera away from the surgical site.

Consequently exaggerated positions are frequently employed in laparoscopic surgery.

The Trendelenburg position for operative gynaecological surgery (LAVH,TLH) LAVH - Laparoscopic Assisted Vaginal Hysterectomy, TLC - Total Laparoscopic Hysterectomy may favour haemodynamics but adversely affects the respiratory system. This position affects the cerebral circulation resulting in an elevation of the intracranial and intraocular pressure.

The reverse Trendelenburg position improves diaphragmatic function and is considered more favourable to respiration, however it does not compensate for the carboperitoneum and increase IAP of long laparoscopic procedures. It is deleterious to the cardiovascular system. A steep head up position causes venous stasis in the legs predisposing these patients to deep vein thrombosis (DVT) particularly in procedures of long duration.[6-8] Therefore DVT prophylaxis is necessary in the population at risk.

Choice of insufflating gas

One of the most important aspects of laparoscopy is the use of an optimal insufflating gas. The ideal gas for pneumoperitoneum should be non toxic, colourless, nonflammable, readily soluble in blood and easily ventilated through the lungs and inexpensive.[6-9]

Air was the first gas[10] to be used since it was cheap and easily available. Later oxygen was also used for a long time. However both these gases have a potential for gas embolism because they have a poor Ostwald's blood gas solubility coefficient (0.006, 0.013) and are inflammable too.

In the 1970s, nitrous oxide (N_2O) emerged as the gas preferred by gynaecologists, however it supports combustion, if mixed with methane (from the bowel).

CO_2 is the standard gas used for carboperitoneum.[6,10] It is relatively inert, permitting the use of electrocoagulation, and is readily absorbed by the peritoneal membrane (blood/gas solubility 0.48) and readily expired via the lung.

Other alternative gases like helium, argon and xenon[6,10] are inert but expensive and have a very low blood gas solubility (0.00018), and therefore, high chances of gas embolism if accidental injection in a blood vessel occurs.

Pathophysiological changes : Anaesthetic challenges

Insufflation of several litres of CO_2 to produce carboperitoneum and consequent rise in intra-abdominal pressure produce several pathophysiological changes, which require adjustments in the anaesthesia technique. CO_2 insufflation results in its peritoneal absorption producing hypercarbia.[6-10]

The threshold pressure that produces minimal changes in the haemodynamics is 12 mmHg. Upto 10 mmHg the filling pressures are maintained and the cardiac output may increase. However, an increase in intraabdominal pressure beyond 15 mmHg results in a fall in the preload, and an increase in the afterload along with an increase in the systemic vascular resistance. This increase in SVR is manifested as hypertension.

Since so many pathophysiological changes occur during laparoscopy, several modifications in anaesthesia technique are necessary. Preloading is necessary but should be done in moderation in cardiac patients. The initiation of the procedure (insufflation) produces peritoneal stretching and vagal stimulation, leading to bradycardia and hypotension. Rise in intra-abdominal pressure increases the intrathoracic pressure which raises the peak airway pressure. Normocarbia is achieved by increasing the minute ventilation, which is done by increasing the respiratory rate rather than the tidal volume. The hypertensive response should not be corrected with opioids or inhalation agents since this will delay recovery, but it should be managed pharmacologically with a b blocker (esmolol or metoprolol) or an a agonist (dexmetedomidine).

The key to limiting perioperative anaesthetic complications lies in educating the anaesthesiologist regarding the potential risks and complications of CO_2 pneumoperitoneum.

Extraperitoneal procedures

There was a surge for extraperitoneal surgery which included inguinal hernia repair, adrenalectomy and nephrectomy including donor nephrectomy. These procedures necessitate extraperitoneal insufflation of gas.

During intraperitoneal insufflation,[2,3] there is a rise in the $EtCO_2$ in the initial 8-10 minutes of insufflation, and then a plateau is reached; however during extraperitoneal insufflation there is no plateau seen and the $EtCO_2$ continues to rise. The reasons for the increased absorption of CO_2 in the extraperitoneal space is probably due to the potential space opening up with insufflation and opening new vessels allowing more absorption. No definite boundaries of the extraperitoneal space allows it to expand with insufflation. During these procedures it is very essential to increase the minute ventilation to achieve normocabia.

Hysteroscopy[2,3,11] is not in itself a new technique as visualization of the uterine cavity was first described by Pantaleoni as long ago as 1869. However, recently, the use of hysteroscopy both as a diagnostic and therapeutic tool has become a routine due to the general drive towards minimally invasive techniques in all the surgical specialities. Because the uterine cavity is a potential space, to visualize the endometrium the operator must dilate it with a suitable distention medium. Glycine is nonconductive, nonhemolytic, has good optical properties and therefore well suited for surgical hysteroscopy. It enters the vascular system directly through truncated blood vessels in the surgical field and also slowly from the peritoneum. It is electrolyte free and therefore excessive systemic absorption can result in

hyponatremia, hypokalemia, hypocalcemia and hypo-osmolarity. As water moves along its osmotic gradient extravascularly, it can result in hypotension, non cardiogenic pulmonary oedema and cerebral oedema. It is essential to keep a record of the infused versus return volume of the fluid and if fluid deficits exceed 500ml to 1 litre, cessation of procedure is advisable.

Pregnancy

Although pregnancy was considered a contraindication to laparoscopic cholecystectomy less than a decade ago,[12-17] it has become the most commonly performed laparoscopic procedure during pregnancy. Other laparoscopic surgeries that have been performed safely during pregnancy are appendicectomy, splenectomy and diagnostic for abdominal pain.

The anaesthesiologist has to pay attention to the maternal and foetal issues as well as positioning during surgery and the mechanical effects of carboperitoneum and raised intra-abdominal pressure. When foetal outcomes were compared between laparoscopies and laparotomies performed in pregnant women, no significant difference was found between the two groups. The standard monitors recommended by the ASA are sufficient for the safety and well being of the parturient.

Since laparoscopic procedures are growing in popularity, almost all patients are accepted for surgery due to the well documented postoperative benefits. However extreme caution has to be taken for patients with ischaemic heart disease.

The procedure should start with a slow insufflation rate at 1L min^{-1}, gradually increasing to 2-3 Lmin[-1]. Gradual positioning with a low IAP ascertains minimal haemodynamic changes.

The alveolar - arterial PCO_2 gradient is maintained around 4 mmHg, but in patients with COPD it has been observed that due to V/Q mismatch, this difference is not maintained, and the $EtCO_2$ does not reflect the arterial CO_2.[13,16] Therefore arterial CO_2 estimation becomes essential in such patients.

Anaesthesia for fundoplication

While in the 1980s, surgery for GERD (Heller's myotomy) was performed only in patients who had failed conservative therapy; in the mid 1990s, the laparoscopic option resulted in a greatly increased number of patients undergoing antireflux surgery (laparoscopic fundoplication).[17,18] Certain problems pertaining to this procedure for the anaesthesiologist are:

Symptom of severe gastroesophageal reflux disease mandates a rapid sequence induction, extreme reverse

Trendelenburg position for gravitational displacement of viscera. Dissection along the crura of the diaphragm, mainly the left crus, may produce an accidental rent in the pleura - producing iatrogenic pneumothorax.

Diagnosis : Sudden rise in peak airway pressure, decrease O_2 saturation, increase $EtCO_2$ and abnormal movement of hemi diaphragm on laparoscopic view should alert the anaesthesiologist of a pneumothorax.

If there is no haemodynamic compromise, the surgery may be allowed to continue. Postoperative PPV is recommended till CO_2 gets absorbed and lung expands. If however, there is haemodynamic compromise, then an intraoperative intercostal drainage is required.

Laparoscopic bariatric surgery[19-23]

The awakening of a health care "sleeping giant" from the perspective of surgeons is the laparoscopic bariatric surgery (surgery for the morbidly obese). It appears that bariatric surgery, much like laparoscopic surgery in the early 1990s is now enjoying its "revolution". And surely it is the laparoscopic option for surgery which is the most important factor that has caused the bariatric revolution.

Laparoscopic thoracoscopy

The first series of thoracoscopic cases were reported in 1921 by Swedish physician Jacobeus for diagnosis and treatment of TB. Video assisted thoracoscopic surgery (VATS) has revolutionized the approach to surgery in the thorax.[24-26] However to facilitate visualization of intrathoracic structures, the ipsilateral lung must be partially or totally collapsed. This can be performed by one-lung ventilation or, less commonly, two-lung ventilation in combination with CO_2 insufflation (Capnothorax).

All these can have significant adverse effects on the cardiopulmonary physiology which can aggravate the pathophysiologic changes already associated with the disease process requiring the surgical procedure.

While performing capnothorax, the insufflation pressures should be maintained between 6-8 mmHg and flow limited to 1-2 $Lmin^{-1}$. The risk of greater flow or increased pressure is sudden mediastinal shift and resultant cardiovascular collapse. Although laparoscopy has been available since several years, it has found application in paediatric patients only since the last decade.[27,28]

While adults require about 2.5 - 5 L of insufflation gas for carboperitoneum, a baby requires only 800-900 ml. Since children have a high level of resting vagal tone, peritoneal stimulation during initiation of insufflation can provoke severe bradycardia. The main drawback of CO_2 is its significant vascular absorption across the peritoneum;

since CO_2 uptake is more efficient owing to the smaller distance between the capillaries and peritoneum, and the greater absorptive area of peritoneum in relation to body weight. In prolonged procedures, therefore, hypercapnia can develop, which may mandate increasing minute ventilation by as much as 60% to restore $EtCO_2$ to baseline values.

However because of greater thoracic distensibility in children, the reduction in lung compliance and increase in peak airway pressure following carboperitoneum are less intense as compared to those seen in adults.

Small children have a high body surface area to mass ratio and little subcutaneous fat or body hair to retain heat. This along with the continuous insufflation of large volumes of cold, non humidified CO_2 directly into the abdominal cavity contributes to a major risk of hypothermia.

Complications

Certain complications are unique to laparoscopic surgery and may result at the initiation of the procedure. Peritoneal stretching due to Veress needle insertion and gas insufflation may produce vagal stimulation and bradycardia. Injury to a blood vessel and accidental intravascular insufflation resulting in gas embolism is very rare but potentially fatal condition. Subcutaneous emphysema may result due to the misplacement of the trocar in the subcutaneous tissue. This results in increased CO_2 absorption and refractory hypercarbia, which requires mechanical ventilation for a few hours postoperatively. Normocarbia is attained by increasing the minute ventilation which is achieved by increasing the respiratory rate rather than the tidal volume. It is very essential that the anaesthesiologists associated with these procedures should have a thorough knowledge of all the pathophysiological changes of pneumoperitoneum; possible complications during the procedure so that early detection and prompt treatment may be instituted.

Teaching and training[29,30]

The introduction of laparoscopic training in the USA began in 1990. While all books dedicated to endoscopy, laparoscopy and operative gynaecological surgery stressed on the physiological aspects of the endoscopic procedures and its anaesthetic implications, due stress should also be laid on this, in the anaesthetic forum. It should be recognized as a subspeciality like neuroanaesthesia and paediatric anaesthesia. The anaesthesiologist should be adequately trained to manage these procedures. Amateur surgeons keen to start laparoscopy in their surgical practice have access to training centres in laparoscopy (although few), while the similar situation is not so in anaesthesia.

Future

Today with new digital technology, teleconferencing has become a reality. A teleconference center allows several surgical suites to transmit surgical views and interact audibly with the surgeon. With the push of a button, a student away from the operating room can observe the operative field and ask the surgeon questions as he is performing the procedure.

The next generation of endosuites allows the surgeon and anaesthesiologists to adjust the monitors and lighting (through voice recognition).[1]

Robot assisted surgery might offer potential benefits in decreasing learning curves and increasing safety in a teaching environment. It allows the tutor to take over at any desired moment, or to literally take the resident by the hand to guide him in videoscopic maneuvers.

Conclusion

Laparoscopy as revolution or evolution, has found its place in the history of medicine. It challenges the anaesthesiologists as much as it challenges the operating laparoscopist and it is important that new anaesthetic approaches are developed to ensure that these techniques are truly safe and associated with minimal complications and rapid recovery. A team approach among the surgeon, anaesthesiologist and theatre staff is essential for a successful outcome.

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Functional endoscopic sinus surgery has become one of the most common head and neck procedures performed. Proper anesthetic management is essential for a successful outcome. Different anesthesia techniques are discussed that include: local versus general anesthesia, LMA versus ETT, inhaled anesthesia versus TIVA. The anesthetic plan should be tailored taking into consideration patient comorbidities, the surgeon and anesthesiologist experience, and individual preference. Specific anesthetic goals are to ensure the best possible surgical field and stable cardiovascular and respiratory status dur Endoscopic surgery - anaesthetic challenges - A historical review. Indian Journal of Anaesthesia. 2006;50(3):178-178.Â Society/Institution: Indian Society of Anaesthesiologists. LCC Subject Category: Medicine: Surgery: Anesthesiology. Country of publisher: India. Language of fulltext: English.