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LAPAROSCOPIC ABDOMINAL PROCEDURES IN CHILDREN – ANAESTHETIC IMPLICATIONS

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Laparoscopy which was once confined to gynaecologists has now become a technique of choice for almost all abdominal surgeries and even demanded by majority of patients. Key-hole surgery has become the norm today. Endoscopic procedures help with visualization and manipulations of all organs including thoracoscopy, neuro and spine endoscopy. After the first diagnostic laparoscopy in 1910 by Hans Christian Jacobaeus, we have come a long way that there is hardly any contraindication for laparoscopic surgery. In 1999 Lobe et al. reported the first repair of oesophageal atresia entirely thoracoscopically, this was accomplished on a 2-3 kg neonate. Since then innumerable paediatric laparoscopic procedures have been performed with development of better technology, equipment and resources. But these procedures are becoming more and more challenging to the anaesthesiologist especially when dealing with the younger paediatric age group.

Video endoscopic technology has developed to such an extent that endoscopic surgery is now commonly being performed for many paediatric abdominal conditions, the major benefits claimed are the small incisions and scars with better cosmetic effects, less surgical manipulations and stress, decreased post-operative pain, earlier enteral feeding, decreased post-op ileus and complications, hence early return of bowel function and more rapid recovery. Laparoscopic procedures may also be cost-effective due to the shorter length of hospital stay although the initial equipment cost may be higher.

There are enough and more pros and cons for open and laparoscopic surgical procedures. Besides many of these are now done as minimally invasive procedures in day care surgery obviating the prolonged hospital stay and benefits claimed with laparoscopic procedures. There is no evidence-based literature on this yet especially in the pediatric age group. But the technique as such is very useful in specific situations and we anaesthesiologists should be able to deal with the particular situation as and when it arises.

Indications

In adults, laparoscopic surgeries like cholecystectomy seems superior to open cholecystectomy in terms of cosmetic effects, respiratory associated complications, analgesic requirements, shorter hospital stay and also from the patient's point of view. The initial concern of serious injuries like bile duct injury is now considered very low with laparoscopic cholecystectomy but its role with other types of surgery like hernias and appendicectomies is not very clear. Higher incidences of vascular and visceral injuries are still a concern

Laparoscopic surgery possible in infants and children are unlimited. The safety and efficacy of commonly performed laparoscopic procedures have been evaluated. Laparoscopic fundoplication has become a common procedure for GERD with a recurrence rate comparable to open surgery. It offers some physiologic benefits especially in the neurologically damaged child and has shown excellent results in terms of preservation of wrap integrity and lack of complications. The steep trendlenberg position to keep off the viscera and accidental pleural tear are problems associated with this procedure.

Laparoscopic orchidopexy is also well appreciated because of the better visualization of the inguinal and retroperitoneal anatomy available at laparoscopy and avoiding the resection of testicular vessels when brought down to the scrotal position. Direct visualization of the impalpable testis is much better than inguinal exploration. Both stages of the Fowler Stephens approach for high orchidopexy can be done laparoscopically.

Laparoscopy for inguinal hernias and hydroceles may often benefit only in bilateral and recurrent cases in children compared to adults.

Laparoscopic appendicectomy may not replace open surgery yet as its usually an emergency procedure and has implications in complicated appendicitis cases like gangrene & perforation. But again studies have

shown complications like wound infection and intra-abdominal abscesses may be lesser and post-operative pain and length of hospital stay is definitely lesser. Some earlier studies have shown wound infections to be more common in the open group but intra-abdominal abscesses shown to be more in the laparoscopic group, especially in the perforated appendicitis. In girls diagnosed with unilateral inguinal hernias, the incidence of bilateral hernias is 60%. Hence diagnostic laparoscopy is advocated for typical right iliac fossa abdominal pain in the adolescent female to look for this without having to resort to a separate incision.

In laparoscopic gastrostomies, the stomach is pulled up to the abdominal wall and the gastrostomy is performed using the Seldinger technique. The surgical time is less than 30 mins and may be safer than percutaneous endoscopic gastrostomy (PEG) in small children as this is done under direct vision. Advocates claim less trauma than with open surgery and earlier feeding within 24 hrs.

Laparoscopic cholecystectomics and splenectomies in pediatric patients have become common. Gallstones in children are uncommon and most are due to some underlying disorder like spherocytosis, thalassemia and sickle cell disease. Other than a lower hospital stay, lower analgesic requirements and acute chest syndrome due to post-operative sickling, there were no major benefits shown with lap procedures. Laparoscopic-guided cholangiography is being routinely used for evaluation of neonatal congenital hyperbilirubinemia, thus avoiding the need for open laparotomy.

Laparoscopic surgery has also been done for Hirschsprung's disease as a minimally invasive pull-through technique when the aganglionic segment is confined to the rectum, sigmoid or proximal left colon.

Biopsies of suspected malignancies, staging or confusing resectability can all be done laparoscopically. Response to chemotherapy, second-look procedures and diagnosis of metastatic disease are all done laparoscopically via minimally invasive procedures. Laparoscopic tumor ablations and curative ablations may all have a role in selected cases. Although proponents of laparoscopic surgery claim improved cosmetic results and other advantages mentioned above, evidence is still awaited for all procedures.

Physiological Changes Related to Laparoscopy

The responses to laparoscopy are different or exaggerated in the paediatric age group. Usually these are related to positioning, increased

abdominal pressure due to gas insufflation and the increased arterial carbondioxide tension due to systemic absorption of CO_2. The magnitude of changes will depend on how young the patient is, the myocardial function and the anaesthetic technique and drugs used.

Cardiovascular Responses to Peritoneal Insufflation and Positioning

The IAP (intra-abdominal pressure), the major factor responsible for the cardio-respiratory effects, involve changes in myocardial contractility and systemic vascular resistance (SVR). A decreased venous return and increased SVR will decrease cardiac output (CO). In adults with minor increases in IAP of less than 15mmHg, there is an increase in venous return and CO due to displacement of blood from the splanchnic bed. When IAP goes above 20mm Hg, SVR increases and preload decreases, leading to decreased CO. In paediatric patients similar changes are seen even with lower IAP. Up to 10 mm Hg, the filling pressures are maintained and CO may increase in older children. After 12 mm Hg, there is an increase in SVR and afterload, leading to a fall in preload and cardiac output.

Tobias and colleagues in their study reported only minimal cardiovascular changes with brief laparoscopy in children. They actually found an increase in arterial BP probably due to an increase in SVR. In children, IAP of 12 mm Hg have shown to cause septal hypokinesis and left ventricular wall motion abnormalities. Huettemanni et al also found significant septal hypokinesia in the paediatric age group. Gueugniand et al using continuous oesophageal aortic doppler found significant reduction in aortic blood volume and increase in SVR with even IAPs of 10 mm Hg in children, though these changes had no deleterious effect clinically and promptly reversed after peritoneal decompression. Sakka et al using echocardiography also found that the cardiac index (CI) decreased significantly when 1AP was increased to 12 mm Hg and came back to normal when IAP was brought down to 6 mm Hg. The LVED & LVES volumes were also increased. Ejection fraction remains unchanged but the arterial BP & heart rate increased, so also airway pressures.

CVS instability can occur due to compression of inferior venacava, pneumoperitoneum, pneumomediastinum, venous gas embolism and hypercarbia induced arrhythmias. Increased intrathoracic pressure can increase systemic and pulmonary vascular resistance leading to decreased cardiac output. Arterial pressure may fluctuate from high to low values. Renal, hepatic and splanchnic blood flows may be reduced causing

increase in plasma catecholamines, cortisol, prolactin, growth hormone and glucose levels. Bozkurt et al found the stress responses in children with acute abdominal pain similar to children who underwent laparoscopic procedures

Systemic hypothermia can lead to arrythmias when cold gas is used for insufflation. The trendlenberg position and pneumoperitoneum can predispose to venous stasis of lower limbs. Intra-ocular and Intracranial pressures are increased with the position. Hidden haemorrhages can occur, vital signs monitored continuously.

Respiratory Responses to Peritoneal Insufflation and Positioning

The reverse Trendelenberg position can cause hypoxemia especially in presence of hypovolemia. The Trendelenberg position causes the diaphragm to be pushed up, causing restrictions to lung inflation and endobronchial intubation. Atelectasis, decrease in FRC and decreased pulmonary compliance leading to V/Q mismatch and decreased arterial oxygen tension are the usual respiratory changes. Severe hypercarbia can occur which should be monitored and frequent adjustments in tidal volume and respiratory rates may be required. High gas flows may be required to maintain normocarbia. Positive pressure controlled ventilation, neuromuscular blockade along with endotracheal intubation will help in decreasing the pulmonary effects. The respiratory mechanics will not normally affect the baby unless the IAP increases beyond 12-15 mm Hg.

CO_2 has become the standard gas for insufflation though helium, argon, xenon are inert but they are expensive and chances of gas-embolism is more with these. Laparoscopic adrenalectomy and nephrectomy necessitate extraperitoneal insufflation of gas. The $ETCO_2$ which plateaus with intra-operitoneal insfufflation does not happen with extraperitoneal insufflation because of more potential spaces and vessels opening up with insufflation. CO_2 can diffuse from the peritoneal cavity to the subcutaneous tissue and various fascial planes and produce pneumothorax, pneumomediastinum and subcutaneous emphysema.

Laparoscopic Technique in Children

Laparoscopy in children involves intraperitoneal or extraperitoneal insufflation of carbondioxide through a Veress needle. When the abdominal pressure reaches 15 mm Hg, a variable flow insuffflator terminates flow which is preset for the particular patient. Once the abdomen is filled with CO_2, the Veress needle is replaced by a cannula

through which a video laparoscope is inserted. Additional ports are made according to the needs of the surgical procedure.

For laparoscopic gastrostomy, an umblical port and a left subcostal cannula for future site of the gastrostomy are made. In children, 4 ports are used for laparoscopic cholecystectomy about 5mm each in diameter and a 10mm port for removal of gall bladder. The initial port placement is now usually done as an open or Hasson approach rather than use the Veress needle.

Anaesthetic Management

General Anaesthesia is usually preferred for laparoscopic procedures especially in children. Neuraxial blocks are not usually given along with GA unless the procedure has to be converted to an open procedure. LMAs have been used in adults especially the pro-seal LMA (for lesser gastric insufflation) with no problem. But in children endotracheal tube (ETT) remains the gold standard.

An extensive pre-operative history and physical examination is mandatory. Pre-operative Haemoglobin is probably the only investigation required for otherwise normal children as blood loss is minimal. But we one can never predict when these procedures need to be converted to open abdominal surgeries, so be prepared.

Oral premedication will help separation of smaller children from parents. Atropine and glycopyrrolate will help with secretions and reflex bradycardia during insufflation. Induction can be an inhalational technique with sevoflurane or halothane in nitrous oxide or intravenous induction agents if an I/V line is secured. Use of nitrous oxide (N_2O) is still controversial. The concerns are bowel distension making the surgical procedure difficult and the decreased visibility. Nausea and vomiting is also thought to be more with the use of N_2O. It can also support combustion and may be a problem when cautery and diathermy are used. Propofol is a good choice mainly for its anti-emetic effects. In combination with remifentanyl, it may be a good combination for rapid emergence but the possibility of propofol syndrome in children must be kept in mind. Prophylatic anti-emetics droperidol, metoclopromide and ondansetron in older children are a must as laparoscopic surgeries are associated with higher incidences of nausea and vomiting. Orogastric suctioning will help. Anti-emetics like Ondansetron 0.1 mg/kg given intra-operatively should be continued post-operatively.

For Laparoscopic pyloromyotomy and fundoplication, a rapid sequence intubation may be required. Volume replacements done, fluid and electrolyte disturbances corrected. In patients with neurological or respiratory compromise, extubation may have to be delayed, ventilatory support and oxygen supplementation may be required post-op.

Muscle relaxation for controlled ventilation may be with one of the intermediate acting muscle relaxants and maintenance of GA with inhalational agents and opioids as required. LMA has been safely used for short procedures and may be useful in asthmatics where one wants to avoid any airway manipulation. In premature infants who have a high incidence of recurrent inguinal hernias and have increased risks with GA, spinal and caudal epidural with LMA have worked well without the need for intubation. If intra-abdominal exploration is required, endotracheal intubation is best to protect the airway. Halothane may not be a good choice for maintenance of GA because the along with the hypercarbia and sympathetic stimulation intra-operatively, it can sensitise the heart and precipitate arrhythmias in combination with halothane.

After tracheal intubation, an orogastric tube is introduced and stomach suctioned to decrease the amount of visceral injury during trocar insertion. Children are usually placed at the foot end of the operating table for easy access especially small infants. The patient should be secured to the operating table with tapes and rolls. Limbs should be well padded and excessive pressure to extremities should be avoided.

The table may have to be positioned in the Trendelenberg and anti-Trendelenberg position many times. The ETT should be secured well or these position changes can cause inadvertent bronchial intubation or extubation. Endobronchial intubation is common with these procedures during gas insufflation and during the procedure due to the cephalad displacement of the diaphragm especially in the Trendelenberg position. This is especially monitored in children. A precordial stethoscope should help for early warning signs.

The vagal stimulation during insufflation and peritoneal stretching causes bradycardia and hypotension. The initial hypertensive response is transient and can be treated with β-blockers or dexmedetomidine. Reflex bradycardia and even asystole can occur especially in smaller children, atropine or glycopyrollate should be at hand. Inadequate anaesthesia at the time when the spermatic cord or viscera is being manipulated causes bradyarrythmias and laryngospasm. Caudal epidural and ilio-inguinal

blocks are very effective in decreasing analgesic and anaesthetic requirements.

These physiological changes are usually well tolerated unless the CVS is already compromised before laparoscopy. The use of positive pressure ventilation can confound all these effects. Ventilation has to be increased 15 – 30% during the procedure to keep the CO_2 levels normal mainly by increasing respiratory rates.

The pneumoperitoneum can cause heat loss in a small child and lack of control over the CO_2 insufflator where the minimum setting is 1L/min can be too much for a neonate. This can be avoided by insufflation of warmed gas and limiting flows to less than 2L/min in older children and minimum possible in neonates. In febrile appendicectomies and other cases, sometimes active cooling may be required.

Monitoring includes all basic including airway pressures, endtidal CO_2 and temperature monitoring. Peak inspiratory pressures are monitored continuously and should return to normal within minutes after decompression of abdomen. The operating table is levelled and residual neuromuscular block reversed at the end of the procedure.

Though laparoscopic surgeries are associated with decreased post-operative pain compared to large incisions with open surgeries, pain due to visceral manipulations, irritation and traction of nerves, vascular traction and injury are common. Inflammatory mediators of pain are thought to be released much more with laparoscopic surgery. The trocar and port sites should be infiltrated with local anaesthetics, opioids or nonsteroidal analgesics via rectal routes or I/V are given intra-operatively and continued post-operatively. Epidural and caudal blocks with opioids have shown to decrease analgesic requirements intra and post-operatively.

Residual gas in the abdomen is manifested as referred pain to the back or shoulder regions and can be distressful post-operatively. Various techniques have been used successfully to reduce this pain. Bupivacaine infiltration before incision of skin sites, low-dose intrathecal morphine, Intraperitoneal local anaesthetic instillation, mesosalpinx block after laparoscopic surgery have all been shown to be beneficial in reducing shoulder pain. Intraperitoneal instillation of both bupivacaine and meperidine combination have shown to be more useful than either through different routes. Toxic doses of LA should be monitored especially in infants. Acetaminophen, non-steroidal analgesics through rectal and

oral routes along with opioids are usually required. Clonidine is especially found to be useful as an adjunct and is thought to reduce the tachycardia associated with pneumopritoneum

Limitations

Laparoscopic surgery has shown to be safe and superior to open surgery even in the neonatal are age group. However, IAP should be limited to 5 – 10 mm Hg in neonates and infants and 10 – 12 mm Hg in older children. Contra-indications for laparoscopic procedures would include hypovolemia, cardiac instability, raised ICP, alveolar distension. Gasless laparoscopic surgery can now be performed in these children and smaller infants where devices are used to tent the abdominal wall.

Future

Natural Orifice Transluminal Endoscopic Surgery (NOTES) is already established in adults in an effort to decrease tissue damage to achieve surgical access. A flexible endoscope is introduced through the wall of an organ like stomach or colon to reach the abdominal cavity via an existing body orifice like buccal cavity, vagina or rectum. Nephrectomy, cholecystectomy, splenectomy, hysterectomy have all been performed via NOTES. The questions remain - who will do the procedure? Is it the endoscopist or surgeon? Do you need General Anaesthesia? Will monitored Local Anaesthesia do? Then, do you need an anaesthesiologist at all? We still do not know all the anaesthetic implications involved.

We now have fiberoptic endoscopes that can be passed through needles and digital video signals that can be electronically modified to yield detailed color images with minimum light intensity. The images can be maintained in the upright position whatever position the telescope is rotated to by digital cameras, they can also be zoomed and magnified. Some of the telescopes are just 2 mm in size. Disposable parts only 2mm in size are mounted on Veress needles and used to introduce these small scopes.

Major advances in endoscopy are on, like the possibility of manipulating digital images by voice or touch screen commands from the operative field. Remote-controlled cameras can direct any view to any monitor or remote site, thus making consultations from remote locations possible. Endoscopic robots are being developed for various surgical applications like robotic tools that can be vocally commanded to position telescopes for optimal viewing and surgical telemanipulators that help with microsurgery in confined spaces even in the smallest infant. Robot

assisted surgery may increase safety especially in a teaching environment. NOTES along with robotic surgery will soon become a reality in pediatrics too.

No doubt, laparoscopic procedures, whether diagnostic or therapeutic, are already evolved and are only going to increase in pediatric surgery. It is only a matter of time before some of the open surgical procedures will become obsolete. It is important we have a thorough knowledge of the pathophysiology of pneumoperitoneum and the complications involved with each stage. Good monitoring and better awareness is essential for early detection and prompt treatment and definitely a team approach for safe, anaesthetic management of these cases.

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