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Principle of minimal access surgery in Children

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Summary

Minimally access surgery (MAS) has overcome many technical limitations and has evolved into a safe alternative for the treatment of many complex pediatric surgical procedures. The introduction of this approach for the correction of many congenital anomalies and other childhood ailments had to wait until instrumentation and surgeons' skills improved enough. With attention to peculiarity of pediatric physiology and anatomic variability, application of MAS to variety of procedures that can be performed in pediatric patients is virtually unlimited. This text detailed the physiology of pneumoperitoneum, ventilation, different MAS approaches and their complications and solutions. The need for improve facility, training and technology transfer in poor resources countries is emphasis.

Introduction

The modern laparoscopic era began in 1901 when Jacobaeus described the use of an optical instrument to inspect the peritoneal cavity of dogs. The evolution of minimally access surgical (MAS) techniques for adults has been among the most important surgical developments of the last century[1]. Pioneers such as Gans, Rodgers, Georgeson, and Lobe showed that MAS was certainly applicable to the pediatric patient but it application lag behind that of adults. Initially, their work was performed on older children since instruments were sized for adults. Technical demands of operating in a small area of an infant was out of the question until instrument makers began to manufacture smaller, shorter tools for pediatric use. Significant recent advances in the downsizing of surgical instrumentation and the development of reliable and safe techniques have broadened the applicability of endoscopic surgery in children. Successful outcomes resulted in more pediatric surgeons and urologists using MAS[2].

In poor resources setting where provision of basic tools for open surgery for children is still inadequate, MAS remains a challenge in children.

Paediatric Peculiarity

Special concerns need to be appreciated in children. The total surface area of the abdominal cavity is markedly reduced compared with adult, as the distance between the anterior peritoneum, the underlying viscera, and major vessels. Special attention and gentleness is required during access. The abdominal wall in children especially infants is very pliable making injury to the underlying vital structures more likely[3].

Anaesthetic consideration

Minimal invasive surgical techniques can present unique problems to the pediatric anesthesiologist in designing and implementing the anesthetic management plan[4]. Induction and maintenance of anesthesia may be with either inhalational or intravenous agents or a combination of both. Nitrous gas increase bowel distension, potentially bringing the peritoneum closer to the area of dissection for retroperitoneal procedures and decreasing the working space for in transperitoneum procedures. Patient positioning during laparoscopy surgery may potentiate the impact of gas insufflations example is trendelenburg position will increase heart rate and vascular resistance while decreasing mean arterial pressure and cardial output, whereas opposite effects is seen in the reverse Trendeleburg position[5]

Physiology

Carbon dioxide is used to form the pneumoperitoneum because it is inexpensive, readily available, very soluble, and unable to support combustion during electrocautery. Multiple hemodynamic and respiratory changes occur during laparoscopy, secondary to the creation of a pneumoperitoneum due to either pressure or absorption effects[4]. As gas is placed in a closed space, it moves depending on the partial pressure gradient. Pressures within the peritoneal cavity above 10 mmHg can lead to compression of the inferior vena cava with a reduced venous return to the heart and to secondary hypotension[6,7]. Furthermore, Limitation of diaphragmatic mobility may cause respiratory restriction, manifested by increase airway pressure, requiring an increase in the peak end-inspiratory pressure to maintain a set tidal volume. Again, renal effects manifested by decrease glomerular filtration rate(GFR) and urine output. The neonates sensitivity to intraperitoneal pressures greater than 10 mmHg must be considered for safe laparoscopy[1]. Georgeson. More hemodynamically important is the mechanical distention of the peritoneal space during insufflation of carbon dioxide[4]. Carbon dioxide insufflation of the peritoneum results in significant decreases in cardiac index and large increases in systemic vascular resistance. Compression of the intraabdominal aorta may contribute to increases in systemic vascular resistance[8]. Another concern during laparoscopic surgery in children is the exaggerated vagal response to peritoneal insufflation.

Absorption effects

Insufflated CO_2 is absorbed into the blood by diffusion, which is limited and determined by many variables; most important are the pressure differential and the cross-sectional area of the absorbing surface. The effects of gas absorbed are either pulmonary or hemodynamics. The pulmonary effects are increased CO_2 retention and increased end-tidal CO_2, exacerbated by decreased functional residual capacity and decreased diaphragmatic excursion. The hemodynamics effects of hypercarbia are increased heart rate, vasodilation, and increased cardiac contractility[9]. The physiological effects of CO_2 pneumoperitoneum may be more pronounced in infants than adults. Neonates have a higher level of end-tidal CO_2 during CO_2 pneumoperitoneum than in adults[1]. Hypercapnia is usually overcome by increasing the minute ventilation and by blowing off the CO_2. Postoperatively, there is a risk that the neonate will be unable to maintain the increased ventilator effort needed to blow-off the CO_2.

Physiology of Ventilation

Although there are several ventilatory techniques that can be used to facilitate surgical exposure during thoracoscopic surgery, the physiologic impact of the resultant one-lung ventilation (OLV) can be quite profound, especially in the youngest and smallest patients. In awake larger children and adolescents, both in the upright and lateral decubitus positions, perfusion is normally distributed preferentially to dependent regions of the lung because of the hydrostatic gradient imposed by gravity. Similarly, ventilation is also preferentially distributed to dependant zones of the lung. This phenomenon is, in large part, due to the cephalad displacement of the diaphragm by the abdominal contents, which paradoxically establishes a mechanical advantage to the diaphragm and facilitates a larger excursion in the dependent portion. Thus, in the awake individual in the supine or lateral position, the overall ventilation to perfusion ratio (V/Q) is maintained. However, V/Q matching is compromised as the child becomes smaller, especially in the lateral decubitus position. In small children, the hydrostatic gradient is less and the chest wall is more compliant, which makes the young child prone to atelectasis (ie, functional residual capacity is closer to residual volume and closing volume) and compromises ventilation[4].(Lynda

It is incumbent on the anesthesiologist to have a clear understanding of all these physiologic changes and potential complications in order to allow minimally invasive surgery to be performed safely and to the maximum benefit of the patient[4]. Intraoperative monitoring should include a routine electrocardiogram, non-invasive blood pressure, SpO_2, temperature and inspired oxygen concentration[10]. Although end-tidal CO_2 may not accurately reflect arterial CO_2 tension, its use is helpful in planning appropriate ventilation strategies[9].

Insufflations

The aim of insufflation is to have unobstructed visualization at optimal pressure. For all laparoscopic procedures, CO_2 insufflation should be started at a pressure of 12-15mmHg for children > 2years olds and 8-10mmHg for children <2years old[9].

Technique

Minimal access surgery contrasts with standard access whereby an operation on an internal organ requires the operator to make a larger incision. The techniques share certain principles. Each requires exposure; each requires lighting. In open operations exposure is accomplished by making an adequate incision in an appropriate location, then holding internal structures aside with retractors. Lighting comes from overhead lights and headlamps worn by the operating team. In laparoscopic and thoracoscopic surgery, access is obtained using ports (valved tubular devices passed through small incisions in the abdominal (or chest) wall. A measured amount of CO_2 is pumped into the abdomen via a port; this allows the abdominal cavity to expand so that the surgeon has room to see and to work. A scope is passed through the port: the scope is attached to a minicamera externally so that the operating team can watch the procedure on a television monitor. Light from an external halogen lamp source passes through fiberoptic rods located within the scope to illuminate the field. After the initial port is placed and the scope is passed, additional ports for instruments are inserted to allow the surgery to proceed. Operative manipulations include division and dissection of tissues, establishing hemostasis, repair of structures, and removal of tissue. Laparoscopic instruments have been developed which allow the surgeon to perform each of the above (Fig 1). In pediatric procedures most instruments used are either 3 or 5 mm in diameter. Specialized graspers permit fragile tissue such as bowel to be handled without trauma. Scissors and dissectors have been designed to permit all of the maneuvers possible with “standard” operating instruments. Irrigation and suction devices allow the workers to keep the operative field clear. Hemostasis is achieved using ligatures, clips, cautery, stapling devices, and ultrasonic coagulation tools. Suturing can be performed internally. Specimens may be removed directly through a port or after first being placed into a protective bag device[2].

Approaches

Laparoscopic

Successful laparoscopy depends on adequate expansion of the peritoneal cavity via pneumoperitoneum for clear visualization of intraabdominal structures. Access to the peritoneal cavity can be obtained either by an open technique or with a Varess needle. Many operated neonates have retained umbilical stumps, making access through the umbilicus problematic. An open technique just below the umbilical stump, through an umbilical fold, is usually successful in giving rapid access to the peritoneal cavity in children. Slippage of trocars can be a major problem, especially in paediatric laparoscopic surgery[11]. The problem can be managed in a variety of ways. Use of radially expanding 5 mm trocar has been found useful. With trocars, 4 mm or smaller, the use of reusable trocars with a snugly fitting red rubber catheter or cut glove sleeve around the outside of the trocar is preferred. The sleeve is sutured to the skin, allowing the trocar to be moved in and out without unintended slippage during operative manipulation[1]. Nearly all procedure performed in a body cavity can be accomplished using the instrumentation available to us today and the variety of laparoscopic procedures that can be performed in pediatric patients is virtually unlimited (Table 1). Contraindications to laparoscopy in infants, children, and adolescent are the same as for any other surgical procedure. Strong contraindications include: cardiopulmonary morbidity, uncorrected coagulopathy and sepsis[9].

Appendicitis

Appendectomy is the most common emergency operation performed by pediatric surgeons. Treatment of appendicitis includes intravenous antibiotics and removal of the appendix. Laparoscopic appendectomy (LA) requires 3 incisions in most cases. One port is placed to accommodate the laparoscope; the other ports allow the surgeon to use instruments to manipulate the appendix and its attachments. Usually the umbilicus is used for the camera/lens port; small incisions in the left lower quadrant and the suprapubic region afford access to the right lower quadrant and upper pelvis. The appendix is identified and isolated. Most surgeons separate the appendix and its blood supply, then secure each either with ligatures, clips, stapling devices, or a combination. The amputated organ may be removed directly through a port, through the largest incision, or placed in a protective plastic bag and removed in either of these fashions. Laparoscopic appendectomy (LA) requires 3 incisions in most cases. One port is placed to accommodate the laparoscope; the other ports allow the surgeon to use instruments to manipulate the appendix and its attachments. Usually the umbilicus is used for the camera/lens port; small incisions in the left lower quadrant and the suprapubic region afford access to the right lower quadrant and upper pelvis. The appendix is identified and isolated. Most surgeons separate the appendix and its blood supply, then secure each either with ligatures, clips, stapling devices, or a combination. The amputated organ may be removed directly through a port, through the largest incision, or placed in a protective plastic bag and removed in either of these fashions[2].

Pyloromyotomy

Pyloromyotomy is often performed during the neonatal period. Laparoscopic pyloromyotomy is
performed using one trocar just below the umbilicus and 2 mm stab wounds in the right and left
upper quadrants. The hypertrophied pylorus is incised with a retractable knife, and the muscle is
split. A pyloromyotomy spreader is used to widely spread the incised hypertrophied pyloric muscle[1]. Geogeson

Fundoplication

Gastrostomy, with or without fundoplication, is a frequent procedure performed in neonates. Common indications include primary aspiration, gastroesophageal reflux, profound neurologic impairment and severe pulmonary and cardiac disease with failure to thrive or recurrent aspiration. Neonates needing fundoplication are usually excellent candidates for a laparoscopic approach. The fundoplication is performed using 3 mm trocars. The distal oesophagus is mobilized and secured in the abdomen, and the crura are approximated behind the oesophagus. The fundal wrap is formed loosely around the intraabdominal oesophagus[1]. Georgeson

Duodenal atresia

The repair of duodenal atresia is amenable as a laparoscopic approach. The proximal and distal
segments of the duodenum are mobilized and approximated with the placement and tying of
anastomotic sutures intracorporeally[1]. Geogeson

Malrotation

Malrotation, with or without mid-gut volvulus, has been successfully repaired laparoscopically. The volvulus is detorsed, and a Ladd's procedure is performed using three or four access trocars.

Appendectomy can also be performed by exteriorizing the appendix through a 3 mm trocar site.

There is some controversy as to whether the lack of adhesions, which usually form after open surgery and prevent recurrent volvulus, may be a flaw of the laparoscopic procedure[1]. Geogeson

Pull-through for Hirschsprung's disease

The management of Hirschsprung's disease has been radically changed by endoscopic surgery. A
pull-through after laparoscopic localization of ganglion cells, proximal to the transition zone, is
utilized. Although the pull-through can be performed using a Duhamel or Swenson technique, the most common procedure performed endoscopically is an endorectal pull-through[12,13].(25,26 geogeson) Hirschsprung's disease is now managed by a single

primary pullthrough as opposed to the two- or three-stage procedure formerly used to correct the disorder.

Repair of Anorectal malformation(ARM)

High imperforate anus is usually repaired by a posterior sagittal anorectoplasty. The alternative
laparoscopic repair of a high ARM starts by the dissection of the recto-urethral or recto-vesicular fistula transabdominally. The muscle complex is identified by muscle stimulation on the perineum. A tract is developed through the muscle complex by identifying the appropriate
landmarks both perineally and transabdominally. This tract is sequentially dilated through a radially expanding trocar. The fistula is pulled down to the perineum through the tract and secured to the perineal skin with sutures. This laparoscopic repair of a high ARM mimics the commonly performed repair of a low imperforate anus, where the fistula to the perineum is mobilized and is then pulled through the external sphincter[14]. Continence after laparoscopic pull-through has not been fully assessed, although the early results appear to be promising[1].

Inguinal hernia repair

Repair of inguinal hernia is one of the most common procedures performed by pediatric surgeons. Controversy exists over whether a child with a hernia on a single side should undergo surgical exploration of the "silent" side[2]. Placement of a purse-string or figure-of eight suture laparoscopically or transabdominally with laparoscopic surveillance closes the internal ring[15]. A potential advantage of the laparoscopic assisted inguinal hernia repair includes the avoidance of injury to the cord structures and testicles. In the classic open hernia repair, the hernia sac is stripped away from the vas deferens and testicular vessels. Many studies have suggested that this stripping of the chord structures may produce unintended permanent changes in the vas deferens and testicles[1]. Laparoscopic evaluation of a patent contralateral processes vaginalitis is now commonly performed around the world. A pneumoperitoneum is developed by way of the exposed hernia sac. An angled scope is then passed through the hernia sac, and the contralateral groin is visualized for patency.

Ovarian and pelvic pathology

Neonatal ovarian cysts can also be treated laparoscopically. Options include decompression, excision, fenestration, oophorectomy, and adnexal detorsion and fixation[16,17]. Laparoscopic dissection of the pelvic portion of a sacrococcygeal teratoma has been described by Bax and van der Zee[18].

Retroperitoneum laparoscopic approach

Retroperitoneal route provide a direct approach to the genitourinary organs, thus necessitating less dissection to expose the kidneys and avoiding the peritoneal contents, potentially decreasing the risk of intraperitoneal adhesion formation[19]. It facilitate the view of the posterior surface of the kidney with rapid access to the renal hilum. Previous transperitoneum surgery does not preclude retroperineoscopy. Incidence of postoperative hernia from trocar site is less[9]. Bowel preparation is common practice in children. Flank position which increase the anteroposterior dimensions of the retroperitoneum space is preferred. Access to the retroperitoneum is preferably achieved by the open(Hasson) technique which provide visual guide. As children have a small retroperitoneum space, and close proximity between the abdominal wall and the major vessels. A 10-mm Hasson trocar with a blunt tip is introduced into the perinephric space, creating the retroperitoneal space with CO2. Further mobilization of the kidneys is done posteriorly by blunt dissection using the laparoscope and CO2 insufflation[20]. This approach is useful for pyeloplasty[20,21]adrenalectomy, nephectomy, pyelolithotomy and ureterolithotomy[9]. It is relatively contraindicated in prior retroperitoneum scar, previous infection or inflammatory retroperitoneum process. The main disadvantage of retroperitoneum approach is difficult manipulation of instrument due to restricted working space[9].

Thoracoscopic

Pediatric surgeon have been involved in thoracoscopy for a long time. The technique provides excellent view of the internal thoracic anatomy and with no trauma to the thoracic wall[22]. For thoracoscopy to be applied in Children, appropriate anaesthetic techniques play a central role. General anaesthesia with positive-pressure ventilation can impair visualization inside the pleural space during thoracoscopy due to lung expansion. Single-lung ventilation by intubation of a mainstem bronchus is the most common technique used by paediatric anaesthesiologists to partially collapse the ipsilateral lung for infant thoracoscopy[23]. Double-lumen tubes are not available in appropriate sizes for neonates. Bronchial blockers, such as a Fogarty catheter passed through or beside an endotracheal tube, can be used to block ventilation in the ipsilateral lung[23]. Low-flow and low-pressure infusion of CO_2 into the ipsilateral pleural space can help to partially compress the lung and improve visualization of intrathoracic structures. This technique is well tolerated in most neonates. Potential complications of the technique, such as CO_2 embolism and hypotension due to impaired venous return, have not been reported as significant problems in neonates. Stopping the infusion and relieving the pneumoperitoneum can readily reverse the hypercarbia and hypoxia due to intrapleural infusion of CO_2[1]. Thoracoscopy has gained a definitive position in the treatment of some childhood conditions. (Table 2)

Diagnostic thoracoscopy

Thoracoscopy for diagnostic purposes is used infrequently due to the advances in diagnostic imaging. In carefully selected patients, however, visualization of the intrathoracic cavity can be nicely achieved using thoracoscopy.

Lung biopsy

Biopsy of lung lesions is one of the most common indications for thoracoscopy. Lung biopsies are usually obtained in children with diffuse lung disease of undetermined origin. The small segment of lung to be biopsied is encircled by a loop ligature. An adequate specimen of lung tissue is obtained by cutting away the tissue peripheral to the loop ligature. The tissue is removed through one of the trocar sites[23]. Lung biopsies can also be obtained using sealing energy sources, which coagulate and seal the lung tissue. The biopsy is then taken using scissors to excise the sealed portion of lung.

Pulmonary resection

Lung resection using a thoracoscopic approach is being performed in some neonatal centres. Cystadenomatoid malformations, intralobar and extralobar sequestrations and lobar emphysema have all been managed by thoracoscopic excision. Usually, the lungs are freed using sealing energy sources followed by stapling of the bronchus and major vessels. A trocar site is then enlarged for the removal of the resected lobe.

Mediastinal masses

Resection of mediastinal cysts and oesophageal duplications are amenable to thoracoscopic
approaches in neonates[24]. Bronchogenic cysts are easily dissected because they have no discrete connections with other important structures in the chest. Oesophageal duplications usually have a common wall with the oesophagus and sometimes have a luminal communication. All mediastinal dissections should be performed with a bougie in the oesophagus. If there is a luminal communication between the oesophagus and the oesophageal duplication, the mucosa and muscle of the remaining oesophagus can be closed using sutures placed thoracoscopically. Great care must be taken not to compromise the oesophageal lumen during closure of the oesophagus. Thoracoscopic biopsy of undefined mediastinal masses is a technique that avoids the large thoracotomy wound normally employed for such a biopsy[1].

Closure of patent ductus arteriosus

Thoracoscopic clipping of a patent ductus arteriosus (PDA) is performed using three or four ports. The patient is placed in a semi-prone position to allow the lung to fall away from the posterior thorax. The ductus is carefully dissected, preserving the recurrent laryngeal nerve, which loops around the PDA. An appropriate trocar site is then enlarged slightly, so that a clip applier can be passed directly through the chest wall. The clip is applied under endoscopic surveillance[25]. The recurrent laryngeal nerve is visualized while the clip is being applied to avoid injury to the nerve. Placement of a chest tube is optional, depending upon the surgeon's preference.

Oesophageal atresia

One of the most dramatic changes in paediatric surgery has been the use of thoracoscopy to clip
and divide a tracheoesophageal fistula and to approximate the proximal and distal oesophageal
segments. Three or four trocars are used. The neonate is placed in a semi-prone position to induce the lung to fall away from the posterior mediastinum. The azygos vein is divided using electrocautery. The tracheoesophageal fistula is identified and clipped immediately adjacent to the trachea. The distal oesophagus is divided. The proximal pouch is dissected thoracoscopically, and the distal end of the proximal pouch is opened. A hand-sewn thoracoscopic anastomosis is fashioned with 10–15 sutures. The

knots are tied either extracorporeally or intracorporeally[26,27]. Suturing in this setting is tedious because of the very small working space in the posterior chest. Only experienced paediatric endoscopic surgeons are currently performing this procedure. With further evolution of robotics and alternative suturing devices, the practice of thoracoscopic repair of oesophageal atresia should expand.

Repair of diaphragmatic hernias and diaphragmatic eventrations
Both Bochdalek and Morgani diaphragmatic hernias have been repaired using an endoscopic technique[28]. Thoracoscopic repair of diaphragmatic hernias has been performed in stable patients, but has not been attempted in infants with pulmonary hypertension and severe pulmonary hypoplasia. Diaphragmatic hernias have been repaired using a primary closure technique as well as by application of a patch graft. Repair of diaphragmatic hernia has been performed both thoracoscopically and laparoscopically. Eventration of the diaphragm and a high-riding paralyzed diaphragm have been plicated with a thoracoscopic technique. If CO_2 infusion is used for enhancement of intrathoracic visualization, there is the added benefit of the diaphragm being pushed down by the pressure of the infused pneumothorax. This pressure enlarges the involved pleural space and aids in the plication of the hemidiaphragm. The plicating sutures are placed and tied thoracoscopically[1].

Fetal Surgery
Laparoscopic procedures performed in utero are described as “fetoscopic” surgery. Numerous procedures have been performed, including bladder decompression in posterior urethral valves[29], laser coagulation of vascular anastomoses in severe twin-twin transfusion syndrome[30], temporary tracheal occlusion in the fetus with diaphragmatic hernia, division of amniotic bands, access to fetal vessels, and drainage of fetal hydrothorax[31]. Early experience with fetoscopic surgery suggests a reduction in the risk of preterm delivery when compared with open fetal surgery[32].

Robotic Surgery
Robotic surgery has been introduced to pediatric surgeons as a method to perform laparoscopic surgical procedures with the additional benefit of three-dimensional imaging and full range of motion. Through the use of robotic arms, surgeons can rotate instruments 360 degrees in all planes. Surgeons perform procedures with robotic arms from a console distant from the patient. A second surgeon at the surgical site changes the robotic arms as needed for electrocautery, dissection, and suturing. The anesthetic concerns remain the same as for other laparoscopic procedures, but access to the patient is extremely limited because the cumbersome apparatus that attaches to the robotic arms is positioned at the head of the operating room bed. In addition, children must be elevated approximately 6 inches off the surface of the bed so that movement of the robotic arms will not impinge on the operating room table[4]

Pitfalls and solutions

Malfunction of the equipment

Success of the laparoscopy and other MAS depends heavily on the proper functioning of the equipment. Well-trained nurses capable of quickly recognizing and correcting equipment malfunctioning are mandatory.

Fogging of the lens

Initially warming the laparoscope in warm saline or povidone- iodine solution or commercial defogging fluids may avoid fogging of lens. Inadequate vision may result from a gas leak around the trocar leading to collapse of the retroperitoneum space. An extra purse-string suture around the trocar may help decrease the leak. Another possible reason for poor vision during retroperitoneoscopy is a peritoneum tear causing intraperitoneum insufflations. This is an indication for conversion to transperitoneum approach or to attempt to vent the peritoneum[9].

Bleeding

Bleeding may occur while bluntly dissecting, especially the retroperitoneum space. In this case, secondary trocar should be inserted posteriorly and small vessels must be handle carefully using electrosurgical scissors or bipolar cautery forceps to secure hemostasis[9].

Subcutaneous emphysema

Subcutaneous emphysema may occur due to leakage of CO_2 into the skin around the area of the ports, as that area is larger than the size of the trocar. Signs of the problem include readily palpable crepitous over the thorax, flank or abdomen. Treatment for this complication includes either placement of the purse-string suture around the leaking port, changing the trocar to a larger size, or reduction of the insufflations pressure[9].

Complication

Complications of laparoscopic surgery

Serious vascular injury is a rare but potentially devastating complication of laparoscopy. Most injuries occur during placement of the initial port at the umbilicus[33,34]. Injury to the inferior epigastric vessels during port placement may also occur. In children the distance between the abdominal wall and the great vessel may be as little as 5cm. to avoid vascular injury, it is advisable to tailor the length of the trocars to the patients age and body habitus[9]. Conversion to open surgery to control bleeding may be preferred in some instances. Bowel injury is a risk of both transperitoneum or retroperitoneum laparoscopy. If bowel injury is identified during laparoscopy, it is best repair at that time. In addition, injuries to the liver or spleen may occur during retroperitoneum laparoscopy. Superficial vascular injuries can be controlled with gel foam, argon beam coagulation otherwise open exploration is recommended[9]. Trocar site herniation and infection have occurred[35]. Herniation may occur at port sites as small as 3mm or 5mm. Laparoscopic correction and repair can be performed[36]. Adhesions form after all intrabdominal operations. The severity of adhesion formation have been found to correlate to the extent of dissection which is less with laparoscopy.

Complications of Thoracoscopic Surgery
With any manipulation involving the airway, trauma or malposition related to the device can occur. Careful and gentle placement of specialized tracheal tubes and endobronchial blockers and diligent confirmation of their position by fibreoptic scope(FS) will avoid problems postoperatively. Meticulous attention to the volume of air placed in both the tracheal and blocker cuffs will help minimize mucosal trauma and avoid bronchial disruption. Hypoxemia and hypocapnia can occur during one lung ventilation(OLV). The causes are multifactorial and include impaired hypoxic pulmonary vasoconstriction(HPV), decreased FRC from atelectasis and airway closure, preexisting pulmonary pathology, malposition of the tracheal tube, and/or bronchial blocker and compromise of the TT lumen by foreign material. Interventions for hypoxemia include maximizing inspired oxygen concentration, reassessing position of the trachea tube TT and any bronchial devices, applying CPAP to the operative lung, and suctioning the TT. Although mild hypercarbia occurs during OLV, it is usually not a serious problem and can often be compensated by increasing respiratory frequency. Soiling of the nonoperative lung by blood or purulent material, unanticipated intraoperative bleeding, and conversion to open technique are other potential problems that must be anticipated during thoracoscopic surgery[4].

Pain Control
Techniques for control of postoperative pain are the same for MAS as for open surgery. Infiltration of bupivicaine at port sites, caudal block and intraperitoneal lidocaine reduces early postoperative discomfort[21,37]. Patient- controlled analgesia works well in both groups and provides a measure by which the degree of postoperative pain of MAS and open surgery can be compared[38].

Training
MAS is a natural extension of traditional surgical therapy, but the techniques and dexterity required to master MAS is a separate set of skills. Training should be incorporated into all surgical residency programs, and fellowships are available. Many didactic courses are offered with animal models to use for learning technique. More complicated procedures often require the surgeon to practice in a laboratory setting. DeCou and colleagues[39] developed a computer based virtual reality model with which

to practice LP. The model allowed them to identify weak areas in the procedure, then make corrections before patient use that result in success once the technique was introduced clinically[2].

Cost

Many laparoscopic procedures cost more than their traditional open counterparts. MAS procedures may take longer and use disposable equipment, increasing operating room expenses. These costs are often offset by avoiding ICU stays and by reducing lengths of stay[40]. Using reusable instruments can further decrease costs[41].

Future

In poor resources countries which characterized by poor human development, endolaparoscopy has been pioneer by personal efforts both in training and provision of facility. The cost of MAS may be difficult to bear by the teeming poverty riddle community. The extension of health insurance to all and sundry may go a long way in propelling us towards the global trend.

Conclusion

Minimally invasive surgical procedures have numerous advantages over their traditional invasive counterparts. These include less pain, smaller incisions and scars, and shorter hospitalizations. Significant physiologic changes and potential complications are associated with one-lung anesthesia for thoracoscopic surgery and creation of a pneumoperitoneum for laparoscopic procedures in children. Lynda MAS clearly has a steep learning curve, and complications with MAS do occur. Often MAS procedures are more expensive in the operating room, but less costly for the hospital room.

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Table 1. Pediatric Laparoscopic Procedures

Achalasia
Adrenalectomy
Antireflux Procedures(Fundoplication) and Gastrostomy
Appendectomy
Bariatric procedures
Cholecystectomy/Hepatobiliary
Colectomy
Excision
Herniorrhaphy/Herniotomy
Nephrectomy
Orchiopexy
Pyloromyotomy

Repair of diaphragmatic hernia **Splenectomy** **Varicocele** **Undescended Testis**

Table 2: Thoracoscopic procedures in children

Anterior spine fusion **Aortopexy** **Cyst excision** **Decortication** **Diagnostic or hardware positioning (Nuss procedure)** **Diaphragmatic hernia repair, plication** **Esophageal atresia repair, myotomy, resection** **Foregut duplication resection** **Lobectomy**

Lung biopsy or resection **Mediastianl biopsy or mass excision** **Patent ductus arteriosus ligation** **Pericardial window** **Pleurectomy** **Sequestration resection** **Sympathectomy** **Thoracic duct ligation** **Thoracic mass excision** **Thymectomy** **Tracheoesophageal fistula repair**