

Current Trends in Minimal Access Surgery for Neonates

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Abstract Minimal access surgery (MAS) is a milestone development in the history of surgery. Several small puncture wounds are used to perform surgical procedures that would otherwise require a large incision. The benefits of MAS have been well documented in adults. With advances in miniaturized instruments, video technology, new surgical techniques and anaesthesia, MAS is increasingly performed in infants and neonates. Currently, it has been used in both neonatal chest and abdominal conditions. However, further clinical studies are required to document the benefit of MAS in neonates in the long term.

Key words Laparoscopy; Minimal access surgery; Neonatal surgery; Thoracoscopy

Introduction

Minimal access surgery (MAS) is an important milestone development in the history of surgery. However, its use is not new to paediatric surgeons. The laparoscope was used for diagnostic purpose in children as early as the 1970s but its use had been confined to such.¹ Since the early 1990s, there has been an explosive expansion of laparoscopic surgery in adults and the potential advantages have been well documented.^{2,3} Its use in children, however, was initially confined to a few centres only. With advances in miniaturised instruments, video technology, surgical techniques and anaesthesia, MAS is being increasingly

applied in children in all areas. Over the last 10 years, the application of MAS techniques to neonates has progressed rapidly and is used in many chest and abdominal conditions.

General Principles of Minimal Access Surgery

In laparoscopic and thoracoscopic surgery, access is achieved via ports inserted through small puncture wounds in the abdominal or chest wall. Carbon dioxide (CO₂) insufflation is used to expand the abdominal or thoracic cavity to allow enough room to work. A scope attached to a camera is passed through a port so that the procedure can be watched on a monitor. Light from an external source passes through fibreoptic rods within the scope and provides illumination to the operating field. Laparoscopic or thoracoscopic instruments are then passed through the ports for operative manipulations. These instruments are specially designed to allow maneuvers similar to standard open operative instruments. For thoracoscopy, single lung ventilation either by intubation of contralateral main stem bronchus or bronchial blocker of ipsilateral lung is the usual technique used to partially collapse the ipsilateral lung.⁴ A low-flow (<1 L/min) and low-pressure infusion (<4 mmHg) of CO₂ is often needed to provide further compression of the partially collapsed lung in order to allow more room to work. For laparoscopy, the intra-abdominal

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pressure is usually maintained below 10 mmHg in neonates and proportionally higher in children. Meticulous control of the pressure is essential as carbon dioxide pneumoperitoneum may have profound physiological effects in neonates resulting in hypercapnia and respiratory acidosis.⁵ This can be compensated for by slight hyperventilation.⁶ Cardiovascular compromise may result from compression of the inferior vena cava leading to decreased venous return and hypotension.⁷

In general, neonates who have an unstable haemodynamic status with severe cardio-pulmonary compromise, bleeding disorders, severe abdominal sepsis or gross abdominal distension are not suitable for laparoscopic/ thoracoscopic surgery.

Laparoscopy

A number of abdominal operations using laparoscopic approach have been performed in neonates. In some conditions, laparoscopy has virtually replaced open surgery as the operation of choice while in others it may be a good alternative.

Fundoplication and Gastrostomy

Fundoplication with or without feeding gastrostomy is a common procedure performed in neonates. Indications include gross oesophageal reflux, recurrent aspiration, and profound neurological impairment with failure to thrive. Laparoscopic approach has virtually replaced open surgery. The operation can be performed using 3 to 4 ports and consists essentially of mobilisation of the distal oesophagus, approximation of the crura behind the oesophagus and loose wrapping of the distal oesophagus with the fundus. For those with feeding problem, a laparoscopic guided gastrostomy button is often inserted in the same setting.⁸ Indeed laparoscopic gastrostomy is often used as an alternative to percutaneous endoscopic gastrostomy as it allows accurate selection of the site for gastrostomy and also avoidance of accidental injury to nearby structures during creation of the gastrostomy.

Pull-through for Hirschsprung's Disease

The management of Hirschsprung's disease has gone through revolutionary changes from the traditional open two to three stage procedure to the open one stage procedure, and more recently to the laparoscopic-assisted or trans-anal one stage pull-through. All the traditional

techniques of Swenson, Duhamel and Soave can be applied laparoscopically but the Soave (endorectal) technique is most commonly performed.⁹ The procedure involves laparoscopic localisation with histological confirmation of the transitional zone, mobilisation of the colon, trans-anal sub-mucosal dissection, pull-through of the colon and anastomosis of the colon proximal to the transition zone to the anal region. Early result of the procedure has been satisfactory.^{9,10} Although further studies are necessary to determine the long-term outcome, it is likely that laparoscopic-assisted pull-through procedure is going to stay and will become increasingly popular.

Pull-through for Imperforate Anus

High type of imperforate anus has been traditionally managed with an initial defunctioning colostomy followed later by pull-through procedure using an abdominal perineal approach or posterior sagittal anorectoplasty. Laparoscopic-assisted pull-through for a high anomaly has been described.¹¹ The fistula is first dissected and ligated using laparoscopic approach. The site of the sphincteric muscle complex is identified by muscle stimulation on the perineum. A tract is then made through the muscle complex into the pelvic cavity as guided by the laparoscope. This tract is then dilated and the large bowel is pulled through to the perineum and a neo-anus reconstructed. Short-term result has been promising though the long-term outcome of continence needs further study. One stage primary pull-through without initial defunctioning colostomy has been reported.¹¹ This has the advantage of saving multiple operations, avoiding the problems of colostomy and the potential neural developmental superiority of the infant stooling through the anus soon after birth. However, primary pull through in newborn is technically difficult, and long-term data is lacking.

Pyloromyotomy

Ramstedt's pyloromyotomy has been regarded as the gold standard for the management of hypertrophic pyloric stenosis. In order to have a better cosmetic effect, approach using peri-umbilical incision has been described with successful outcome.¹² Laparoscopic pyloromyotomy gives equally good result¹³ with excellent cosmetic effect and is becoming an increasingly popular alternative.

Intestinal Atresia

The repair of intestinal atresia is possible using laparoscopic approach. Laparoscopic repair for duodenal

atresia has been reported¹⁴ although cases with associated severe cardiac anomaly may limit its use. The proximal and distal segments are mobilised and then joined together using intracorporeal sutures. For more distal intestinal atresia, the dilated bowel loops may render laparoscopic approach more difficult and technically demanding.

Malrotation and Volvulus

Malrotation with or without volvulus has been repaired using laparoscopic approach.^{15,16} The volvulus is untwisted and a Ladd's procedure performed. For cases with equivocal findings, laparoscopy can provide a diagnostic tool.¹⁶ In those cases with significant bowel ischaemia and dilatation, laparoscopic approach may be difficult and an open approach is preferable.

Inguinal Hernia

Laparoscopic herniotomy has been reported.¹⁷ Advantages include the detection of contralateral hernia allowing repair in the same setting, and the avoidance of potential injury to the vas deferens and cord vessels that might be associated with the conventional open repair while the hernia sac is being stripped off the vas and vessels.

Intussusception

Intussusception is a common cause of intestinal obstruction in infants but less so in neonates. Non-operative treatment using pneumatic or hydrostatic reduction usually suffices for 80-90% of cases. Laparoscopy may have a role in those cases with equivocal complete reduction or unsuccessful non-operative treatment.¹⁸

Hepatobiliary Disorders

Laparoscopy has been used in operative cholangiogram¹⁹ and liver biopsy in cases of prolonged jaundice. Sporadic cases of laparoscopic-assisted repair of biliary atresia and choledochal cysts have been reported.²⁰ However the long-term results of these cases are not available and laparoscopic repair should only be used in selected cases.

Ovarian and Pelvic Disorders

Laparoscopy has been used in the treatment of ovarian cysts in neonates²¹ and in the dissection of the pelvic portion of sacrococcygeal teratoma.²²

Urological Disorders

The application of laparoscopic surgery in paediatric urology is beginning to accelerate. Indications have

expanded from diagnostic to ablative and recently to reconstructive procedures. The current status of its application includes orchidopexy for high undescended testis, varicocelectomy, total or partial nephrectomy, dismembered pyeloplasty, adrenal surgery and ureteric re-implantation etc.²³ However, these procedures are seldom required to be performed in the neonatal period. Instead, endo-urology may be required for ablation of posterior urethral valve and for provision of external or internal drainage in cases of obstructive uropathy.

Necrotising Enterocolitis

Necrotising enterocolitis (NEC) is the most common gastrointestinal emergency in neonates affecting mainly premature infants. Lack of specific indications for surgical intervention is occasionally encountered in critically ill babies with suspected NEC. Laparoscopy has been used in these cases either confirming the diagnosis or reviewing the extent of the disease, which can guide the subsequent management.²⁴

Thoracoscopy

Thoracoscopy is not as commonly used as laparoscopy in neonates. It can be used for diagnostic purpose such as biopsy of lung lesions.⁴ Resections of thoracic lesions like cystadenomatoid malformations, sequestrations, mediastinal masses²⁵ can be performed via thoracoscopy.

Oesophageal Atresia

The management of oesophageal atresia has gone through revolutionary changes. One of the recent advancement is the use of thoracoscopy to clip and divide the tracheo-oesophageal fistula and to join the proximal and distal oesophageal segments.²⁶ Apart from the minimal wound pain and the excellent cosmetic effect, there is the avoidance of the potential musculoskeletal weakness that may result from the conventional open thoracotomy. However, thoracoscopy may not be applicable in babies who are premature or small for dates and with associated severe cardiac and pulmonary anomalies.

Diaphragmatic Hernia and Eventration

Thoracoscopic or laparoscopic approach has been used in the repair of diaphragmatic hernia in stable infants.^{27,28} Symptomatic eventration of the diaphragm can be plicated using a thoracoscopic technique.

Patent Ductus Arteriosus

A patent ductus arteriosus can be clipped using thoracoscopic means preserving the recurrent laryngeal nerve.²⁹

Potential Benefits and Complications of Minimal Access Surgery

Despite the exponential growth of MAS in children in the past few years, its application in neonates should not be considered as a direct transposition of techniques used in older children.³⁰ Because of the much reduced working space and the potential effects of carbon dioxide pneumoperitoneum and pneumothorax on an immature neonatal cardiopulmonary system, neonatal MAS is rendered more difficult.³¹ Most of the reports on the feasibility of MAS in neonates are case reports or small clinical series, and there is hardly any multicentric study on the complications and cardiorespiratory effects of neonatal MAS.³² A multicentric assessment of the safety of neonatal MAS was reported recently.³³ There was no mortality but a significant morbidity (19.2%) including both surgical (7.5%) and anaesthetic incidents (12%). The majority of the surgical incidents was minor and was likely to be related to the learning curve of the surgeons. The anaesthetic incidents occurred during insufflations including desaturation, transient hypotension, hypercapnia, hypothermia and metabolic acidosis. It was possible to limit these respiratory, haemodynamic and thermic imbalances in 42% by ventilatory adjustments, vascular expansion and external warming. Insufflations had to be temporarily (35%) or definitively (23%) stopped, and conversion to open surgery was required in the latter. The significant risk factors for an insufflation-related incident were young age, low body temperature, thoracic insufflation, high pressure and flow of insufflation, and length of surgery. The overall rate of conversion to open surgery was 15%. This study stresses the importance of thorough preoperative evaluation and close surveillance of the haemodynamic and ventilatory status during insufflation. A pressure of 8 mm of Hg appears to be the limit beyond which the risk of insufflation-related incident tends to increase. The advances in specifically designed instruments for neonates and the growth in the experience of the surgeons will decrease the incidence of the surgical complications and the need for conversion to open surgery.

The benefits of MAS are evident with less adhesion, less postoperative pain, better cosmetic result and less length

of hospital stay.³⁴ It seems that the limit of MAS for neonates is not the technical feasibility but rather the right selection of those who would benefit.

State of Development in Hong Kong

In Hong Kong, MAS has been adopted in children as early as the 1990s but the rapid expansion occurred since 1998. Rapidly it is being used in all the paediatric surgical centres, and currently, all of the aforementioned procedures can be performed. As these procedures require the close co-operation of multi-disciplines, they can only be performed in recognised paediatric surgical centres. Indeed Hong Kong has become one of the leading centres in laparoscopic surgery with new pioneers and innovations. These innovative procedures on complex anomalies have been presented and subsequently published. International and regional conferences on paediatric MAS take place regularly, and prove to be of great help in its development.

Conclusions

Minimal access surgery has grown remarkably over the last twenty years and is continuing to expand. A lot of surgical operations in neonates can now be performed with minimal access surgery with good reported results. However few studies to date have been subjected to critical analysis and results must be interpreted with caution. With further advances and refinement in technology and technique, minimal access surgery should continue to expand and will be seen as a major changing trend in neonatal surgery.

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