CURRENT TOPIC

Laparoscopic surgery in children

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Laparoscopic surgery in children is not new. Paediatric surgeons were among the pioneers of laparoscopic surgery in the early 1970s,[1] but the vast potential of this "minimally invasive" approach to treat children with surgical conditions has only recently begun to be realised. For over two decades, paediatric laparoscopy was restricted mainly to diagnostic use. In the early 1990s, an explosive expansion of laparoscopic surgery occurred in adults as a result of the success of laparoscopic cholecystectomy. Nevertheless, interest in laparoscopic surgery in children remained confined to a few enthusiasts initially,[2–4] while the rest of the paediatric surgical community adopted a "wait and see" attitude. More recently however, with increasing experience in paediatric laparoscopic procedures,[5–7] and advances in miniaturised instrumentation, laparoscopy's place in the modern paediatric surgical armamentarium has finally become accepted. In the USA, it is estimated that 82% of paediatric surgeons perform laparoscopic surgery.[8] The question is no longer whether laparoscopic surgery should be done in children, but what conditions should be treated laparoscopically.

Principles

Laparoscopic surgery involves insertion of a telescope for visualisation, and additional ports for therapeutic instrumentation under general anaesthesia. Initially, adequate illumination and clear images were obtainable only with relatively large telescopes, but in the past few years good quality paediatric telescopes as little as 2 mm in diameter have become available. The telescope is usually inserted through the umbilicus, resulting in an invisible scar. The image is transmitted to one or more television monitors.

The number of instrumentation ports needed is related to the complexity of the therapeutic procedure—for example, one or two for laparoscopic clipping of varicocele, four for laparoscopic fundoplication. The laparoscopic instruments are designed for the same purposes as those used in open surgery: tissue holding, dissection, retraction, haemostasis, suturing, etc. These days, most paediatric laparoscopic instruments measure 2–5 mm in diameter. A 10 mm trocar is only needed for complex items such as stapling devices. Technological innovations such as ultrasonically activated (harmonic) scalpel and laser have greatly facilitated laparoscopic dissection and haemostasis.

A pneumoperitoneum is usually required for laparoscopy. Insufflation of carbon dioxide is limited to a pressure of 8–15 mm Hg in children to minimise diaphragmatic splinting. Gasless laparoscopy is achievable by lifting the abdominal wall with special retractors (PKH Tam *et al*. XLVI annual international congress of British Association of Paediatric Surgeons, Liverpool, UK, July 1999) or subcutaneous wiring,[9] but the modification is not widely practised. For renal/adrenal surgery, a retroperitoneal approach can be adopted by opening up the perirenal space with blunt dissection.[10]

Thoracoscopic surgery for chest pathology is the equivalent of laparoscopic surgery for abdominal diseases and entails single lung ventilation.[11] This requires close cooperation between surgeon and anaesthetist.

Advantages

Unlike other major advances in surgical management, such as parenteral nutrition and organ transplantation, which involve introduction of new concepts of treatment, laparoscopy only provides an alternative means of doing the same procedures as in open surgery. No additional lives are saved by the new approach. Instead, the benefits are seen in terms of the quality of life after the procedure. Although the idea of laparoscopy is dependent on technology, there are many human elements involved in its development—the clamour for laparoscopic surgery is often patient driven even though the results of the procedure are very surgeon dependent.

The main advantages of laparoscopic surgery for patients are less postoperative pain, reduced wound complications, minimal scarring, a shorter hospital stay, and an earlier return to normal activities including feeding, bowel movements, and work/school. In the debate of open versus laparoscopic surgery in children, the old argument that "my incision is smaller than your trocar sites"[6] has been weakened by the development of finer and finer laparoscopic instruments. From the socioeconomic viewpoint, although children's early return to normal activity after laparoscopic surgery does not add productivity directly, their parents' early resumption of work does. Hospital charges can also be lower for laparoscopic surgery as a result of reduced hospital stay and pain medication, but these may be offset by increased operating time and expensive consumables. More importantly, a lower hospital charge for laparoscopic surgery is dependent on a low complication rate,

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which might be achieved only in experienced centres.

For the surgeon, laparoscopy is particularly attractive for operations in deep cavities of small children—for example, the hiatus and the pelvis, because of good illumination and magnification. Whereas the observers' view of open surgical procedures in small children is limited, video imaging of laparoscopy allows surgical assistants, anaesthetists, and nurses to see what the laparoscopic surgeon is doing and to participate actively in the procedure in their respective roles.

Disadvantages

Apart from longer operating times, expensive consumables, and a large capital cost, laparoscopic surgery has inherent limitations for the surgeon. These include a two dimensional visual image, a loss of touch sensation, difficulty in controlling bleeding (limited suction, no manual pressure), limitation in the number and directions of instruments, difficulty in suturing. As a result, new skills have to be acquired. Fortunately, intensive, well structured training courses are now readily available.

Nevertheless, there is a learning curve and laparoscopic skills have to be maintained and improved. This presents a bigger challenge to paediatric surgeons than to adult surgeons, who have a regular procedure such as laparoscopic cholecystectomy to refine their laparoscopic skills. For laparoscopic cholecystectomy, the learning curve ranges from 10 to 75 procedures.[8] For laparoscopic fundoplication in children, proficiency could be achieved after 25 procedures.[12] In a series of laparoscopic pyloromyotomy, good results were achieved after 23 procedures, but these were associated with seven complications (30%), six of which required reoperation.[13] A potentially high complication rate in the early part of the learning curve is one of the most uncomfortable facts the surgeon will have to face, especially when this is judged against the excellent results of many paediatric procedures achieved by open surgery. A recent survey that highlights the increasing popularity of laparoscopic surgery suggests that many paediatric surgeons are early in their learning curve.[8]

Most complications of paediatric laparoscopic surgery are technique related. Haemorrhage is a dreaded complication because intraperitoneal bleeding is more difficult to control laparoscopically and children respond poorly to haemodynamic disturbances. Inadvertent visceral injury during trocar insertion is another feared complication. The use of an open technique for the insertion of the first trocar and placement of subsequent trocars under direct vision minimises unintentional major vessel and visceral injuries. New designs of trocars with safety mechanisms further reduce such risks. Diathermy injury can lead to intestinal perforation.[14] Complications related to port sites include postoperative herniation of intra-abdominal contents, which can occur even through small port sizes.[15] Technical limitations could result in failure of the procedure, which might be recognised either intraoperatively or postoperatively. Conversion to open surgery is often described as a complication and a criterion to define the learning curve of laparoscopic surgery. In fact, it is much better for surgeons not to regard conversion of a laparoscopic procedure to open surgery as a complication, but rather as an attempt to prevent complications. Safety of the patient is far more important than the ego of the surgeon.

Rarely, complications arise from CO_2 insufflation for pneumoperitoneum during laparoscopy. These include gas embolism, cardiovascular compromise, hypercapnia. The risks are minimised by the use of low pressure CO_2 insufflation in children. Slight increases in end tidal CO_2 and peak airway pressures might be detectable intraoperatively. This can usually be compensated for by slight hyperventilation.[16]

Overall, in large centres, a low complication rate (1–2%) of laparoscopic surgery in children can be achieved.[6 17] Despite the perceived technical difficulties of working in a restricted space in small infants, laparoscopic surgery has been carried out successfully in neonates as small as 1.3 kg body weight with no added complications.[6]

Indications

Most surgical procedures have been attempted laparoscopically. However, because a procedure can be done laparoscopically does not mean that it should be done this way. There are many important factors to be considered, patient's/parent's preference, the surgeon's experience, complexity of the procedure, the patient's medical condition, and costs compared with open surgery. Unfortunately, in the era of evidence based medicine, very few prospective randomised clinical trials of laparoscopic surgery in children are available. The division of surgical conditions/procedures into good indications, equivocal indications, and non-indications for laparoscopy is highly individual. It is also likely to change with time because the scene is fast moving. More and more surgeons are getting past their learning curves. Younger surgeons are well trained in laparoscopic techniques early on in their careers. Video and instrumentation technology continue to improve. What is now classified as an equivocal indication or non-indication for laparoscopic surgery could become a good indication in the future.

GOOD INDICATIONS

Laparoscopy has replaced open surgery as the diagnostic gold standard for impalpable testes, allowing accurate localisation of intra-abdominal testes, as well as identification of the absence of testes and canalicular testes by direct visualisation of the courses of the vas and testicular vessels.[18] Intra-abdominal testes can be treated by laparoscopy assisted Fowler-Stephens orchidopexy, which involves division of the short testicular vessels to allow the testes with blood supply from the vas to reach the scrotum. Dysmorphic testes, on the other hand, are best removed.

Laparoscopic division of testicular vessels is also a satisfactory method of treatment for varicoceles.[19] However, percutaneous transcatheter embolisation of the internal spermatic vein has been advocated as an alternative approach to varicoceles.[20] Long term follow up to assess fertility and recurrence is necessary to decide which method should be preferred.

As gynaecologists have long known, laparoscopy is an ideal technique to evaluate ovarian pathology. Benign ovarian conditions can also be treated effectively by laparoscopy—for example, ovarian cysts and dysgenic gonads.

Laparoscopic cholecystectomy is the method of choice for treating gallstones in adults. Gallstones are much more rare in children and are usually related to haemolytic diseases. Nevertheless, in experienced centres, the superiority of laparoscopic cholecystectomy over open cholecystectomy in children has similarly been confirmed.[21]

Two large series of laparoscopic fundoplication in a total of more than 600 infants and children have been reported.[7 22] In experienced hands, the operating time can be reduced to under one hour. The average postoperative hospital stay was 1.6 days. Complications occurred in 10% of the patients.[7] The procedure can be combined with a gastrostomy for feeding if necessary.

Early experience with laparoscopic pullthrough for Hirschsprung's disease has been favourable. Results of 75 laparoscopic pullthroughs from four centres suggest that the approach is safe, and postoperative hospital stay is reduced (average, two days).[23] Laparoscopic pullthrough can be done as a primary procedure, but a preliminary colostomy remains advisable for patients who present with enterocolitis.

Laparoscopic nephrectomy is particularly suitable for non-functioning kidneys. For duplex system, partial nephrectomy can be effectively undertaken.[24]

EQUIVOCAL INDICATIONS

In some cases laparoscopic surgery may not be better than open surgery, but if it is not worse its practice might be justified to increase the laparoscopic experience.

In children with unilateral inguinal hernia, a fine laparoscope can be inserted through the hernia sac to assess patency of the contralateral processes vaginalis with 99.5% sensitivity and specificity.[25] However, a patent processus vaginalis does not invariably proceed to become a hernia and, therefore, the clinical relevance of this information remains hotly debated. It is possible to repair inguinal hernia laparoscopically in both female[26] and male (Scheir F, personal communication) children.

Considerable experience in laparoscopic appendicectomy has been accumulated.[27] There are no major differences in the results between the open and laparoscopic techniques. Laparoscopy is sometimes used in the diagnosis of obscure abdominal pain, and Meckel's diverticulum can be removed laparoscopically.

Splenectomy can be performed for haemolytic disease by the laparoscopic technique.[28] However, very large spleens present problems of specimen retrieval without spillage into the peritoneal cavity (splenosis).

One of the more controversial laparoscopic procedures is pyloromyotomy for hypertrophic pyloric stenosis. There is no doubt that it can be done effectively after overcoming the learning curve,[13 29] but the excellent results of Ramstedt's pyloromyotomy with the possible use of a cosmetically pleasing umbilical incision have made it difficult for the laparoscopic approach to gain widespread acceptance, at least for the time being.

In general, reconstructive procedures, such as pyeloplasty,[5] are more difficult laparoscopically, and it is best to avoid laparoscopy for treating very complex problems. Some surgeons perform laparoscopic biopsy and staging of tumours, but there is a risk of tumour implantation at the port site.

NON-INDICATIONS

Patients who have an unstable haemodynamic status are not suitable for laparoscopic procedures which involve prolonged operating times. Laparoscopy should be avoided in patients with severe cardiac diseases, pulmonary insufficiency or bleeding disorders. Laparoscopy is more hazardous in patients with abdominal scars and adhesions resulting from repeated abdominal procedures, and in patients with ileus, intestinal obstruction, and pregnancy. In patients with abdominal sepsis, laparoscopy increases the risk of spreading infection. Laparoscopic resection of malignant tumour is contraindicated. Laparoscopic intervention for abdominal conditions such as intussusception[30] and malrotation remains highly controversial.

The future

Laparoscopic surgery in children is here to stay. However, doomsday predictions for the complete demise of open surgery are overexaggerated. The challenge ahead is to define more objectively the relative benefits of various laparoscopic and open techniques. Meanwhile, the potentials of endoscopic surgery should continue to be explored in appropriate settings—fetal endosurgery is one exciting example.[31] An equally exciting, but potentially frustrating, challenge is how to transfer this expensive medical technology to benefit children in the developing countries.

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