Minimally invasive surgery in paediatric patients

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Abstract

Minimal access techniques have revolutionized surgery in the past 20 years. The concept originated in the early twentieth century and has now become part of standard surgical practice.

The potential benefits of laparoscopy include reduced pain, functional impairment, inpatient stay and improved cosmesis. Recent technological advances have assisted in the application of the techniques to a paediatric population. There are now few paediatric surgical procedures remaining that have not been performed using minimal access techniques. The scope of laparoscopy in paediatric surgery encompasses neonatal surgery, thoracic surgery, gastrointestinal surgery, oncology and urology.

The evidence base for laparoscopic surgery in childhood remains small but is growing. Laparoscopic surgery has been demonstrated to be at least equivalent to its open counterpart in some procedures and superior in a few. The indications for laparoscopic surgery continue to be further refined as more studies are published.

Keywords ambulatory surgery; laparoscopy; minimally invasive; pediatrics; robotics; thoracoscopy

What's new?

- The use of minimally invasive techniques has continued to grow in paediatric surgery
- The indications for the use of minimally invasive techniques in certain conditions have been further refined
- Robotic surgery has been the most enduring innovation in minimally invasive surgery in recent years

Introduction

Minimal access techniques have revolutionized surgery over the past 20 years. The essence of the concept is that a scope can be inserted into a body cavity and instruments introduced through small incisions to operate within the cavity. This avoids the need for large incisions and associated trauma resulting from dividing muscles, vessels and nerves. The potential benefits are reductions in post-operative pain, functional impairment, length of hospital stay and improved cosmesis. The downside is that the surgery becomes increasingly technically demanding, potentially more costly, and technology dependent.

There are now few abdominal and thoracic operations remaining that have not been reported as having been performed using minimally invasive techniques. The potential benefits are as important to a paediatric population as to an adult population, both to the patient and the health service more generally. Earlier return to activity minimises the disruption to normal development and schooling caused by surgical treatment and shorter hospital stays have the potential to improve the efficiency of service delivery.

History

Laparoscopy was first performed in 1901 by Kelling, using a rigid cystoscope on a dog. Jacobaeus presented the first major series in humans some 10 years later. Initially it was merely a diagnostic technique but in the 1930s it was first used therapeutically, when Fervers divided intra-abdominal adhesions using a laparoscope. Laparoscopic liver biopsy was described in the 1970s and laparoscopic cholecystectomy in the 1980s.

Two technological advances were key in the development of laparoscopic surgery. The first was the rod-lens system invented by Hopkins in 1952. The rod-lens system reversed the ratios of air and glass within the laparoscope, creating ''air lenses''. This dramatically improved the light delivery and visual field, making laparoscopic surgery much easier and safer. The next leap came with the introduction of the digital chip camera. Until this was introduced, only the surgeon could see what was being done inside the patient, making it impossible for their assistants to actively assist them. Video cameras could be mounted on the laparoscope and the image projected onto a television screen so all involved in the operation could see. This not only meant increasingly complex procedures could be carried out, it also vastly improved training and safety in laparoscopy.

As the use of laparoscopy increased in the 1990s, awareness of unique hazards grew. Although the benefits of laparoscopy seemed self-evident, reports of inadvertent visceral injury occurring during 'blind' access to body cavities and injuries resulting from instruments when not in the field of view of the video camera led to vigorous debate as to the benefits of 'keyhole' surgery versus conventional surgery. These concerns, in addition to the natural conservatism of surgeons, led to relatively slow adoption of these techniques. The public's impression was however much more favourable and ''keyhole'' surgery was much in demand. This public demand meant that laparoscopic surgery was able to develop as resources were made available to invest in the necessary equipment.

Improved training, instrumentation and techniques have reduced the risks of minimal access surgery to acceptable levels. It is now firmly established in accepted surgical practice.

An obvious barrier to its application in paediatric surgical practice was the physically smaller size of the paediatric surgeon's patient, compounded in the very young child by the relatively large liver and intra-abdominal bladder. This was

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Conflict of interest: none.

exacerbated by the lack of components small enough to be used in children. The ergonomic issues were twofold, reduction in instrument diameter to reduce incision size, and reduction in shaft length of the instruments to allow comfortable and efficient operating in the restricted space encountered in neonates and young children. If a long instrument is used in a small patient then a disproportionate length remains outside the body, meaning that large movements of the hand give only small movements of the instrument tips. Equal lengths inside and outside the body of the patient improve the ergonomics of the procedure (Figure 1).

Relatively few manufacturers were attracted to producing paediatric instruments for what was perceived as a restricted and specialist market. Those that were have been rewarded by such instruments being eagerly used by adult surgeons keen to reduce incision size, post-operative scarring and pain.

The quality of operative image has also greatly improved with the advent of digital and high definition cameras, some with widescreen facility to increase the visual field. These have improved safety, making unnoticed iatrogenic injuries much less likely. The use of flat screen technology on arms now allow optimum positioning of the image to improve surgeon performance by reducing the difficulties of tissue manipulation when the image and the child are not in same axis (Figure 2). Now operating theatres are purpose-built to create the ideal set up for laparoscopic and endoscopic surgery, for example incorporating built-in screens. Table 1 provides an outline of principal procedures in which a laparoscopic approach has been described.

Some examples are discussed in more detail below.

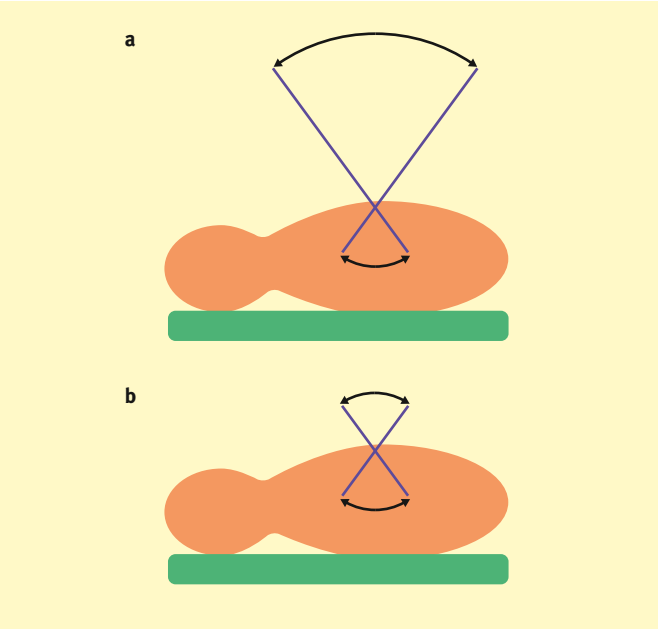

Figure 1 Long instruments and a small patient mean large movements of the hand produce only small movements of the instrument tips **a**. Shorter instruments give equal movements of the hand and within the body **b**, improving the ergonomics of laparoscopy.

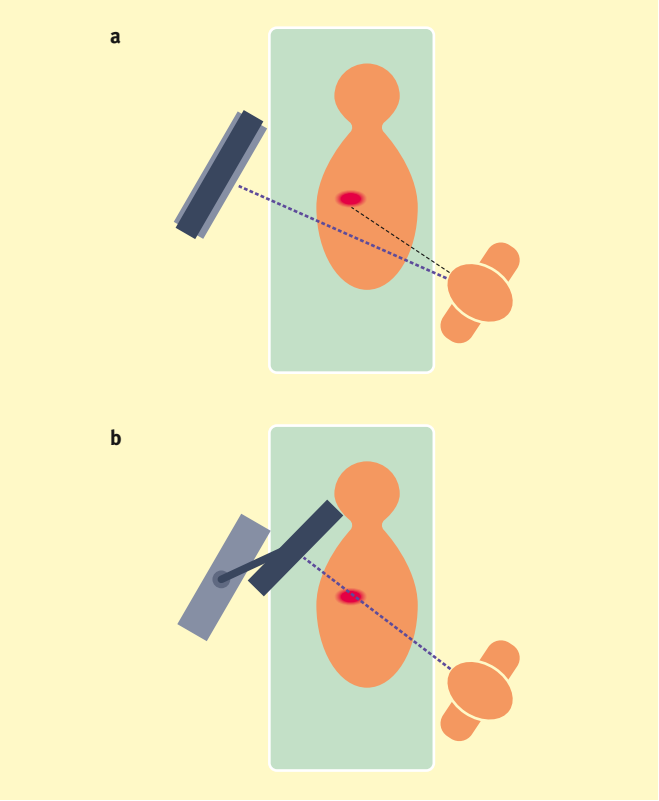

Figure 2 Conventional cathode-ray displays can only be placed adjacent to the operating table **a**, new flat screen displays can be mounted on moveable arms enabling them to be placed precisely so that the surgeon, operating field and display are all in line **b**, again improving ergonomics.

Applications of paediatric laparoscopy

Neonatal surgery

Laparoscopy has gained a place in the management of several abdominal congenital conditions. In Hirschsprung's pull-through, laparoscopy can be used to perform biopsies to determine the level of ganglionosis and to help in the mobilization of the bowel, especially useful in long-segment disease. In the surgical management of anorectal malformations laparoscopy can again be useful in the mobilization of bowel but also in the identification of the fistula, particularly in high lesions, for example bladder-neck fistulae in male patients. Intestinal atresias may be amenable to laparoscopic correction but this approach makes thorough examination of the rest of the gastrointestinal tract for further coexistent atresias more challenging.

The surgical correction of oesophageal atresia (OA) and tracheo-oesophageal fistula (TOF) remains one of the most technically demanding procedures for the paediatric surgeon. It is only relatively recently that it has been performed thoracoscopically but already a large series has demonstrated that it can be performed successfully with short-term outcomes comparable to an open approach. Longer term outcomes are now becoming available and are demonstrating results comparable to open techniques. A key benefit of thoracoscopy is a reduction in the musculoskeletal complications and deformities that are associated with thoracotomy. This equivalence of functional outcome may lead to wider adoption of a thoracoscopic approach but for the time being it remains confined to a few enthusiasts.