Trends in the use of minimally invasive surgery in children

Preechapon Pleay Tovaranonte, Spencer W Beasley, Kiki Maoate, Russell Blakelock, Adrian Skinner

Abstract

Aim To determine trends in the scope of use of minimally invasive surgical (MIS) techniques in children as a predictor of future operative workload and operating theatre requirements.

Method A retrospective review was conducted of all paediatric patients less than 16 years of age who underwent minimally invasive surgical procedures at Christchurch Hospital, New Zealand between 1996 and 2007.

Results There were 1693 children who received 1826 MIS procedures during a period in which 11,893 operative procedures were performed. MI case-weights, an indirect measure of the financial burden and technical difficulty of the procedures, represented 29% of the workload of the unit overall. There was a rapid rise of the number of MIS procedures from 1996 to 2000, but since then the scope and volume has changed little.

Conclusion Use of MIS in children increased rapidly until 2000 since which time it has remained relatively constant. Recent additional applications have involved a small number of rare low-volume and more complex procedures. These observations may assist in the planning of theatre allocation requirements for MIS in children.

Refinements in the design of laparoscopic instrumentation and resolution of a number of technical issues have facilitated the application of minimally invasive surgery (MIS) in children, including even the smallest infants. The range of indications for MIS now match those in adults. It has become the preferred technique for many procedures including appendicectomy, for impalpable testis, pyloromyotomy and Nissen fundoplication. Sometimes it has greatly advanced the operative technique, such as for appendicostomy stomas (the ACE procedure), significantly reducing the complexity of surgery and morbidity.

The purpose of this study was to determine trends in the use and scope of minimally invasive surgical procedures as they are applied to children.

Method

A retrospective study was conducted of all paediatric patients under 16 who underwent minimally invasive surgical procedures at Christchurch Hospital, New Zealand, between September 1996 and December 2007 inclusive. Operative procedures were identified through the Paediatric Surgery Departmental Audit Database and the Main Operating Theatre Database. Any discrepancies in diagnoses or procedures were clarified through examination of individual medical records, and correlated with the International Classification of Diseases, 10th revision (ICD-10) used by the Christchurch Hospital Patient Management System.

The scope of application of MIS procedures is summarised in Table 1.
Table 1. Examples of the scope of the application of MIS in children

<table>
<thead>
<tr>
<th>Thoracic procedures</th>
<th>Thoracoscopic lung resection, VATS for empyema, thoracoscopic lung biopsy, thoracoscopic excision of intrathoracic tumours and cysts, and other thoracoscopic procedures (e.g. removal of lung abscesses and diagnostic thoracoscopy)</th>
</tr>
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<tbody>
<tr>
<td>Abdominal procedures</td>
<td>Laparoscopic appendicectomy, pyloromyotomy, intussusception reduction, Ladd’s procedure for malrotation, cholecystectomy, splenectomy, pancreatic procedures, Nissen fundoplication, ACE (appendicostomy), Meckel’s diverticulectomy, surgery for congenital anorectal malformations, gastrostomy, drainage of abscesses, adhesiolyis, colonic biopsies, ovarian cyst removal, oophoropexy, salpingectomy, and diagnostic laparoscopy</td>
</tr>
<tr>
<td>Urological procedures</td>
<td>Laparoscopy for undescended or impalpable testes, nephrectomy/ heminephrectomy, pyeloplasty, varicocele repair, and others (e.g. cystoscopy with intervention, nephroscopy)</td>
</tr>
</tbody>
</table>

Procedures excluded
- Gastrostomy, oesophagoscopy, bronchoscopy and colonoscopy.

Endoscopic procedures such as gastroscopy, oesophagoscopy, bronchoscopy and colonoscopy were excluded due to difficulties identifying them accurately from ICD codes and because they involved techniques already in existence before laparoscopy and thoracoscopy were introduced. Children whose procedure was converted from a laparoscopic to an open approach, were recorded in both the laparoscopic and open categories of our database.

As most paediatric surgical procedures involve minor open procedures, procedure numbers alone provide a poor indication of surgical workload: MIS operations tend to involve more major and more time-consuming procedures in theatre. For this reason, case-weights were calculated to provide an indirect measure of the complexity of procedure, its technical difficulty, theatre time and overhead costs. The case-weight measure has been validated previously.\(^5\)

Case-weight data were only available from 1998 onwards, when fiscal data were recorded electronically. Case-weights were applied to match each procedure for each year. Percentages were calculated from the product of the number of MIS cases by case-weight (referred to as “MIS Workload”) in relation to the sum of all case-weights existing on our database (“Total Workload”). Some selected MIS procedures (nephrectomy, appendicectomy, pyloromyotomy, Nissen fundoplication) were compared with their corresponding open approach to provide an indication of when, and the extent to which the MIS approach became adopted.

Results

During the period reviewed there were 11,893 operative procedures performed, of which 1827 involved MIS. There was a general trend towards an increase in all MIS cases until 2001 after which it plateaued off. The highest number of cases was in 2000, when 211 children underwent MIS. Since then the number of MIS cases has fluctuated around 170–180 cases annually (Figure 1). Overall, this has represented 14.2% of the total cases.
A summary of case-weight data for each year is shown in Figure 2. The MIS Case-weight Workload peaked in 2002 (36%) and over the last 5 years the MIS Workload became stabilised at about 29%.

Figure 3 shows the body regions in which MIS procedures were performed. Abdominal MIS procedures account for 88% of the total MIS workload. Figures 4–7 show the trends for nephrectomy excluding all malignancies (Figure 4), appendicectomy (Figure 5), pyloromyotomy (Figure 6) and Nissen fundoplication (Figure 7).
Figure 3. MIS workload pie chart

Figure 4. Fundoplication (*incomplete year)
Figure 5. Appendicectomy (*incomplete year)

Figure 6: Nephrectomy for benign disease (*incomplete year)
**Discussion**

The introduction of laparoscopy started in children almost 40 years ago for the management of the impalpable testis, but more recent expansion of the indications for laparoscopy in children has lagged behind that of adults, in part for technical reasons and in part because of the relative rarity of conditions for which laparoscopic surgery was most commonly performed—e.g. cholecystectomy. Once the size and calibre of instruments became more appropriate for children, and light sources improved, the techniques were adopted more quickly.

Nevertheless, many paediatric surgeons worldwide were initially reluctant to acquire laparoscopic skills when they considered themselves already highly skilled in open surgery and laparoscopy in children was perceived as conferring few advantages over open surgery. Our rapid acceptance of MIS compared with many other centres – some of which still perform laparoscopy only infrequently – is in part a reflection of the fact that the paediatric surgical department lies within a general hospital that has a long history of routine laparoscopic surgery in adults.

There was a rapid increase in the number of MIS cases from 1996 to 2000, but later became stable in both total number and as a percentage of volume (Figs 1 & 2). MIS procedures tended to utilise more complex equipment, had greater overhead costs and consumed more operating time for which reason their Case-weight volume was employed, as a crude and indirect measure of the proportion of “workload” they created. Overall, MIS represents almost 30% of the operative workload.

In children MIS is performed for a wide variety of surgical procedures and its perceived applications grow yearly – although most recent new applications have involved relatively rare and complex conditions, for example, anorectal...
malformations and oesophageal atresia. In our institution the two most frequent MIS procedures are laparoscopic appendicectomy and fundoplication.

The influence of MIS in the treatment of four procedures is summarised in Figures 4–7. Since 1999 laparoscopy has been the preferred approach to fundoplication in infants and children of all ages, with few requiring conversion. Laparoscopic appendicectomy was also introduced early and rapidly became routine (Figure 5), with few open appendicectomies since 2000. The conversion rate has remained steady around one to two per year. Review of perforated appendicitis in 2000 identified a postoperative intra-abdominal abscess rate of 6% following laparoscopic appendicectomy.8,9

The complication rate for perforated appendicitis is decreasing as surgeons become more experienced.8 Complications tend to occur with less experienced operators, regardless of patient age, operative time, pre-operative duration of symptoms, or the extent of intraperitoneal soiling.9,10 Laparoscopic nephrectomy or heminephrectomy has been undertaken in 80 children (Figure 6) with an age range of 8 months to 15 years. Mean operative times have decreased from 105 to 90 minutes, indicating a flat learning curve. Conversion to an open procedure (6.3% overall) was due to marked fibrosis, large renal size, difficulty gaining access to the retroperitoneal space and major peritoneal breech.11

Laparoscopic pyloromyotomy was introduced more recently in our institution, and does not yet have its own ICD-10 procedure code. In the USA, the procedure became common from about 1997.7 It has made no difference to outcome.

The main advantages of MIS have been related to better cosmesis (smaller less obvious scars), reduced post-operative discomfort, reduced analgesic requirements and a reduction in average length of hospital stay for procedures such as appendicectomy.12 Overall, the introduction of MIS has had little other demonstrable effect either on the complication rate or longer term outcomes.

**Conclusion**

At our institution, MIS in children increased in volume until 2000 by which time most of its applications had been established. Subsequent additional applications have been limited to a few uncommon and complex procedures, such as anorectal malformations and thoracic tumours, affecting total workload little. Knowledge of the recent trends in the use of MIS techniques (now in a “plateau phase”) may assist in planning likely future operating theatre requirements.

**Competing interests:** None known.

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References: