



Minimally invasive pediatric surgery: Increasing implementation in daily practice and resident's training

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Abstract

Background: In 1998, the one-year experience in minimally invasive abdominal surgery in children at a pediatric training center was assessed. Seven years later, we determined the current status of pediatric minimally invasive surgery in daily practice and surgical training.

Methods: A retrospective review was undertaken of all children with intra-abdominal operations performed between 1 January 2005 and 31 December 2005.

Results: The type of operations performed ranged from common interventions to demanding laparoscopic procedures. 81% of all abdominal procedures were performed laparoscopically, with a complication rate stable at 6.9%, and conversion rate decreasing from 10% to 7.4%, compared to 1998. There were six new advanced laparoscopic procedures performed in 2005 as compared to 1998. The children in the open operated group were significantly smaller and younger than in the laparoscopic group ($p < 0.001$ and $p = 0.001$, respectively). The majority (64.2%) of the laparoscopic procedures were performed by a trainee. There was no difference in the operating times of open versus laparoscopic surgery, or of procedures performed by trainees versus staff surgeons. Laparoscopy by trainees did not have a negative impact on complication or conversion rates.

Conclusions: Laparoscopy is an established approach in abdominal procedures in children, and does not hamper surgical training.

Key words: Pediatric surgery – Minimally invasive surgery – Training

Background

In adults, the known advantages of minimally invasive surgery are improved cosmesis due to smaller incisions, and fewer postoperative ileus and pain, which results in less analgesic use, less respiratory morbidity, shorter hospital stays, and a swift return to preoperative activities [1]. In pediatric surgery, minimally invasive surgery has been introduced at a slower pace, in part because the patients are smaller, the operations are often already performed through small incisions, and many of the conditions that require surgery are rare, and therefore require a longer training period [2]. Davenport stated in 2003 that the majority of procedures in children were still conventional rather than laparoscopic [3]. In addition, in the early 1990s, prudence was widely advocated [4, 5] and it is well known that a surgeon's experience and learning curve are very important predictors of outcome.

On the other hand, in 1998 we found that of all abdominal surgery performed in our hospital, already as much as 60% had been performed by minimally invasive techniques as opposed to laparotomy, with a conversion rate of 10.1% (mainly appendicitis) and a complication rate of 6.8% [6]. Moreover, as we described earlier, trainees easily learned the laparoscopic pyloromyotomy procedure without any increase in the complication rate [7]. However, it could be speculated that with an increase in laparoscopic procedures, the surgical training of a trainee might be compromised since the procedures are more strenuous than in open surgery and therefore require intensive training.

In this study we retrospectively assessed all consecutive abdominal surgical procedures in 2005. We evaluated the current use of minimally invasive surgery and open surgery in pediatric patients, in order to determine its role in the training of surgical trainees.

Table 1. Patient characteristics

	Open	Laparoscopy	
Median age (range)	15 (0–25 weeks)	76 weeks (0 days–17 years)	$p = 0.001$
Under one year of age	30 (68.1%)	89 (48.7%)	
Under four weeks of age	20 (45.5%)	25 (14.4%)	
Mean weight, in kg (range)	3.6 (0.76–61)	8.2 (0.76–90)	$p < 0.001$

Patients and methods

All consecutive children undergoing an abdominal surgical procedure in the Department of Pediatric Surgery of the University Medical Center Utrecht during a period of one year (1 January 2005 to 31 December 2005) were included. All medical data was retrieved from the patients' files, including gender, age, weight, procedure, emergency or planned, operating surgeon (one surgical resident, two fellows and four staff surgeons), duration of operation, intraoperative surgical and technical problems, conversions, and complications. Well-supervised surgical residents and fellows in pediatric surgery — henceforth referred to as trainees, unless stated otherwise — were distinguished from staff surgeons, and it was noted by whom a procedure was performed. A procedure was defined as an emergency procedure when it was performed within 12 hours after diagnosis. The pyloromyotomies were considered a planned procedure. The postoperative course was reviewed, and complications, reinterventions and time to follow-up were assessed. The type of operation was graded according to its complexity as *easy*, *difficult*, or *demanding* using the grading of Costi et al. for laparoscopic procedures in adults [8], modified for pediatric laparoscopies by Metzelder et al. [9].

For the record, it should be noted that in our department no resections of solid tumors or urologic procedures are performed.

For laparoscopic procedures, a standard open introduction technique of the first port through the inferior umbilical fold was used. Laparoscopy was performed routinely with reusable instruments and devices, mostly 3–5 mm ports (Storz® Tutlingen, Germany). The maximum intra-abdominal pressure was kept at 8 mmHg and the maximum flow at 5 L/min in older children, and at 5 mmHg and 2 L/min in infants. Monopolar electrocautery devices were used. At the end of the operation all port sites were closed by use of a resorbable suture. In laparoscopic-assisted surgery, dissection was performed laparoscopically followed by a small local incision to perform an anastomosis outside of the abdominal cavity.

Statistical analysis was performed using independent sample Mann-Whitney *t*-test.

Significance was determined by a *p* value less than 0.05. SPSS (Inc Chicago, Illinois) software package for Windows was used. Results are presented as mean \pm standard deviation, or median (range).

Results

In total, 231 patients underwent abdominal surgery in 2005, of which 44 (18.9%) were performed via laparotomy and 187 (81%) were performed laparoscopically. Patient characteristics are summarized in Table 1.

As compared to 1998, six new procedures were performed in a minimally invasive fashion in 2005 ($n = 14$), of which all but one were classified as *demanding* procedures, and are indicated by an asterisk in Table 3. A trainee was the operating surgeon in 72.7% of the open procedures (Table 2) versus 64.2% in the laparoscopic group (Table 3). The percentage of the laparoscopic procedures classified as *difficult* and performed by a trainee was 48%.

Of the open procedures, 40.9% were planned compared to 74.8% of the laparoscopic procedures. Of the minimally invasive procedures, the trainees performed

Table 2. Indications for laparotomy

Laparotomy	Total number	Number performed by trainees	Number performed by staff surgeons
Easy			
Appendectomy	3	2	1
CAPD*	3	3	
Difficult			
Enter-enterostomy/adhesiolysis	10	7	3
Ventral hernia**	8	5	3
Resection of the ileum	4	2	2
Intussusception	3	3	
Adhesion	3	3	0
Gastroschisis closure	3	2	1
Gastrostomy	1	1	
Ileostomy	2	2	
Demanding			
Subtotal colectomy	1	1	0
Derotation/adhesiolysis	1	1	
Duodenoduodenostomy	1	1	
Diaphragm closure		1	1
Total	44	32	12

* CAPD, Continuous ambulant peritoneal dialysis

** Omphalocele

35% of the planned procedures and 66.7% of the emergency procedures. A trainee performed 72% of all emergency procedures that were conventionally operated.

Intraoperative and postoperative complications were encountered in 12 patients (6.9%) that underwent laparoscopic operations (see Table 4). Two complications (incomplete myotomy and bleeding) occurred in one patient. In the open group, the complication rate was 4.4%. The conversion rate from laparoscopy to laparotomy was 7.4% (Table 5). The reason for conversion in the majority of patients ($n = 4$) was distention of the bowel and/or adhesions that prevented good overview. Intraoperative complications (i.e., bleeding) caused conversion in three patients. In four patients, a diagnostic laparoscopy identified generalized peritonitis, and in two patients, intussusception was found; all followed by conversion [10]. The small diameter of the intestine together with multiple atresia did not permit laparoscopic duodenoduodenostomy in one patient.

The mean duration of the laparoscopies did not significantly differ from the duration of the open procedures ($p = 0.104$). The duration of pyloromyotomies performed by the trainees ($n = 36$) was 44.6 ± 15.9 minutes versus 37.3 ± 16.7 minutes for staff surgeons ($n = 14$; $p = \text{NS}$). Follow-up median was six months (1–613 days).

Table 3. Indications for laparoscopy by performing surgeon

Laparoscopic procedures	Total number	Performed by trainees	Performed by staff surgeons
Easy			
Appendectomy	22	20	2
Diagnostic	11	5	6
Hernia, inguinal rec*	1	1	1
Total	34	25	9
Difficult			
Cholecystectomy	1	0	1
Cholecystotomy	1	0	1
Colostomy	1	1	
Hernia, incisional	1	0	1
Colectomy, subtotal	1	0	1
Gastrostomy	39	36	3
Intussusception	2	2	
Perforation	1	0	1
Pyloromyotomy	50	36	14
Splenectomy	7	3	4
Thal	16	11	5
Transverso-transversostomy	1	0	1
Abscess evacuation	1	1	0
Total	122	90	32
Demanding			
Duodenoduodenostomy	7	0	7
Gastrocolic fistula	1	0	1
Hirschsprung, Duhamel	1	0	1
Ileorectal anastomosis*	1	0	1
Ileumresection*	1	0	1
Kasai*	4	0	4
Laparoscopic-assisted cecumresection	1	0	1
Obstruction, adhesiolysis	5	2	3
Pyloromyotomy, redo**	4	2	2
Rectosigmoidres, transanal*	1	0	1
Retroperitoneal lymph node biopsy	1	1	
Diaphragm closure	1	0	1
Subtotal colectomy with J-pouch*	1	0	1
Thal, redo	2	0	2
Total	31	5	26

* New procedure performed laparoscopically since 1998

** Two were referred from elsewhere

Discussion

In the Wilhelmina University Children's hospital in 2005, 81% of 231 abdominal procedures were performed by minimally invasive surgery, compared to 60% of 244 procedures in 1998 [6]. Since 1998, the conversion rate has decreased from 10 to 7.4%, whilst the complication rate remained unchanged (6.8% in 1998 vs. 6.9% in 2005; Tables 4 and 5). The indication for laparoscopic surgery has been broadened with the addition of six different procedures, five of which are amongst the most difficult operations. This increase in the use of laparoscopic procedures during the past seven years is partly due to complete establishment of the laparoscopic approach by the surgeons, and probably also due to the acceptance and skills of staff (i.e., anesthetists, nurses).

Meanwhile, children in the open group were significantly smaller and younger than in the laparoscopic group ($p < 0.001$ and $p = 0.001$, respectively), indicating that there is specific a group of patients deemed not suitable for laparoscopic surgery. In addition, more

Table 4. Intraoperative and postoperative complications in all laparoscopies ($n = 187$)

	Total number	Number performed by trainees	Number performed by staff surgeons
Complications of laparoscopy			
Incomplete myotomy in pyloromyotomy	2	2	
Mucosal injury in pyloromyotomy, laparoscopic repair	1	1	
Abscesses postappendectomy, followed by laparotomy	2	1	1
Bleeding (see conversion)	3	1	2
Anastomotic leakage			
One in duodenoduodenostomy; laparoscopic repair			
One in ileoanal pouch, open repair	2		2
Portsite hernia, local repair	1		1
Dysphagia after reflux surgery, laparoscopic repair	1		1
Tear endobag in appendectomy	1	1	
Total	13	6	7

Table 5. Events leading to conversion and laparotomy by performing surgeon

	Total number	Number performed by trainees	Number performed by staff surgeons
Conversion			
Lack of overview due to peritonitis/adhesions	4	2	2
Lack of overview due to bowel distention	4	2	2
Lesion art epigastrica in appendicitis	1	1	
Venous bleeding crus in redo-Thal	1		1
Bleeding, redo pyloromyotomy	1		1
Small diameter of the intestine	1		1
Insufficient result scopic reduction intussusception	2	2	
Total	14	7	7

than half of the laparotomies performed would not benefit from an endoscopic approach, given the indications such as gastroschisis and adhesiolysis (Table 2).

The operating time of the laparoscopic group was not significantly longer than that of the open group, reflecting that laparoscopy has become a standard procedure. This adds favor for minimally invasive procedures: Laparoscopy does not take longer, and therefore does not affect operating schedules in a negative manner. Moreover, the duration of surgery performed by trainees is no different than when the same procedures are performed by staff surgeons. This contradicts the concern expressed by some that the trainees might not be able to gain sufficient expertise.

We found that a trainee was the operating surgeon in as many as 64.2% of all laparoscopic procedures, and 48% of all minimally invasive procedures classified as difficult (Table 3). All together, the complication and

conversion rates were not increased in the patients on which trainees operated as compared to staff surgeons.

Trainees in a pediatric laparoscopic training center can perform laparoscopic procedures in children with good results, which is in concordance with the findings of others [11]. As we described earlier, trainees learned to perform a laparoscopic pyloromyotomy, which can be classified as an easy procedure, without an increase in the complication rate [7]. In this study, we have shown that the more difficult procedures are equally well performed by trainees. Furthermore, the increase in laparoscopic procedures as opposed to conventional procedures does not imply that trainees perform fewer procedures: they are still able to perform a significant amount of operations, and develop skills in minimal invasive surgery.

In conclusion, in a pediatric laparoscopic training center, up to 81% of all abdominal procedures are currently performed by minimally invasive surgery. Operating time is no different between laparoscopy and conventional surgery. Residents or fellows do not take significantly longer to operate than staff surgeons. In addition, the trainees perform up to 64% of all laparoscopic procedures, which indicates not only that they are able to perform more difficult procedures, but also that minimally invasive surgery does not necessarily hamper surgical training.

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