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Laparoscopy in pediatric surgery: Implementation in Canada and supporting evidence

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ABSTRACT

Background/purpose: The purpose of this study was to assess the diffusion of laparoscopy usage in Canadian pediatric centers and the relationship between uptake of laparoscopic surgery and the level of evidence supporting its use.

Methods: National data on four pediatric laparoscopic operations (appendectomy, pyloromyotomy, cholecystectomy, splenectomy) were analyzed using the Canadian Institute for Health Information Discharge Database (2002–2013). The highest level of evidence to support the use of each procedure was identified from Cochrane, Embase, and Pubmed databases. Chi-square test for trend was used to determine significance and time to plateau.

Results: There were 28,843 operations (open: 12,048; laparoscopic: 16,795). Use of laparoscopic procedures increased over time ($p < 0.0001$). A plateau was reached for cholecystectomy (2006), splenectomy (2007), and appendectomy (2012), but not for pyloromyotomy. Laparoscopic pyloromyotomy in 2013 remains less diffused than the other procedures ($p < 0.0001$). Laparoscopic appendectomy and pyloromyotomy are supported by level-1a evidence in children, whereas cholecystectomy and splenectomy are supported by level-1a evidence in adults but level-3 in children.

Conclusions: In Canada, it has taken a long time to reach high-level implementation of laparoscopic surgery in children. Laparoscopic cholecystectomy first reached plateau, whereas laparoscopic pyloromyotomy continues to increase but remains low despite high level of evidence in support of its usage compared to open surgery.

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During the last two decades, one of the major innovations in general surgery has been the introduction of laparoscopy. Although randomized controlled trials (RCT) [1] and systematic reviews [2] have been performed to assess the benefit of laparoscopic *versus* open surgery in children, the uptake of laparoscopic surgery in children has been slower than in adults. Contributory factors include patient size, rarity of the diseases, training of attending surgeons [3] and learning curve [4]. Interestingly, te Velde et al. have reported an increase in the proportion of laparoscopic procedures that can be performed safely and successfully from 60% in 1998 to 81% in 2005 [3]. Despite this reported increase over time, there are no published data regarding the implementation of laparoscopy into routine practice in children and no parallel analysis of the evidence corresponding to laparoscopy in surgical practice.

We therefore sought to assess: (i) the diffusion curve of laparoscopic surgical procedures in Canadian pediatric hospitals and departments of pediatric surgery and to determine if a plateau was reached; (ii) the relationship between the uptake of laparoscopic surgery and the level of evidence supporting its use.

1. Methods

1.1. Study design

This study was conducted with the approval of the Hospital for Sick Children Research Ethics Board (100045867). We evaluated 4 pediatric operations, which can be performed laparoscopically in children: appendectomy, pyloromyotomy, cholecystectomy, and splenectomy. A 12-year analysis (2002–2013) of these operations was carried out nationally using data from the Canadian Institute for Health Information (CIHI) Canadian Discharge Abstract Database (all provinces excluding Quebec since the database does not include this province [https://www.cihi.ca/en/types-of-care/hospital-care/acute-care/dad-metadata]) in 11 Canadian specialist pediatric surgery centers (10 pediatric hospitals and 1 pediatric surgery department). CIHI codes were used for searching and translated to International Statistical Classification of Diseases (ICD) and Canadian Classification of Health Interventions (CCI) codes for identification of the hospital procedures (Appendix A). Anonymity in relation to hospital

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source was maintained. Information collected included: year of surgery, procedure type, and laparoscopic or open procedure.

1.2. Level of evidence

Highest level of evidence available that related to each procedure was identified from the Cochrane Central, Embase, and Pubmed databases. Databases were searched from inception until June 2014. Searches were limited to English language publications comparing the traditional *versus* laparoscopic procedures (appendectomy, pyloromyotomy, cholecystectomy, splenectomy) that included participants 0–18 years of age. Evidence based surgery was classified according to Oxford Centre for Evidence-Based Medicine (OCEBM) Levels of Evidence Working Group (Table 1) [5].

1.3. Statistical analysis

Differences between groups (surgical procedures) were evaluated using chi square analysis. Bonferroni correction was used for multiple comparisons. Chi square test for trend was used to evaluate changes of the percentage of operations performed laparoscopically over time. Plateau was defined as the first year in which the chi square test for trend did not indicate a significant increase in proportion of specific operation performed laparoscopically. A p value of <0.05 was considered significant.

2. Results

2.1. Laparoscopy diffusion curve trends in 11 pediatric centers in Canada

When considering the four procedures: appendectomy, pyloromyotomy, cholecystectomy and splenectomy, there were a total of 28,843 operations (open: 12,048 (41.8%); laparoscopic: 16,795 (58.2%)) performed in 11 Canadian pediatric centers evaluated in the years 2002–2013. The change in proportion of each procedure performed laparoscopically over time is shown in Fig. 1. The proportion of each procedure performed using the open and laparoscopic approaches overall during the study period is shown in Table 2.

2.2. Appendectomy

Of the four procedures assessed, 73.4% were appendectomies. The use of laparoscopic appendectomy significantly increased with time ($p < 0.0001$, Fig. 1). In the first year of our analysis (2002), 29.3% appendectomies were performed laparoscopically and by 2013 as many as 83.6% were performed laparoscopically. A plateau was reached for laparoscopic appendectomy in 2012 (Fig. 1). Laparoscopic appendectomy is supported by level 1a evidence in children from systematic review of RCTs [6] and meta-analysis of randomized and nonrandomized trials – Aziz et al., 2006 [7].

Table 1
Oxford Centre for Evidence-Based Medicine levels of evidence.

Level	Type of study
1a	SR/MA of RCTs
1b	Individual RCT
2a	SR/MA of cohort studies
2b	Individual cohort study (including low quality RCT)
3a	SR/MA of case–control studies
3b	Individual case–control study
4	Case series (and poor quality cohort and case–control studies)
5	Expert opinion

Abbreviations: RCT, randomized controlled trial; SR, systematic review; MA, meta-analysis.

2.3. Pyloromyotomy

Pyloromyotomy constituted 15.9% of the four procedures performed during the study period. The use of laparoscopic pyloromyotomy significantly increased with time ($p < 0.0001$, Fig. 1). In 2002, 5.9% of pyloromyotomies were performed laparoscopically and 37.2% in 2013 (Fig. 1.). In 2013, the proportion of pyloromyotomies performed laparoscopically is significantly lower than the other three procedures ($p < 0.001$, Fig. 1). A plateau was not reached for laparoscopic pyloromyotomy in the study period. Laparoscopic pyloromyotomy is supported by level 1a evidence in the pediatric population: meta-analysis of RCTs – Jia et al., 2011 [8], meta-analysis of RCTs – Oomen et al., 2012 [9].

2.4. Cholecystectomy

Cholecystectomy constituted 8.2% of the four procedures performed. The use of laparoscopic cholecystectomy significantly increased with time ($p < 0.0001$, Fig. 1). In 2002 82.9% of cholecystectomies were performed laparoscopically and 89.4% in 2013 (Fig. 1). A plateau was reached for laparoscopic cholecystectomy in 2006 (Fig. 1). The highest level of evidence in children supporting laparoscopic cholecystectomy is 3b: retrospective case–control studies – Kim et al., 1995 [10], Al-Salem et al., 1997 [11], Miltenburg et al., 2001 [12].

2.5. Splenectomy

Splenectomy constituted 2.5% of the four procedures analyzed. The implementation of laparoscopic splenectomy significantly increased with time ($p < 0.0001$, Fig. 1). In 2002 13.6% of splenectomies were performed laparoscopically and 73.0% in 2013 (Fig. 1). A plateau was reached for laparoscopic splenectomy in 2007 (Fig. 1). The highest level of evidence in children supporting LS is 3a: review of retrospective case–control studies – Bax et al., 2001 [13]; 3b: retrospective case–control studies – Yoshida et al., 1995 [14], Hicks et al., 1996 [15], Curran et al., 1998 [16], Rescorla et al., 1998 [17], Wood et al., 2011 [18].

2.6. Interhospital laparoscopy diffusion curve trends

An analysis of the three most common procedures (appendectomy, pyloromyotomy, cholecystectomy) showed that there is considerable variation between the pediatric centers in the use of laparoscopy (Fig. 2A–C). The sample size for the splenectomy procedure for each pediatric center was too small to represent the interhospital trends in the form of a meaningful graph.

3. Discussion

This study is the first to report the diffusion curve over a 12-year period in pediatric centers across Canada for four laparoscopic pediatric procedures: appendectomy, pyloromyotomy, cholecystectomy, and splenectomy. Additionally, we set out to assess the corresponding level of evidence and determined the highest level of evidence supporting each laparoscopic technique.

Since the early 1980s, minimally invasive surgery has revolutionized adult surgical practice and yet there has been marked delay in its adoption to pediatric surgery. The implementation of laparoscopy in pediatric procedures has been made feasible with the advent of customized technological tools suitable for smaller patients as well as adequate surgical training in overcoming the learning curve [3,19]. Now a wide range of procedures are performed laparoscopically [20] ranging from those performed on infants to those performed on older children and adolescents. Today, medicine is increasingly being governed by evidence-based practice, which has been defined as: “the integration of best research evidence with clinical expertise and patient values” [21]. The prospective RCT performed to eliminate selection, allocation,

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