



## Role of laparoscopy in the prevention and in the treatment of adhesions

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### ABSTRACT

The formation of adhesions after abdominal surgery can lead to increased morbidity in children, increases the incidence of readmission, and may pose a significant challenge to subsequent surgical care over their lifetime. As the pathophysiology of peritoneal adhesion formation has been better understood, preventive strategies that minimize surgical trauma and contamination have been sought. Laparoscopy, over the past few decades, has become an increasingly utilized approach for many pediatric surgical problems and intuitively should have an advantage over open surgery in reducing adhesion formation. In this review, we examine the utility of laparoscopy in both the prevention and the treatment of intraabdominal adhesive disease in children.

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### Introduction

Postoperative adhesion formation is nearly inevitable following intraabdominal surgery. The risk of adhesion formation after surgery, however, is often widely underestimated among surgeons.<sup>1</sup> Adhesions can have significant consequences on both the child and their family. They can lead to a number of clinical problems including infertility, chronic abdominal pain, intestinal strangulation from a single band, failure to thrive, and, of course, small bowel obstruction. Additionally, the presence of adhesions requiring adhesiolysis at subsequent elective abdominal surgery increases morbidity.<sup>2</sup> Ten Broek et al.<sup>3</sup> found a 10.5% risk of inadvertent enterotomy and 3- to 4-fold increase in other organ injury for adults undergoing elective operation who also needed concomitant adhesiolysis. These complications lead to increases in time missed at school and work along with increased cost. Children, it stands to reason, are at higher risk for these problems when compared to adults, given their life expectancy, and thus effective preventative strategies are needed.

Adhesive small bowel obstruction can complicate all abdominal surgeries, but the rates vary by age and type of initial operation. The incidence of postoperative adhesive obstruction requiring surgical treatment following neonatal laparotomy is 6–8%,<sup>4,5</sup> and 90% of them developed within 1 year of surgery.<sup>4</sup> In a retrospective review at a children's hospital, Young et al.<sup>6</sup> found the incidence of postoperative bowel obstruction following abdominal operation to

be greater in infants < 1 year old than those > 1 year old. This may be related to the more complicated procedures needed in neonates as compared to the less complex procedures performed in the older children where the most common operation is an appendectomy. A Scottish population-based study of 1581 children showed that children younger than 16 years who had open lower abdominal surgery had a 5-year readmission rate for adhesive small bowel obstruction of 5.3% when appendectomy was excluded (1.1% when included).<sup>7</sup> The highest readmission rate was after small intestine surgery (9.3%), while it was only 2.1% after colonic surgery.<sup>8</sup> Just over half of the readmissions due to adhesions occurred within the first postoperative year. In a large meta-analysis including pediatric and adult patients, the incidence of adhesive small bowel obstruction was found to be highest in pediatric surgery and in lower gastrointestinal tract surgery.<sup>9</sup>

### The role of laparoscopy in the prevention of adhesions

Halstedian principles of meticulous hemostasis, gentle handling of tissues to minimize trauma, and keeping tissues moist have long been suggested as effective strategies at preventing adhesions.<sup>10–13</sup> Peritoneal injury, trauma to the abdominal wall, introduction of foreign bodies, trauma to adjacent or distant organs, and tissue ischemia are all thought to play a role in the pathogenesis of adhesion formation.<sup>14</sup> These risk factors are theoretically more easily avoided using a laparoscopic approach.<sup>15</sup> Laparoscopy generally does not require the use of retractors or packing of the bowel and thus perhaps less tissue manipulation.

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Other potential advantages of laparoscopic surgery for preventing adhesion formation include diminished drying of the peritoneal surface and reduced impairment of gut motility.<sup>16</sup> Perioperative peritoneal fibrinolytic activity has also been an area of ongoing research. Brokelman et al.<sup>17</sup> showed that there was no difference in tPA antigen, tPA-activity, or PAI-1 antigen concentrations in peritoneal biopsies taken at the beginning and end of a laparoscopic cholecystectomy. For right colectomy, Brokelman et al.<sup>18</sup> reported an initial, more rapid decline in tPA antigen for open compared to laparoscopic surgery. However, by the end of the surgery, the effect on tPA antigen was the same, suggesting that the benefits of laparoscopy may diminish with increased operative time.

There are a number of possible reasons that laparoscopy may not reduce or prevent adhesions. First, there are experimental models that demonstrate the negative effects that cold-dry CO<sub>2</sub> pneumoperitoneum may have on the peritoneal and serosal surfaces for prolonged laparoscopic procedures (>3 h).<sup>19</sup> However, this has not been seen in studied patients undergoing laparoscopic bariatric surgery.<sup>20</sup> Short-term laparoscopy, as well, does not appear to affect peritoneal fibrinolytic activity.<sup>17</sup> Next, the products of tissue combustion may have a negative effect.<sup>21</sup> Additionally, the pneumoperitoneum exposes the entirety of the peritoneal cavity, remote from the operative focus, which may have had a more limited exposure with a conventional approach. Lastly, the benefits of laparoscopy may be negated when a larger incision is needed at the end of the operation for specimen removal.

The meta-analysis from Ten Broek et al.<sup>9</sup> showed the incidence of adhesive bowel obstruction to be significantly lower in the laparoscopic versus open surgery cohorts. Another recent meta-analysis showed a reduction in the incidence of adhesions with laparoscopy but not in adhesion-related complications such as small bowel obstruction or infertility.<sup>22</sup> In children, Molinaro et al.<sup>23</sup> found the overall incidence of postoperative intestinal obstruction to be significantly reduced when comparing a laparoscopic (0.89%) versus an open (3.21%) approach for the same type of abdominal operation. In a comparison of laparotomy, laparoscopy, and NOTES with a porcine liver biopsy model there was a decreased incidence of adhesions with the less invasive procedure.<sup>24</sup>

A number of researchers have looked at specific surgical procedures to see if the incidence of postoperative intestinal obstruction could be reduced when using a laparoscopic compared with an open approach. The incidence of adhesive small bowel obstruction following anti-reflux surgery in children has been reported to be between 4% and 10%.<sup>25,26</sup> Stanton et al.<sup>27</sup> showed a 0% incidence of small bowel obstruction requiring surgical treatment after 170 laparoscopic funduplications with a median 3-year follow-up in children. Their rate of small bowel obstruction following open anti-reflux surgery was 4.8%, which is similar to other reports. In lower abdominal surgery (i.e., distal to ligament of Treitz), the highest risk of adhesion-related problems are total colectomy with ileal pouch–anal anastomosis (19.3%), gynecologic surgeries (11.1%), and open colectomy (9.5%).<sup>11</sup>

Appendectomy is one of the more common pediatric surgical procedures performed. A large, population-based study in Scotland showed a 0.3% adhesion-related readmission risk after open appendectomy within 5 years for children <16 years old.<sup>7</sup> A retrospective, single-institution study in the US demonstrated a 1% overall incidence of postoperative bowel obstruction after open appendectomy in children.<sup>6</sup> When nonperforated appendicitis was excluded, the incidence increased to 2.6%. Tsao et al.<sup>28</sup> found a significantly lower incidence of adhesive small bowel obstruction after laparoscopic appendectomy (0.5% laparoscopic and 3.1% open) in 1105 children at a single institution being treated for

appendicitis. The incidence of perforated appendicitis was nearly identical in their 2 groups. Another group demonstrated similar findings, showing a reduction (1.19% laparoscopic and 4.51% open) in postoperative bowel obstruction in children undergoing laparoscopic appendectomy over a 15-year period.<sup>29</sup> This difference held true when only the group with perforated appendicitis was analyzed (1.8% laparoscopic and 9.78% open).

The benefits of laparoscopy in the prevention of adhesions in colorectal surgery have been well demonstrated in adults. An observational study showed decreased adhesion scores in the laparoscopic compared with open group following elective colorectal resection.<sup>30</sup> A large database study from Burns et al.<sup>31</sup> found that patients selected for laparoscopic colorectal resection had lower rates of readmission for adhesions (6.3% versus 8.2%) and reintervention for adhesions (2.8% versus 3.6%) than patients undergoing open colorectal resection. Patients who had ileal pouch–anal anastomosis using a laparoscopic approach developed significantly fewer adhesions, including adnexal adhesions in women, when compared to an open approach.<sup>32,33</sup> This reduction in adhesions was found to be present even when compared to open operations with the use of glycerol hyaluronate/carboxymethylcellulose bioresorbable adhesion barrier.<sup>33</sup> Other studies demonstrate some improvement in fertility rates following laparoscopic compared with open total proctocolectomy.<sup>34,35</sup>

In comparing laparoscopic and open total colectomy in children, Fraser et al.<sup>36</sup> found no significant difference in postoperative bowel obstruction. In a comparison of laparoscopic-assisted and open total proctocolectomy with ileal pouch–anal anastomosis in children, Linden et al.<sup>37</sup> demonstrated a significantly lower rate of postoperative small bowel obstruction (3% laparoscopic and 23% open). Their multivariable regression analysis confirmed that the only significant risk factor for postoperative bowel obstruction was the initial operative approach. However, a cohort of children undergoing laparoscopic (or lap-assisted) colorectal surgery for inflammatory bowel disease developed late postoperative bowel obstruction in 16% of cases.<sup>38</sup>

When comparing laparoscopy to laparotomy for bowel resection in adults, there is a decreased incidence of postoperative small bowel obstruction and ventral hernia for the laparoscopic group.<sup>39</sup> On second-look laparoscopy in pediatric urology patients, adhesions occurred in only 9.8%.<sup>40</sup> The mean time between procedures was 5.5 months. In adults undergoing second-look urologic laparoscopy, postoperative peritoneal adhesions were found in 22.2%, with 3.5% being at trocar sites.<sup>41</sup> Similarly, the incidence of trocar site adhesions (omentum or bowel) in children has been shown to be relatively low at repeat laparoscopy.<sup>42</sup>

### The role of laparoscopy in treating adhesions

Historically, laparotomy with lysis of adhesions has been the conventional management for adhesive small bowel obstruction in children.<sup>4,25</sup> The risk of recurrence of adhesive small bowel obstruction is greatest during the first 5 years following an operation for adhesive small bowel obstruction.<sup>43</sup> Additionally, however, the cumulative recurrence risk for patients operated on once for adhesive small bowel obstruction reaches 29% at 25 years.<sup>43</sup> In the adult literature, there have been multiple retrospective publications demonstrating the utility of laparoscopy in the treatment of adhesive small bowel obstruction. They show earlier recovery of bowel function and reduced length of stay as well as decreased incisional complications.<sup>44,45</sup> Additionally, laparoscopy has the theoretical advantage of reducing additional adhesion formation and thus recurrence. Patients with acute small bowel obstruction followed up prospectively received successful

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