Effect of Laparoscopy on the Risk of Small-Bowel Obstruction
A Population-Based Register Study

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Objective: To investigate the incidence and risk factors for small-bowel obstruction (SBO) after certain surgical procedures.

Design: A population-based retrospective register study.

Setting: Small-bowel obstruction causes considerable patient suffering. Risk factors for SBO have been identified, but the effect of surgical technique (open vs laparoscopic) on the incidence of SBO has not been fully elucidated.

Patients: The Inpatient Register held by the Swedish National Board of Health and Welfare was used. The hospital discharge diagnoses and registered performed surgical procedures identified data for cholecystectomy, hysterectomy, salpingo-oophorectomy, bowel resection, anterior resection, abdominoperineal resection, rectopexy, appendectomy, and bariatric surgery performed from January 1, 2002, through December 31, 2004. Data on demographic characteristics, comorbidity, previous abdominal surgery, and death were collected.

Main Outcome Measures: Episodes of hospital stay and surgery for SBO within 5 years after the index surgery.

Results: A total of 108,141 patients were included. The incidence of SBO ranged from 0.4% to 13.9%. Multivariate analysis revealed age, previous surgery, comorbidity, and surgical technique to be risk factors for SBO. Laparoscopy exceeded other risk factors in reduction of the risk of SBO for most of the surgical procedures.

Conclusions: Open surgery seems to increase the risk of SBO at least 4 times compared with laparoscopy for most of the abdominal surgical procedures studied. Other factors such as age, previous abdominal surgery, and comorbidity are also of importance.


Small-bowel obstruction (SBO) is a mechanical bowel obstruction and a common reason for emergency admission. The dominating etiology is intraperitoneal adhesions that develop as a response to peritoneal trauma, such as abdominal surgery, and form within days after a surgical procedure. Adhesion-related morbidity is related to substantial health care costs and, as a complication of surgery, it is becoming a medicolegal issue.

Reduction of adhesion-related morbidity, such as SBO, is thus of importance for patients as well as for society. Risk factors for SBO after surgery include age, site and type of surgery within the abdomen, previous surgery for SBO, emergency surgery, and inflammatory conditions. Because adhesions can be reduced by improvement of surgical technique and different types of mechanical barriers and adhesion-reducing solutions, it is probable that these measures would reduce the risk of SBO; however, the clinical impact has not been fully elucidated. Laparoscopic surgery is considered to be associated with less surgical trauma, implying a reduction of adhesions. The reports in the literature regarding the clinical effect of laparoscopy on adhesion-related morbidity have not been convinc-
Laparoscopic surgery is evolving and is now part of the routine practice in most hospitals. Some clinical advantages of laparoscopic surgery compared with open surgery have been shown, such as shorter hospital stay, less postoperative pain, and a faster recovery. Open surgery has advantages with better overview and tactile feedback, and laparoscopy has a longer learning curve, but reports have proven the 2 techniques similar in outcome, for example, in colorectal malignancy. Despite prolonged operating time and initial higher costs compared with open surgery, laparoscopic surgery has been reported to reduce costs in a longer perspective.

The aim of this study was to explore the incidence of SBO after abdominal and pelvic surgery for several common surgical and gynecological conditions and to identify possible risk factors for SBO.

METHODS

STUDY DESIGN

Study Population

This study was undertaken using the Inpatient Register held by the Swedish National Board of Health and Welfare, which contains information on hospital discharge diagnoses (coded according to the International Classification of Diseases, Tenth Revision [ICD-10]) and on performed surgical procedures (coded according to the Swedish version of the Nordic Medico-Statistical Committee Classification of Surgical Procedures, version 1.9) in all Swedish hospitals. It is required by legislation that all health care providers keep records of and report all treated patients, including those in day care. More than 98% of all episodes of hospitalization in Sweden are reported to the registry. The validity is considered high for surgical procedures.

Inclusion Criteria

The study was undertaken in several steps. The use of laparoscopy was not sufficiently frequent before 2002 to allow for separate analyses of surgical technique, so no procedures before 2002 were included. Because previous studies have demonstrated that the site and type of surgery affect adhesion formation, we chose the most common abdominal procedures performed by an open or a laparoscopic approach in 2002. All patients with surgical codes identifying any of these procedures from January 1, 2002, through December 31, 2004, were included: cholecystectomy; hysterectomy; salpingo-oophorectomy; bowel resection, including small-bowel resection and all types of colonic resections but not rectal resections; anterior resection of the rectum; abdominoperineal resection of the rectum; rectopexy; appendectomy; and bariatric surgery, including gastric bypass and other procedures to diminish gastric volume.

Exclusion Criteria

All patients with hospitalization or surgery for SBO before the index operation were excluded.

Variables Studied

Age, sex, comorbidity (defined as at least 1 extra diagnosis apart from the main diagnosis), surgical technique (open or laparoscopic), and abdominal surgery before the index operation were studied.

Follow-up Time

Follow-up lasted until death or up to 5 years after the initial surgical procedure. No patient was followed up more than 5 years.

Outcome Measures

We extracted data for each individual on hospital stay due to SBO defined by the following ICD-10 diagnoses: K56.5 ("small bowel obstruction due to adhesions"), K56.6 ("other and not specified obstruction of the bowel"), and K56.7 ("small bowel obstruction without further specification"). Early postoperative SBO (defined as hospitalization or surgery within 7 days of the index procedure), which mainly represents postoperative ileus and not mechanical obstruction, was not included.

All surgical procedures during this period indicating surgery for bowel obstruction were identified by the Swedish surgical codes alone or in combination with the ICD-10 code for bowel obstruction just mentioned. The surgical codes for colonic resection were not included to reduce the risk of including patients with bowel obstruction due to causes other than adhesions. Each patient was counted for only the first admission or the first surgical procedure for SBO, even if there were more episodes during the 5-year follow-up period.

ETHICAL ASPECTS

The data retrieval from the register did not include patient or hospital identification. No individual patient medical records have been studied, and results are presented only for groups. No individual patient can be identified; thus, no approval from the ethics committee was required or obtained.

STATISTICAL ANALYSIS

The age of an individual was replaced by the average age in the corresponding age class (each age class ranged 5 years). For comparing age between groups, either the independent t test or, in the case of a significant Levene test indicating heteroscedasticity, the Welsh version of the test was used. For comparison of categorical variables between groups, the χ² test was used. When comparing the risk of hospitalization for SBO, surgery for SBO, and mortality between surgical techniques (open vs laparoscopic), the odds ratio was calculated. In an adjusted analysis, the risk of hospitalization for SBO was studied by using logistic regression with surgical technique (open vs laparoscopic), age (dichotomized: older vs younger than the median age per surgical procedure), previous abdominal surgery (yes vs no), comorbidity (yes vs no), and when applicable, also sex (male vs female) as explaining factors. When analyzing abdominoperineal resection, surgical technique was excluded as an explaining factor because of the few cases of laparoscopic surgery.
Sex was excluded as an explaining factor when analyzing rectopexy because there were few cases in the male population.

RESULTS

Data on 112,190 patients were extracted from the register; however, 4049 of those patients had a previous hospitalization for SBO and were thus excluded from further analysis. The remaining 108,141 patients were included in the study (Figure). The incidence of SBO ranged from 0.4% to 13.9% depending on the type of operation. The effect of age, sex, previous abdominal surgery, and comorbidity on the rate of SBO is displayed in Table 1 (bivariate analysis). For most surgical procedures, patients with SBO were older, and SBO was more common in patients with previous abdominal surgery. In patients who underwent cholecystectomy, bowel resection, or appendectomy, a higher comorbidity was associated with a higher incidence of SBO. In the group of complicated cholecystectomy as well as the group of anterior resection, SBO was more common among men. Within 5 years, SBO was associated with an increased risk of mortality (Table 1).

The mean age, sex, history of previous abdominal surgery, and the comorbidity for each procedure subdivided into groups of open and laparoscopic surgery are displayed in Table 2. The mean age was higher in the open group for cholecystectomy, hysterectomy, salpingo-oophorectomy, bowel resection, complicated appendectomy, and bariatric surgery. In general, there were more

Table 1. Effect of Age, Sex, Previous Abdominal Surgery, and Comorbidity on the Rate of SBO

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No.</th>
<th>% SBO</th>
<th>Age, Mean (SD), y</th>
<th>Female Sex, %</th>
<th>History of Surgery, %</th>
<th>Presence of Comorbidity, %</th>
<th>Died During Follow-Up, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholecystectomy</td>
<td>18395</td>
<td>0.4</td>
<td>56 (17)</td>
<td>71</td>
<td>28</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>Cholecystectomy due to complicated disease</td>
<td>16264</td>
<td>0.8</td>
<td>64 (14)</td>
<td>42</td>
<td>32</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>14392</td>
<td>3.3</td>
<td>62 (13)</td>
<td>100</td>
<td>100</td>
<td>49</td>
<td>10</td>
</tr>
<tr>
<td>Salpingo-oophorectomy</td>
<td>9319</td>
<td>2.8</td>
<td>61 (14)</td>
<td>100</td>
<td>100</td>
<td>42</td>
<td>10</td>
</tr>
<tr>
<td>Bowel resection</td>
<td>14486</td>
<td>6.6</td>
<td>64 (14)</td>
<td>54</td>
<td>53</td>
<td>58</td>
<td>40</td>
</tr>
<tr>
<td>Anterior resection</td>
<td>3523</td>
<td>10.2</td>
<td>65 (14)</td>
<td>40</td>
<td>24</td>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>Abdominoperineal resection</td>
<td>1183</td>
<td>13.9</td>
<td>66 (13)</td>
<td>39</td>
<td>31</td>
<td>50</td>
<td>43</td>
</tr>
<tr>
<td>Rectopexy</td>
<td>275</td>
<td>5.8</td>
<td>74 (14)</td>
<td>100</td>
<td>25</td>
<td>62</td>
<td>26</td>
</tr>
<tr>
<td>Appendectomy due to flegmonous appendicitis</td>
<td>18803</td>
<td>0.4</td>
<td>43 (21)</td>
<td>37</td>
<td>43</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>9605</td>
<td>1.8</td>
<td>47 (24)</td>
<td>52</td>
<td>12</td>
<td>46</td>
<td>6</td>
</tr>
<tr>
<td>Bariatric surgery</td>
<td>1896</td>
<td>3.2</td>
<td>42 (12)</td>
<td>74</td>
<td>77</td>
<td>36</td>
<td>3</td>
</tr>
</tbody>
</table>

Abbreviation: SBO, small-bowel obstruction.

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females in the laparoscopic groups, especially for cholecystectomy and appendectomy. Previous abdominal surgery was more common in the open group for cholecystectomy, but the opposite was true for hysterectomy. There were more patients with comorbidity in the open groups for cholecystectomy, salpingo-oophorectomy, and bowel resection, but fewer in the open group for hysterectomy and appendectomy.

Except for bariatric surgery, there were no procedure groups that had a higher frequency of hospitalization for SBO in the laparoscopic group than in the open group (Table 3).

An adjusted comparison between the 2 surgical techniques was performed as a multivariate analysis displayed in Table 4. The risk, calculated as an odds ratio, was generally higher for the open technique with the exception of bariatric surgery. This was true especially for cholecystectomy (odds ratio, 2.9), cholecystectomy for complicated cholecystitis (4.0), salpingo-oophorectomy (7.6), bowel resection (4.9), and appendectomy due to flegmonous appendicitis (4.5), where the odds ratio for the surgical technique exceeded the odds ratio for all other factors. Age was an important risk factor for SBO, as were previous abdominal surgery and to some extent comorbidity.

The aim of this study was to identify the incidence and risk factors for mechanical SBO after a number of common abdominal and pelvic procedures. Small-bowel obstruction is a substantial health care challenge, and correctly identified risk factors can provide improved tools to reduce the risk of SBO after an abdominal surgical procedure. Of the possible factors to examine in a population-

### Table 2. Mean Age, Sex, History of Abdominal Surgery, and Presence of Comorbidity for Each Procedure Divided into Groups of Open and Laparoscopic Surgery

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No.</th>
<th>% Lap</th>
<th>Age, Mean (SD), y</th>
<th>Female Sex, %</th>
<th>History of Surgery, %</th>
<th>History of Comorbidity, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholecystectomy</td>
<td>18 395</td>
<td>89</td>
<td>55 (17)</td>
<td>66a</td>
<td>77</td>
<td>22a</td>
</tr>
<tr>
<td>Cholecystectomy due to complicated disease</td>
<td>16 264</td>
<td>62</td>
<td>62 (16)</td>
<td>50a</td>
<td>65</td>
<td>21a</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>14 392</td>
<td>1</td>
<td>56 (13)</td>
<td>100</td>
<td>100</td>
<td>10a</td>
</tr>
<tr>
<td>Salpingo-oophorectomy</td>
<td>9319</td>
<td>30</td>
<td>55 (15)</td>
<td>100</td>
<td>100</td>
<td>10a</td>
</tr>
<tr>
<td>Bowel resection</td>
<td>14 486</td>
<td>2</td>
<td>68 (16)</td>
<td>53</td>
<td>52</td>
<td>19 a</td>
</tr>
<tr>
<td>Anterior resection</td>
<td>3523</td>
<td>2</td>
<td>69 (13)</td>
<td>46</td>
<td>56</td>
<td>21 a</td>
</tr>
<tr>
<td>Abdominoperineal resection</td>
<td>1163</td>
<td>1</td>
<td>68 (12)</td>
<td>43</td>
<td>60</td>
<td>21 a</td>
</tr>
<tr>
<td>Rectopexy</td>
<td>275</td>
<td>24</td>
<td>65 (18)</td>
<td>90</td>
<td>92</td>
<td>24 a</td>
</tr>
<tr>
<td>Appendectomy due to flegmonous appendicitis</td>
<td>18 803</td>
<td>17</td>
<td>29 (18)</td>
<td>63</td>
<td>63</td>
<td>10a</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>9605</td>
<td>12</td>
<td>36 (23)</td>
<td>48a</td>
<td>46</td>
<td>9 a</td>
</tr>
<tr>
<td>Bariatric surgery</td>
<td>1896</td>
<td>35</td>
<td>41 (10)c</td>
<td>78</td>
<td>76</td>
<td>21 a</td>
</tr>
</tbody>
</table>

Abbreviation: Lap, laparoscopic.

aP < .001.
bP < .01.
cP < .05.

### Table 3. Frequency of Hospitalization or Surgery for SBO After Surgical Procedure

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No.</th>
<th>% Lap</th>
<th>Hospitalized for SBO, %</th>
<th>Underwent Operation for SBO, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholecystectomy</td>
<td>18 395</td>
<td>89</td>
<td>1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Cholecystectomy due to complicated disease</td>
<td>16 264</td>
<td>62</td>
<td>1.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>14 392</td>
<td>1</td>
<td>3.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Salpingo-oophorectomy</td>
<td>9319</td>
<td>30</td>
<td>3.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Bowel resection</td>
<td>14 486</td>
<td>2</td>
<td>6.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Anterior resection</td>
<td>3523</td>
<td>2</td>
<td>10.2</td>
<td>9.5</td>
</tr>
<tr>
<td>Abdominoperineal resection</td>
<td>1163</td>
<td>1</td>
<td>14.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Rectopexy</td>
<td>275</td>
<td>24</td>
<td>7.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Appendectomy due to flegmonous appendicitis</td>
<td>18 803</td>
<td>17</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>9605</td>
<td>12</td>
<td>1.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Bariatric surgery</td>
<td>1896</td>
<td>35</td>
<td>2.9</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Abbreviations: Lap, laparoscopic; OR, odds ratio; SBO, small-bowel obstruction.
aP < .001.
bP < .01.
cP < .05.
based registry, our study identified the surgical technique, open vs laparoscopic, to be one of the more important for the risk of SBO. Also, in contrast to several other risk factors, it is possible to influence the choice of surgical technique.

The Swedish Inpatient Register provides an excellent opportunity to provide information on factors important to consider in adhesion-related prevention. Even if this study does not replace a properly performed controlled randomized trial, it includes a large number of patients and is population based.22 The external validity is high regarding surgical procedures,23 and there is no reason to expect a biased reporting to the register dependent on any of the factors of interest. There is a risk of identifying patients with other types of bowel obstruction using the ICD-10 codes,25 and this remains a risk unless each patient’s medical record is reviewed. We consider this risk to be equally distributed in all groups and thus should not influence the outcome of the analysis. It is possible that some port-site hernias causing SBO26 have been missed because of our exclusion of all registrations of SBO the first week after the index surgery; however, we also reduce the risk of including patients with postoperative ileus, probably more common in the open group.27

We identified age as a risk factor, but the results are not similar for all groups. Younger patients operated on for colorectal conditions had a higher risk of SBO, which confirms previous results,10 but, in contrast, older patients undergoing a cholecystectomy or an appendectomy had a higher odds ratio for SBO. These findings are in part new, indicating that risk factors may vary with the type of procedure. It is probable that age as a risk factor requires further study before any clinical recommendation based on age can be developed.

Abdominal surgery before the index operation has been considered a risk for SBO,10,11 and our results confirm this. In the clinical setting, previous abdominal surgery has often been regarded as a contraindication for laparoscopic surgery, although there are studies indicating that it is possible to perform laparoscopy in spite of previous abdominal surgery.28 The fact that previous abdominal surgery is a risk factor for adhesive disease should perhaps prompt a more liberal approach to laparoscopy in these patients to possibly reduce further adhesive disorder, but caution must be taken to avoid complications due to already existing adhesions.29

It is problematic to define comorbidity, and our use of secondary diagnoses as a definition of comorbidity at the time of discharge must be considered a simplification. There is a risk that the number of secondary diagnoses has been registered incorrectly, because this registration is the basis of reimbursement, and studies indicate that certain hospitals have added more secondary diagnoses to achieve better settlements.23 However, this is probably performed systematically, and there is no reason to believe that this is performed differently because of choice of surgical technique. In bivariate analysis as well as in multivariate analysis, comorbidity was related to the incidence of SBO in cholecystectomy, bowel resection, and appendectomy, but comorbidity was also related to whether open or laparoscopic surgery was performed. This suggests a possible confounding by indication, although this must be further studied before any conclusions can be made.

Some groups did not seem to benefit from laparoscopic surgery in the reduction of SBO. A previous large study did not find an effect of laparoscopy on adhesive morbidity compared with open surgery for patients undergoing hysterectomy,11 and our findings support these results. One hypothesis is that this result may be related to a limited dissection in the pelvis, but it is possible that the small number of laparoscopic hysterectomy procedures in our study has affected our results, and we refrain from further conclusions.

In patients undergoing bariatric surgery, we found no clear risk factors for SBO. However, interpretations should be made with caution. Studies have shown that most SBO-
related readmissions in patients who have had bariatric surgery are due to internal obstruction after gastric bypass and not classic mechanical obstruction possibly related to adhesive disease. It is unfortunate that there is no proper ICD-10 classification for this type of obstruction; many are probably classified as K36.6 or K36.7, making it difficult to distinguish patients with internal obstruction from other types of mechanical obstruction.

This study shows that, beyond important factors such as age, previous abdominal surgery, and comorbidity, the surgical technique is the most important factor related to SBO. Compared with laparoscopic surgery, open surgery seems to increase the risk of SBO at least 4 times. Of course, confounding by indication must be considered, which could affect the results. We have attempted to address this with our separation of different types of appendicitis and different indications for cholecystectomy, and although it may not be totally sufficient, we believe that the present results certainly point in a clear direction.

The fact that this study is population based and that the group size is sufficiently large indicate that our results represent an actual difference due to surgical technique. The safety and the short-term benefits of laparoscopy are already known, and it is possible that laparoscopy should be regarded as the preferred technique in an attempt to further reduce the complications of surgery.

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Author Contributions: Drs Angenete, Gellerstedt, and Haglind had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Angenete, Gellerstedt, and Haglind. Acquisition of data: Angenete, Jacobsson, Gellerstedt, and Haglind. Analysis and interpretation of data: Angenete, Gellerstedt, and Haglind. Drafting of the manuscript: Angenete and Gellerstedt. Critical revision of the manuscript for important intellectual content: Angenete, Jacobsson, Gellerstedt, and Haglind. Statistical analysis: Angenete, Jacobsson, Gellerstedt, and Haglind. Obtained funding: Angenete and Haglind. Administrative, technical, and material support: Angenete and Haglind. Study supervision: Gellerstedt.

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REFERENCES

Minimal Invasion and Maximal Benefit

The short-term benefits of laparoscopy have been well documented over the past 20 years: less postoperative pain, quicker return to baseline function, and shorter hospital stays. This study by Angenete and colleagues1 suggests that the benefits of laparoscopy may extend beyond the immediate postoperative period. Using a robust national database of more than 100,000 patients who were followed up for up to 5 years or until death, the authors found that laparoscopy correlated highly with a reduced incidence of postoperative small-bowel obstruction (SBO) compared with open surgery. This relationship held true for numerous commonly performed procedures including cholecystectomy, hysterectomy, oophorectomy, bowel resection, rectopexy, and appendectomy. The reduction in SBO incidence remained for each of these procedures even after accounting for patient factors such as age, comorbidity, and previous surgery.

This finding adds to the body of literature suggesting that laparoscopy decreases the incidence of adhesion-related readmissions2 and has important implications for both the quality and cost of surgical care. For patients, who typically face up to a 1-in-3 chance that they will be readmitted for management of adhesive-related disease within 10 years of open abdominal surgery,3 it offers an opportunity for improved quality of life and decreased morbidity. For surgeons, it highlights another potential benefit of minimally invasive surgery and challenges us to continue to offer less invasive procedures whenever they are feasible. For payers and health care policy leaders, it suggests that substantial cost savings could be achieved if open surgery were replaced with laparoscopic surgery more often. Given that inpatient expenditures on adhesiolysis-related complications exceed $2 billion annually in the United States,4 these savings could be substantial.

One issue that has yet to be addressed is the way that newer payment models, such as bundled or episode-based payments, would account for the higher initial cost of laparoscopy but lower long-term cost related to shorter hospitalizations, lower wound complication rates, fewer readmissions, and fewer reoperations. Despite this unknown, Angenete and colleagues1 have provided strong evidence that minimal invasion often results in maximal benefit.

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