The incidence and morbidity of adhesions after treatment of neonates with gastroschisis and omphalocele: a 30-year review

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Omphalocele;
Gastroschisis;
Small bowel obstruction;
Risk factors

Abstract

Background/Purpose: Adhesive small bowel obstruction (SBO) is a feared complication after correction of abdominal wall defects in neonates. Knowledge of its incidence and potential risk factors in a well-documented group with strict follow-up is needed to guide preventive measures.

Methods: Records of 170 neonates with abdominal wall defects, 59 gastroschisis (GS) and 111 omphalocele (OC), were reviewed focusing on SBO. Risk of SBO was calculated, and potential risk factors were analyzed. Long-term complaints possibly associated with adhesions were assessed through questionnaire.

Results: One hundred forty-seven neonates were operated on, 12 were treated nonoperatively, and 11 patients died shortly after birth. Defects were primarily closed in 128, 7 neonates needed prosthetic mesh, and 12 had a silastic sac inserted. Twenty-six (18%) neonates had SBO, 14 (25%) of 55 with GS, and 12 (13%) of 92 with OC (P = .06). Of the 26 with SBO, 26 (88%) needed laparotomy. Four patients died because of SBO. Most episodes (85%) were in the first year. Sepsis and fascia dehiscence were predicting risk factors for SBO. Abdominal pain and constipation were frequent long-term complaints not significantly associated with SBO.

Conclusions: Adhesive SBO is a frequent and serious complication in the first year after treatment of congenital abdominal wall defects. Sepsis and fascial dehiscence are predictive factors.

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children have a longer lifetime risk for development of adhesion-related complications [13,14]. Children treated for congenital abdominal wall defects seem to be particularly at risk developing adhesion-related morbidity. Small bowel obstruction, for example, occurs 2 to 3 times more often in comparison with children undergoing other abdominal operations [13-17]. Pediatric patients might benefit from adhesion preventive measures. However, more accurate data on incidence and short- and long-term adhesion-related morbidity and mortality in a large group of patients are needed before a plea for routine adhesion prevention can be made. We therefore undertook a retrospective analysis in a large well-documented group of pediatric patients treated for gastroschisis (GS) and omphalocele (OC) focused on incidence, risk factors, and morbidity of adhesion formation.

1. Patients and methods

Medical records of consecutive neonates having GS or OC treated in our department between 1971 and 2004 were reviewed. One pediatric surgeon meticulously listed relevant demographic and perioperative data of all these neonates during the entire 30-year period in the records. The following demographic and operative data were extracted: gestational age, sex, type of abdominal wall defect, and other congenital malformations. Treatment was divided into nonoperative and operative. Initial operative treatment was divided into primary closure, insertion of prosthetic mesh, and temporary closure using a silastic sac. Major systemic and abdominal postoperative complications were noted including infant respiratory distress syndrome (IRDS), sepsis, cause of death, anastomotic leakage, need for reoperations, fascial dehiscence, and the occurrence of SBO. Small bowel obstruction was defined based on history (pain, nausea, vomiting, and cessation of stool production), physical examination (abnormal bowel sounds, abdominal distension), and abdominal radiography (dilated loops of small bowel, air-fluid levels). Findings had to be positive in at least 2 of 3 categories. Small bowel obstruction was considered adhesive if adhesive bands were divided relieving distended bowel at laparotomy.

Potential risk factors for SBO were analyzed including sex, gestational age, type of abdominal wall defect, giant omphalocele, type of treatment, type of operation, number of reoperations, need for bowel resection at initial surgery, inadvertent enterotomy at initial and subsequent laparotomies, and major postoperative complications.

Long-term morbidity focused on consequences of postoperative adhesions was obtained from data from medical records and a questionnaire sent to all surviving patients. This included hospital readmission for abdominal complaints, abdominal operations, SBO, chronic abdominal pain, and chronic constipation.

1.1. Statistical analysis

The Kaplan-Meier method was used to calculate the probability of developing SBO. This method calculates incidence curves over time by using follow-up data from all individuals in the cohort, regardless of duration of follow-up. End points of follow-up were first occurrence of SBO, death, loss to follow-up, and end of the observational period. The log-rank test was used to determine potential risk factors for developing SBO. The Student’s t test was used for analyzing gestational age as potential risk factor. A multivariate modeling approach (Cox proportional hazards) was used to identify any variable that predicts SBO. Analyses of long-term morbidity (chronic abdominal pain and constipation) related to SBO was performed using the Fisher’s Exact test. A P value of less than .05 was considered statistically significant.

2. Results

2.1. Patients

One hundred seventy neonates were identified with a congenital abdominal wall defect. Their demographic data are shown in Table 1. One hundred forty-seven neonates underwent surgery and 12 were not operated on awaiting closure by primary epithelialization. Eleven patients died within 36 hours after birth because of multiple congenital defects and were excluded for further evaluation. Median follow-up of the remaining 159 patients was 87 months (range, 5 days-32.5 years).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic data of 170 neonates with congenital abdominal wall defect treated between 1971 and 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Omphalocele</td>
</tr>
<tr>
<td>Total</td>
<td>111</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>56</td>
</tr>
<tr>
<td>Female</td>
<td>55</td>
</tr>
<tr>
<td>Mean (range) gestational age (wk)</td>
<td>38.4 (31-42)</td>
</tr>
<tr>
<td>Other congenital anomalies a (%)</td>
<td>34 (31)</td>
</tr>
<tr>
<td>Operative group (%)</td>
<td>92 (83)</td>
</tr>
<tr>
<td>Nonoperative group (%)</td>
<td>12 (11)</td>
</tr>
<tr>
<td>Mortality b within 36 h (%)</td>
<td>7 (6)</td>
</tr>
<tr>
<td>Mortality after 36 h</td>
<td>19 (17)</td>
</tr>
</tbody>
</table>

a Beckwith-Wiedemann syndrome, trisomy 13/18/21, pentalogy of Cantrell, VACTERL association (vertebral, anal, cardiac, tracheal, esophageal, renal, and limb), OEIS syndrome (omphalocele, exstrophy of the cloaca, imperforated anus, spinal abnormalities).

b Patients were excluded for further evaluation.
2.2. Nonoperative group

Of 12 patients, 2 had a giant omphalocele (defined as abdominal wall defect >4 cm and liver included). Eight (67%) patients died (all in OC group), 3 after severe sepsis and 5 as a result of other congenital disorders. Four patients survived. No patient in this group had SBO with a median follow-up of 4 months (range, 6 days-26 years).

2.3. Operative group

Primary closure was performed in 128 (87%) neonates, prosthetic mesh insertion in 7, and silastic sac coverage in 12 patients. Sixteen (11%) patients died (9 GS, 7 OC), and time of death varied between 2 days and 7.5 years. Syndrome-related mortality occurred in 6 of 7 patients with OC. Four patients, all with gastrochisis, died because of bowel ischemia. Two patients died because of sepsis, 2 because of respiratory failure, and 2 patients died because of asporation at the age of 5 and 7.5 years.

Small bowel obstruction occurred in 26 (18%) of 147 patients, 14 (25%) of 55 with GS, and 12 (13%) of 92 with OC (P = .06). Of 12 SBOs in OC, 7 occurred in giant omphaloceles (n = 23). In 23 (88%) of 26, adhesive SBO was confirmed at laparotomy. The median time to develop SBO after the first operation was 39.5 days (range, 8 days-13 years). Sixteen patients (62%) had SBO within the first 3 months after initial operation and in 85% within the first year. In-hospital SBO occurred in 17 (66%) patients and out-hospital SBO (readmitted after primary discharge) in 9 (33%) patients between 5 months and 13 years. Cumulative hazard to develop SBO as calculated by the Kaplan-Meier method is 0.27 and 0.10 within 6 months, 0.27 and 0.12 within 1 year, and 0.27 and 0.13 within 2 years for GS and OC, respectively (Fig. 1).

Three patients with SBO were successfully treated nonoperatively. Laparotomy was done in 23, and in those, SBO was because of adhesive bands. Eight (35%) patients needed small bowel resection and 4 of them had to undergo a second look to check bowel vitality. Of 26 patients (15%), 4 died after operative treatment of SBO; 1 patient because of postoperative sepsis after repeated relaparotomies for ischemic bowel, 1 because of diffuse intravascular coagulopathy, 1 as a result of an anastomotic leak, and 1 patient with lung hypoplasia because of pulmonary failure.

Results of univariate analysis are shown in Table 2. Incidence of SBO was significantly higher in patients who had fascia dehiscence (P < .01), anastomotic leakage (P = .01), and sepsis (P = .01) and tended to be higher in the GS group (25%) than in the OC group (11%) (P = .06). At multivariate analysis, sepsis and fascial dehiscence were independent predictors of SBO (hazard ratio, 2.66 [95% confidence interval, 1.03-6.85] and 14.71 [95% confidence interval, 2.33-92.97], respectively).

The response rate of the questionnaire was 102 (76%) of 135 patients. Operation for SBO was the second most common operation in the follow-up of children after correction of congenital abdominal wall defects. Chronic abdominal pain and constipation occurred in 30 (30%) and 20 (20%) of the 102 patients, respectively, and were not correlated to occurrences of SBO (6/30 and 4/21 patients, respectively; P = .27 and P = .38). Follow-up by

Table 2  Univariate analysis of potential risk factors for SBO in the operative group (n = 147)

<table>
<thead>
<tr>
<th></th>
<th>No SBO</th>
<th>SBO</th>
<th>Total</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS</td>
<td>41</td>
<td>14</td>
<td>55</td>
<td>.06</td>
</tr>
<tr>
<td>OC</td>
<td>80</td>
<td>12</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Male/female</td>
<td>68/53</td>
<td>15/11</td>
<td>83/64</td>
<td>.72</td>
</tr>
<tr>
<td>Mean gestational age</td>
<td>37.9</td>
<td>37.2</td>
<td></td>
<td>.19*</td>
</tr>
<tr>
<td>Type of correction</td>
<td></td>
<td></td>
<td></td>
<td>.66</td>
</tr>
<tr>
<td>Primary closure</td>
<td>108</td>
<td>20</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>Silastic sac</td>
<td>9</td>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Prosthetic mesh</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Small bowel resection at first operation</td>
<td>7</td>
<td>3</td>
<td>10</td>
<td>.23</td>
</tr>
<tr>
<td>1 or more reoperations</td>
<td>31</td>
<td>12</td>
<td>43</td>
<td>.06</td>
</tr>
<tr>
<td>Postoperative complication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRDS</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>.36</td>
</tr>
<tr>
<td>Fascia dehiscence</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Anastomotic leakage</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>.01</td>
</tr>
<tr>
<td>Sepsis</td>
<td>32</td>
<td>13</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Chronic abdominal pain</td>
<td>23</td>
<td>6</td>
<td>29</td>
<td>.27*</td>
</tr>
<tr>
<td>Chronic obstitution</td>
<td>16</td>
<td>4</td>
<td>20</td>
<td>.38*</td>
</tr>
</tbody>
</table>

A log-rank test was used.
* t Test.
* Fisher’s Exact test.

Fig. 1  Cumulative incidence of SBO using the Kaplan-Meier method for time-related incidences.
questionnaire revealed SBO in 2 patients who both have had surgery in another hospital.

3. Discussion

The present study demonstrates that the risk of adhesive SBO after operation for congenital abdominal wall defects is considerably high and that SBO is associated with marked morbidity and mortality particularly in the first year of life. Fascial dehiscence and sepsis predicted SBO in this series. Small bowel obstruction did not correspond with chronic abdominal complaints such as pain and constipation, which are present in 20% to 30%, respectively, of patients years after abdominal wall reconstruction.

This is the first study reporting on SBO exclusively in neonates treated for gastroschisis and omphalocele. Previous studies showed results of all neonatal surgeries, making accurate and long-term analysis of incidence and risk factors for SBO in this distinct relatively small subgroup difficult [13,14,18]. Studying neonates with gastroschisis and omphalocele was chosen for 2 reasons. First, these neonates undergo extensive peritoneal manipulation for abdominal wall closure and often need repeated laparotomy or insertion of prosthetic mesh, which are key factors inducing adhesion formation. Second, new techniques for abdominal wall closure and modern antiadhesive products give promising results in adults but need to be validated in neonatal laparotomy with extensive peritoneal manipulation for abdominal wall closure and often need repeated laparotomy or insertion of prosthetic mesh, which are key factors inducing adhesion formation.

The calculated incidence of SBO within 1 year was 12% in the OC group and 27% in the GS group increasing to 15% vs 37%, respectively, after 10 years. Both incidences are considerably higher than previously reported and may be explained by the completeness and accuracy of data and almost 10-year median and 30-year maximum follow-up in comparison with other series [13,14,18,21]. Wilkins and Spitz, who reported 15% SBOs after gastroschisis, had a 10.5-year follow-up and only 58% reply on questionnaires. Choudhry and Grant reported a 6% and 0% incidence after gastroschisis and exomphalos, respectively, with a short median follow-up of 39 months. In a population-based analysis of children younger than 5 years with a 4-year follow-up, Grant and coworkers found a 6.3% cumulative incidence of SBO after abdominal wall surgery directly related to adhesions and 14.2% incidence of SBO possibly related to adhesions. Long follow-up, however, is not the only explanation because most SBOs (85%) developed within the first year of life. The early occurrence of SBO is in concordance with other studies regarding adhesive bowel obstruction after neonatal laparotomy but has recently been challenged by Grant and coworkers [13,14,18,21]. They relate the highest incidence in the first year to the preponderance of short-term follow-up in most studies; however, this does not hold true for the observation in our study. The population-based study including a small proportion of neonates in a group of children younger than 5 years does not allow for proper conclusions on incidences of early SBO. The reason why SBO develops early in neonates after laparotomy has not been accurately addressed, but findings from our study and that of Choudhry suggest repeated laparotomies within a short period, extensive intraperitoneal tissue handling, and abdominal and systemic infections (sepsis, wound dehiscence, anastomosis leakage) to play a role. Dissecting adhesions during relaparotomy rapidly induces adhesion reformation that can be very dense. The early reformation, which is more difficult to prevent than de novo adhesion formation, is attributed to increased levels of fibrinolytic inhibitors and transforming growth factor in adhesive bands [22]. Operative procedures in adults with extensive tissue dissection also seem to induce early adhesive morbidity [23]. We previously reported a 11% calculated risk within 1 year to develop SBO after (sub) total colectomy, a surgical procedure with extensive dissection [12]. For other procedures with less peritoneal injury such as appendectomy and hysterectomy, time interval seems to be significantly longer and adhesive SBO may occur for the first time even 25 years after surgery.

The incidence of adhesive SBO tended to be higher in gastroschisis than in omphalocele. Several theories are conceivable regarding the massive adhesion formation propensity of GS correction beside extensive tissue manipulation. First, bowel is exposed to amnion fluid causing toxic and inflammatory reaction of the serosal lining [15,16], secondary healing of the fascia is accompanied by granulation tissue covering the viscera, ultimately leading to adhesive bands to the ventral abdominal wall. Intraabdominal sepsis in particular aggravates the inflammatory response in the abdominal cavity inducing diffuse adhesions. Both locations of adhesions are known to cause SBO [12]. Because of the small number of neonates who underwent small bowel resection at initial surgery, we could not confirm bowel resection as important risk factor for SBO in contrast to others [21].

Early morbidity after SBO was significant and related mortality was 15%, underlining the great impact of...
adhesions in sick children and this vulnerable patient group in particular [14]. We have a strong impression that the surgical community underestimates the great impact of adhesive SBO on morbidity and mortality. In our series, mortality after SBO was higher than mortality after surgery for neonates with GS and OC. In adult population, SBO-related mortality varies between 2% and 10% and equals the mortality rate of major abdominal surgery such as pancreatectoduodenectomy or open aortic aneurysm repair [25-27].

Furthermore, we have to be aware that even neonates with abdominal wall defects have a high risk for adhesive SBO and can benefit from adhesion prevention. There are new developments aiming at reduction of intestinal injury or prevention of adhesion formation. The use of amnion exchange during pregnancy may reduce bowel damage and subsequent SBO [29]. Waiting for complete epithelialization in giant omphaloceles before operation might reduce serosal injury and limit adhesiogenic areas. The component separation technique is a promising technique to primarily close the abdominal wall defect without tension and avoiding insertion of foreign material [30]. Recently, Inoue et al [20] reported a significant reduction in incidence and severity of postoperative adhesions and mean relaparotomy operation time with the use of hyaluronate-based barrier membrane in a series of 122 neonates, infants, and children.

Based on these results, we plan a multicenter study aiming at reduction of admission-related morbidity using adhesion reduction products at initial laparotomy in neonates with congenital abdominal wall defects.

**References**


