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Major stoma related morbidity in young children following stoma formation and closure: A retrospective cohort study

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ABSTRACT

Background: Little is known about stoma related morbidity in young children. Therefore, the aim of this study is to assess major morbidity after stoma formation and stoma closure and its associated risk factors.
Methods: All consecutive young children (age ≤ three years) who received a stoma between 1998 and 2018 at our tertiary referral center were retrospectively included. The incidence of major stoma related morbidity (Clavien-Dindo grade ≥III) was the primary outcome. This was separately analysed for stoma formation alone, stoma closure alone and all stoma interventions combined. Non-stoma related morbidity was excluded. Risk factors for major morbidity were identified using multivariable logistic regression analysis.
Results: In total 336 young children were included with a median follow-up of 6 (IQR:2–11) years. Of these young children, 5% (n = 17/336) received a jejunostomy, 57% (n = 192/336) an ileostomy, and 38% (n = 127/336) a colostomy. Following stoma formation, 27% (n = 92/336) of the young children experienced major stoma related morbidity, mainly consisting of high output stoma, prolapse and stoma stenosis. The major morbidity rate was 23% (n = 66/292) following stoma closure, most commonly comprising anastomotic leakage/stenosis, incisional hernia and adhesive obstructions. For combined stoma interventions, major stoma related morbidity was 39% (n = 130/336). Ileostomy was independently associated with a higher risk of developing major morbidity following stoma formation (OR:2.5; 95%-CI:1.3–4.7) as well as following closure (OR:2.7; 95%-CI:1.3–5.8).
Conclusions: Major stoma related morbidity is a frequent and severe clinical problem in young children, both after stoma formation and closure. The risk of morbidity should be considered when deliberating a stoma.

1. Introduction

Stoma creation can be necessary and lifesaving in young children with a bowel perforation, necrosis or obstruction [1,2]. In these critically ill children, a stoma is often created instead of a primary anastomosis to avoid the risk of anastomotic leakage. Stoma formation can result in major stoma related morbidity such as stoma necrosis, stenosis, prolapse, and incisional or parastomal hernia [3]. Additionally, excessive fluid loss might lead to dehydration and failure to thrive most specifically in case of ileostomies. [4,5] Most stomas are reversed, which means that these young children undergo a second surgery, after which anastomotic leakage or other complications might still occur. Overall stoma related morbidity is reported to occur in 20–38% of pediatric patients taking into account both stoma formation and closure [2,3,6]. The true incidence of major stoma related morbidity cannot reliably be established based on the currently available studies because of small cohort sizes [2,3,6].

Identification of risk factors for major stoma related morbidity could aid in the development of preventative strategies, or might lead to changes in surgical approaches. Previous studies identified

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a lower weight at stoma closure as a risk factor for postoperative morbidity in patients treated for necrotizing enterocolitis [3]. However, other studies could not confirm low weight as a risk factor for morbidity following stoma closure [7–9]. In addition, prematurity and underlying inflammatory disease have been reported to be correlated to stoma morbidity [5,10,11]. Large cohort studies are needed to more reliably define relevant risk factors.

Thus, the aim of this study was to assess major stoma related morbidity and its associated risk factors, both after stoma formation and stoma closure.

2. Methods

2.1. Patients and management

All young children (age ≤ three years) that received a stoma between January 1998 and December 2018 at our tertiary referral center were retrospectively identified. The ethical committee of the Amsterdam university medical center approved the study protocol (reference number: W18_233#18.278). Patients and parents received an opt-out letter for consent. Following consent, patient records were checked for eligibility. Data was retrieved and stored in an electronic database (Castor EDC).

2.2. Data extraction

Baseline characteristics and complications are presented for all patients. Diseases with $N<10$ were included as "Other" and are specified in supplementary Table 1.

The primary outcome included the incidence of major stoma related morbidity, which was defined as Clavien-Dindo grade ≥III complications (morbidity that led to redo-surgery, intensive care admission or death) [12]. Non-stoma related morbidity and stoma related complications with a Clavien-Dindo grade I or II were excluded. Patients that died within 30 days following formation or closure to non-stoma related causes were excluded from the analysis. Stoma related morbidity included: central line sepsis, high output stoma, stoma prolapse, stoma necrosis, stoma stenosis, adhesive obstruction, parastomal hernia, fistula to stoma and anastomotic leakage. Furthermore, following stoma closure, any morbidity related to the initial stoma site which resulted in surgery (e.g. correction of scar tissue or abscess drainage under general anesthesia) was included [12]. Major stoma related morbidity was noted for both types of stoma interventions (formation and closure) and classified according to the moment of occurrence following surgery (within 30 days or after 30 days).

Patients with a high-output stoma were only included if they underwent redo surgery for insertion of a central venous line. Central line sepsis was only included if the blood culture was positive in concordance with clinical suspicion which led to replacement of a new central venous line under general anesthesia or admission to the intensive care. Adhesive obstructions were identified based on the combined information from the electronic patient file, and surgical and radiological reports, and were recorded only if leading to redo surgery. In case of uncertainty based on the reports, a pediatric surgeon (JD) was consulted. Parastomal hernias were included based on physical examination or ultrasound results and the need for a re-intervention. For anastomotic leakage, the definition and classification of the International Study Group of Rectal Cancer (ISREC) was used [13,14]. There is no consensus on a definition for anastomotic stenosis. For this reason, anastomotic stenosis was presumed in patients with obstructive symptoms and description of a stenosis at the anastomotic site seen on contrast enema or during surgery. To distinguish anastomotic stenosis from post disease strictures in necrotizing enterocolitis, an anastomotic stenosis was only included if the stenosis was described at the site of the anastomosis in the surgical report.

Risk factors for the overall occurrence of major stoma related morbidity (any patient who experienced one or more high grade complications either during or after 30 days) were analysed following stoma formation and following stoma closure separately. Factors that were analysed included gender, surgery before stoma formation, underlying inflammatory disease (necrotizing enterocolitis and meconium peritonitis patients), vasopressin usage post-surgery, history of prematurity (defined as gestational age < 37 weeks), weight at surgery, location of the stoma (ileostomy, jejunostomy or colostomy), duration of presence of a stoma in days and suture resorption speed (defined as normal (Vicryl©, Novosyn©, Monocryl©) or slow (PDS and Monosyn plus©)) used for fascial suturing. These factors were chosen based on previous literature as well as clinical significance aiming to identify general, rather than disease specific, risk factors.

2.3. Statistical analysis

Descriptive data were reported as median with interquartile range. Comparison between treatment groups were performed using chi-square test for categorical data, and the Mann-Whitney U test for non-parametric continuous data. Chi squared testing was used to analyze if overall major stoma related morbidity differed over the years comparing patients operated within a consecutive five-year period starting from 1998. Multivariable logistic regression analysis was performed separately for both stoma formation and closure in order to identify risk factors for morbidity. The assumption of linearity of the logit of ordinal variables was assessed using the Box-Tidwell test. Backward Wald selection was used for selection of variables and assessment of confounding (increase in B-coefficient of >10%) and effect modification (significant interaction term). Significant risk factors were reported in odds ratio (OR) with 95% confidence intervals (95%-CI). Additionally, the adjusted R-squared is reported to show the proportion of the variance in the occurrence of major morbidity explained by the model.

3. Results

Patient and stoma characteristics are displayed in Table 1. In total, 336 young children were included of which 35% (n = 118/336) were treated for an underlying inflammatory disease (necrotizing enterocolitis and meconium peritonitis). Of all patients, 61% (n = 205/336) was male. The median birthweight was 2640 gs and the median gestational age was 36 weeks. Of all patients, 41% (n = 137/336) was born prematurely. The type of stoma was a jejunostomy in 5% (n = 17/336), ileostomy in 57% (n = 192/336), and colostomy in 38% (n = 127/336). Mortality at the end of follow-up was 15% (n = 49/336).

Major stoma related morbidity occurred in 15% (n = 49/336) of patients within 30 days following formation (Table 2). The most common morbidity was high output (6%, n = 19/336), stoma necrosis (3%, n = 9/336) and stoma prolapse (2%, n = 8/336). Death within 30 days to non-stoma related causes occurred in 9% (n = 29/336), leaving 307 patients to be assessed for complications risk after 30 days. Following 30 days, a major complication occurred in 19% of patients (n = 58/307). Most reported were high output (6%, n = 19/307), stoma prolapse (5%, n = 14/307), and stoma stenosis (2%, n = 6/307). Overall a complication, either within or after 30 days, occurred in 27% of the patients after stoma creation (n = 92/336).

Of all young children, 87% (n = 292/336) underwent stoma closure. Stoma closure was not performed in 38 patients since they died before stoma closure could be performed. In four patients a

Table 1
Baseline table $N = 336$.

Characteristic	Total = 336 N (%)
Underlying disease	
Necrotising enterocolitis	109 (32)
Meconium peritonitis	9 (3)
Anorectal malformation	88 (26)
Hirschsprung disease	37 (11)
Intestinal atresia	29 (9)
Meconium ileus	20 (6)
Complex gastroschisis	12 (3)
Other[¶]	32 (10)
Underlying disease infectious disease	118 (35)
Male gender, n (%)	205 (61)
Median birthweight (IQR), gram[*]	2640 (1650–2640)
Median gestational age (IQR), weeks	36 (31 - 39)
Premature, n (%)	137 (41)
Type of stoma, n (%)	
Jejunostomy	17 (5)
Ileostomy	192 (57)
Colostomy	127 (38)
Median age at stoma formation (IQR), days	8 (2 – 39)
Median weight stoma formation (IQR), gram [Π]	2900 (2000–3570)
Median age at stoma closure (IQR), days	142 (81 – 241)
Median weight at stoma closure (IQR), gram [†]	5380 (3493–7500)
Median time to stoma closure (IQR), weeks	15 (9–29)
Major stoma related morbidity at any time, n (%)	130 (39)
Mortality at end of follow up, n (%)	49 (15)
Median follow-up after stoma formation (IQR), months [τ]	76 (33–148)

[¶] Specified in supplementary table 1
[*] Birthweight unknown: 20ΠWeight at stoma formation unknown: 53τexcluding deceased patients†Weight at stoma closure unknown: 59.

permanent stoma was already intended at initial surgery. The remaining two young children are awaiting their stoma closure. Following stoma closure, 5% ($n = 16/292$) of the young children received a new stoma due to post-operative morbidity or functional problems, of which four underwent construction of a permanent colostomy.

Following stoma closure, major stoma related morbidity occurred in 8% ($n = 24/292$) of the patients within 30 days (Table 3). The most commonly occurring complications were anastomotic leakage (2%, $n = 6/292$), anastomotic stenosis (2%, $n = 5/292$), and central line sepsis (1%, $n = 3/292$). After 30 days, a complication was registered in 16% ($n = 47/288$) of patients, mostly comprising incisional hernia (6%, $n = 17/288$), anastomotic stenosis (5%, $n = 13/288$), and adhesive obstruction (4%, $n = 12/288$). Overall stoma related morbidity rate either within or after 30 days was 23% ($n = 66/292$).

Overall, major stoma related morbidity, either after stoma formation and/or after closure, occurred in 39% ($n = 130/336$) of the young children. Of the patients that underwent stoma closure 10% ($n = 28/288$) had a high grade complication after stoma formation, as well as after stoma closure. Over time, splitting the cohort into four groups of five consecutive years, there was no significant change in overall major stoma related morbidity rates ($p = 0.52$).

Young children treated with an ileostomy were more at risk of major stoma related morbidity after stoma formation compared to young children treated with a colostomy (OR 2.5; 95%-CI 1.3–4.7, ≤0.01). Gender ($p = 0.35$), having had a surgical procedure before stoma formation ($p = 0.76$), inflammatory disease ($p = 0.44$), prematurity ($p = 0.47$), weight at stoma formation ($p = 0.14$) and the need for vasopressin after stoma formation ($p = 0.31$) were not related to the risk of major stoma related morbidity (Supplementary Table 2).

Following stoma closure, patients with an ileostomy were also more at risk of major stoma related morbidity (OR:2.7; 95%-CI:1.3–5.8, ≤0.01). Inflammatory disease ($p = 0.22$), weight at stoma closure ($p = 0.18$), time to stoma closure in days ($p = 0.82$), and suture resorption speed ($p = 0.84$) did not significantly affect the risk of stoma related morbidity (Supplementary Table 3).

4. Discussion

Major stoma related morbidity, leading to redo surgery, intensive care admission or death, was high in this retrospective study including 336 young children. Following stoma formation, 27% ($n = 92/336$) of the young children experienced major stoma related morbidity, mainly consisting of high output stoma, prolapse and stoma stenosis. The major morbidity rate was 23% ($n = 66/292$) following stoma closure, most commonly comprising anastomotic leakage/stenosis, incisional hernia and adhesive obstructions. For combined stoma interventions, major stoma related morbidity was 39% ($n = 130/336$). The rate of this morbidity was stable over the years. Ileostomy was the only factor that was independently associated with a higher risk of developing major mor-

Table 2
Major stoma related morbidity following stoma formation, $N = 336$.

Characteristic	Creation (total = 336)	Clavien Dindo 3	Clavien Dindo 4	Clavien Dindo 5
Morbidity within 30 days				
Stoma related morbidity, n (%)	**49 (15)**	**35**	**13**	**1**
Type of morbidity, n (%)				
High output	19 (6)	14	5	
Stoma necrosis	9 (3)	9		
Stoma prolapse	8 (2)	7	1	
Stoma stenosis	7 (2)	3	3	1
Central line sepsis	6 (2)	2	4	
Morbidity after 30 days	**Total = 307[≠]**			
Stoma related morbidity, n (%)	**58 (19)**	**51**	**7**	
Type of morbidity, n (%)				
High output	19 (6)	16	3	
Stoma prolapse	14 (5)	14		
Stoma stenosis	6 (2)	6		
Parastomal hernia	5 (2)	5		
Adhesive obstruction	3 (1)	3		
Revisions stoma for persistent leakage	2 (1)	2		
Fistula to stoma	1 (1)	1		
Other[*]	8 (3)	4	4	
Overall stoma related morbidity, n (%)	**92 (27)**			

≠Patients that died to non-stoma related cause within 30 days after stoma closure not included in the analysis ($n = 29$).
[*] E.coli meningitits ($n = 2$), removal broviac van cava ($n = 1$), platzbauch ($n = 1$), stoma revision for bowel torsion ($n = 1$), diversion colitis ($n = 1$), perforation ($n = 1$), conversion colostomy to ileostomy for functional problems ($n = 1$).

Table 3
Major stoma related morbidity after stoma closure, $N = 292$.

Characteristic	Count (total = 292)	Clavien Dindo 3	Clavien Dindo 4	Clavien Dindo 5
Stoma related morbidity, n (%)	**24 (8)**	**19**	**5**	
Type of morbidity, n (%)				
Anastomotic leak	6 (2)	5	1	
Anastomotic stenosis	5 (2)	5		
Central line sepsis	3 (1)	3		
Wound abscess	1 (1)	1		
Other*	9 (3)	5	4	
Morbidity after 30 days	**Total = 288≠**			
Stoma related morbidity, n (%)	**47 (16)**	**35**	**11**	**1**
Type of morbidity, n (%)				
Incisional hernia	17 (6)	15	2	
Anastomotic stenosis	13 (5)	9	3	1
Adhesive obstruction	12 (4)	7	5	
Correction scar tissue	3 (1)	3		
Enterocutaneous fistula (from old stoma)	2 (1)	1	1	
Overall stoma related morbidity, n (%)	**66 (23)**			

* Relaparotomy without additional resection ($n = 2$), septic arthritis ($n = 1$), perforation after dilatation ($n = 1$), anastomosis during stoma closure, removal NG tube sigmoid ($n = 1$), 1x additional resection sigmoid, dehydration ($n = 1$), torsion after Duhamel ($n = 1$), bleeding ($n = 1$)≠Patients that died within 30 days after stoma closure not included in the analysis ($n = 4$).

bidity following stoma formation (OR:2.5; 95%-CI:1.3–4.7) as well as following closure (OR:2.7; 95%-CI:1.3–5.8). Duration of stoma, underlying inflammatory disease, weight at closure and suture resorption speed were non-significantly related to major stoma related morbidity during stoma closure.

The most common complications following stoma formation was a high output stoma, which can result in malnutrition. Prolonged malnutrition, due to nutrient and fluid loss via a stoma, can negatively impact growth and adverse cognitive development [15,16]. It is reported that in the presence of a stoma, up to 90% of the young children are declining on the growth chart, which is why some advocate early stoma closure [17–20]. This opinion is supported by the finding that most young children thrive after stoma closure, irrespective of morbidity, weight, or underlying pathology [17].

Considering the increased risk of malnutrition due to stoma morbidity and its impact on growth, it is interesting to see that weight at stoma closure and days until stoma closure were not significantly associated with morbidity following closure in our cohort. This contradicts the accepted preference of many surgeons to wait for a safe weight (e.g. >2.5 kg) before considering stoma closure as to reduce the risk of surgery in a fragile patient [10]. Due to the negative effects of a stoma, some surgeons advocate for early closure within 6 to 8 weeks after creation [4,21]. Until now there is no consensus on the optimal timing of stoma closure in young children. It seems that early closure or closure at a lower weight does not increase the risk of morbidity. Combining this with the finding of recent reports that early closure might result in early catch-up growth might imply the feasibility of early closure [4,21,22]. An argument against early closure is the presence of adhesions, potentially resulting in difficulties during stoma closure. Part of the adhesions might resolve in the first few weeks to months following index surgery, but this highly depends on the extensiveness of surgery and degree of inflammation with high inter-individual variability. Therefore, the perfect timing of early closure demands future research.

Following stoma closure anastomotic leakage and stenosis were amongst the most common major complications within 30 days. With an overall incidence of 2% for anastomotic leakage and 6% for anastomotic stenosis, the occurrence in our cohort is similar to previous studies [17]. It shows that anastomotic morbidity, which seems the main reason not to perform a primary anastomosis, is not completely prevented by stoma formation. Previous studies have recommended construction of primary anastomosis in infantile disease like necrotizing enterocolitis and intestinal atresias [23,24]. Although comparing both treatment options is beyond the scope of this study, the high risk of major stoma related morbidity should not be undervalued when considering both options.

Incisional hernia and obstructive adhesions were most frequently observed after more than 30 days following surgery. Although the mortality rates of these forms of stoma related morbidity are lower than in adults, they still demand redo surgery, sometimes in an emergency setting [3,25]. The development of new treatment strategies aiming at prevention of stoma formation could lower the risk burden relate to long-term morbidity. This has already been shown by the gradual change in treatment from a two staged (including a stoma) Rehbein's procedure to a one staged pull through in Hirschsprung's disease patients, which started around the new millennium. This change in surgical approach has seemingly lowered the incidence of adhesive obstructions from 10 to 20% to 4–5% [25–28].

The incidence of major stoma related morbidity did not differ between patients with an inflammatory and non-inflammatory disease, which underlines the high morbidity of stomas regardless of the underlying disease and inflammatory state of the patient which has been stated previously [17,29]. Although a higher non-stoma related mortality following stoma formation is to be expected from diseases such as necrotizing enterocolitis, the survival following stoma closure does not differ between these two groups [30].

Identification of risk factors for the development of morbidity following stoma formation and closure might lead to prevention and could aid in the selection which patients to treat with primary anastomosis instead of a stoma. In our cohort, only the location of the stoma was significantly related to the occurrence of morbidity, whilst all other factors were not.

Limitations of this study are the retrospective design which might have led to underreporting of morbidity, although it is unlikely that serious morbidity was missed. To classify major morbidity related to a stoma, Clavien-Dindo grading was used. This reflects the most severe morbidity, but does not consider the minor morbidity that might have an impact on the overall stoma related morbidity as experienced by the young children. Moreover, this study attempted to identify risk factors for morbidity, but only location of the stoma was found to be an independent predictor. Potentially relevant patient or surgical risk factors might have been missing in the dataset.

5. Conclusion

Major stoma related morbidity occurs often in young children, both after stoma formation and closure. The risk of morbidity should be taken into account when considering treatment with the formation of a stoma.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jpedsurg.2021.11.021.

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