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Gastroschisis: Prenatal Diagnosis and Outcome

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<http://dx.doi.org/10.5772/intechopen.74270>

Abstract

The purpose of this retrospective cohort study was to investigate and identify prenatal predictors of perinatal outcomes of gastroschisis. Antenatal data included extra-abdominal bowel dilatation (EABD) and intra-abdominal bowel dilatation (IABD). Perinatal data included gestational age, sex, and birth weight. Surgical data included presence of intestinal atresia, necrosis, perforation, strictures, and method of closure. Outcome data included duration of mechanical ventilation and total parenteral nutrition, pseudoobstruction, sepsis, reoperations, length of hospital stay, and mortality rates. Results were analyzed in 65 patients. EABD was documented in 55 patients with no significant difference between simple and complex gastroschisis group. In 27 patients (in 32% of simple and 73% of complex cases), IABD persisted until the last ultrasound scan. Simple gastroschisis group had a shorter hospital stay, shorter ventilation support duration, less bowel pseudoobstruction, less need for reoperation, and received less parenteral nutrition. The most frequent extraintestinal complication was sepsis. The only factor that has been shown to predict poorer outcomes of gastroschisis is the presence of complex gastroschisis. Current available evidence suggests that antenatal bowel dilatation is not associated with increased risk of adverse perinatal outcome in infants with gastroschisis. Also, the absence of bowel dilatation cannot fully exclude complex patients.

Keywords: gastroschisis, primary fascial repair versus staged closure, management, outcomes complex versus simple, vanishing, prenatal diagnosis, intra-abdominal bowel dilatation, extra-abdominal bowel dilatation

1. Introduction

Gastroschisis is a birth defect of the abdominal wall, in most cases located to the right of the umbilicus and typically smaller than 2 cm, with the herniation of abdominal organs into the amniotic cavity [1, 2].

This anomaly occurs in approximately 0.01–0.06% of births and it could be detected prenatally in up to 95% of cases using the obstetric sonography. Identifying the gastroschisis by fetal echosonography is possible as early as in 12 weeks of gestation by observing the ventral wall defect with loops of bowel protruding outside the abdomen, floating freely in the amniotic fluid [3, 4].

Researchers still have not discovered the precise cause of gastroschisis [5]. Some of them claim that it is probably the results of mesenchymal damage and failure of the epidermis to differentiate at the site of the defect, which is caused by premature atrophy or abnormal persistence of the right umbilical vein [6]. Others have proposed that the condition may be caused by ischemia of the base of the cord due to intrauterine disruption of the right omphalomesenteric artery, which then lead to herniation of the gut through this infarcted area [7].

Furthermore, it is very important to make the distinction between various ventral wall defects, especially between gastroschisis and omphalocele [8]. Omphalocele is characterized by a midline defect of abdominal muscles, fascia, and skin at the umbilicus, resulting in herniation of intra-abdominal structures into the base of the umbilical cord. The herniated organs in omphalocele are always covered by an amniotic membrane, unlike to gastroschisis where the abdominal organs float freely in amniotic cavity, exposed to potentially negative influence of amniotic fluid [1]. However, it is proved that gastroschisis has got much better prognosis, because it is, on contrary to omphalocele, not associated with chromosomal abnormalities and usually not associated with other structural anomalies. Survival rates of gastroschisis are more than 90% [9, 10].

On the other hand, infants with gastroschisis are at high risk of postnatal complications, especially gastrointestinal ones. The most common gastroschisis-associated gastrointestinal anomaly is intestinal atresia [3]. Besides, we can identify intestinal stenosis, as one of the most common bowel complication, probably caused by lack of the blood flow as a result of compression of eviscerated bowel at the site of the abdominal wall defect. Intestinal atresia as well as other intestinal anomalies could lead to bowel dysmotility, peritonitis, small-bowel pseudo obstruction, perforation, necrotizing enterocolitis, cholestatic jaundice, short-bowel syndrome, vomiting, and fistulas. In fact, the most significant factor determining the prognosis is the condition of the bowel at birth. The more the bowel is damaged, the worse the long-term outcome is. If the bowel distension, atresia, or necrosis is identified, primary repair with the resection of necrotic segment could be usually done; however, staged repair is sometimes required. These infants often have long-term morbidity caused by severe intestinal hypoperistalsis and poor absorptive capacity, requiring prolonged or permanent parenteral nutrition with its associated risks of infection, growth restriction, metabolic disturbances, and liver disease.

Regarding to all above-mentioned parameters, researchers Molik et al. [11] proposed classification of gastroschisis into simple (**Figure 1**) and complex (**Figure 2**) cases. Complex gastroschisis was defined as gastroschisis associated with at least one of the following intestinal pathologies:

intestinal atresia, perforation, necrotic segments or volvulus. Simple gastroschisis was defined as gastroschisis in absence of any of these conditions causing additional bowel damage.

In addition, having good, early prenatal diagnosis of gastroschisis gives the possibility of following of the intrauterine development of fetus, identifying possible growth restriction or gastrointestinal obstruction. This could be helpful in making the strategy for perinatal treatment in a tertiary referral hospital. Having in mind that the prognosis of the infant born with gastroschisis depends primarily on the condition of the bowel at birth, researchers have tried to find sonographic predictors of bowel damage [4] which can be used to make decisions about the timing of delivery [12]. Recent researches show different results: some of them have shown connection between the dilatation of the herniated bowel and thickening of the bowel wall with postnatal gastrointestinal complications and poor outcomes [13]. Other studies, on the other hand, show that the dilatation of herniated bowel is not the predictor of poor outcome [14]. The results of our study did not show that there was a statistically significant difference in outcome between patients without prenatally detected bowel dilatation and those one who had dilated bowel prenatally identified. Future researches should be focused on discovering some other prenatal sonographic parameters in patients with gastroschisis which could be useful for poor outcome prediction.



Figure 1. Simple gastroschisis.



Figure 2. Complex gastroschisis—gastroschisis associated with intrauterine necrosis and perforation of the bowel.

Although numerous articles considering the optional management of gastroschisis are available in the professional literature, it still remains controversial. There are two preferable methods in operative approaches: primary closure and staged closure using customized silo [15]. Primary surgical repair is the method of choice of gastroschisis treatment at our Institution, whenever it is feasible. During the last decade, we have moved toward staged reduction of the herniated intestines (without intestinal anomalies) into the abdominal cavity using a silo (**Figure 3**), which is then followed by elective abdominal wall closure (**Figure 4**). We also reviewed differences of the outcome of newborn with simple and complex gastroschisis treated at our Institution over the past 15 years and tried to identify factors associated with mortality [9]. In majority of published studies reported mortality of gastroschisis is less than 10%, which is mostly the result of development of the modern neonatal intensive care, advanced pediatric surgery, and new prenatal diagnostic procedures [4, 16]. All this provides better results in overcoming the gastroschisis-associated complications such as extensive intestinal loss, short bowel syndrome, prolonged total parenteral nutrition, liver failure, sepsis, and early baby death.

Several studies have examined the different outcomes in fetuses with gastroschisis [14], but most of them have included all abdominal wall defects, not just gastroschisis [17, 18]. In future, more researches should be focused on discovering the factors which could indicate the presence of complex gastroschisis. Besides, new studies should provide improvement of prenatal diagnosis and postnatal management.



Figure 3. Eviscerated organs placed into silastic bag.



Figure 4. Eviscerated organs removed from a silastic bag, preparing for reducing into abdominal cavity and abdominal wall defect closure.

The aim of this study was to investigate and identify prenatal predictors of perinatal outcomes of gastroschisis. Also, we tried to compare the outcomes in infants with simple and complex gastroschisis.

2. Material and methods

We performed a retrospective cohort study where we included all the patients treated at the Institute for Mother and Child Health Care of Serbia “Dr. Vukan Čupić” in period 2001–2017 with the diagnosis of gastroschisis ($n = 70$). The exclusion parameters were prematurity (<34 weeks of gestation) and birth weight less than 1500 g, so the five patients were excluded ($n = 5$). We used patient records and neonatal intensive care unit database to obtain infant birth history, demographic and clinical parameters that were necessary for this research.

Antenatal data included extra-abdominal bowel dilatation (EABD) (bowel diameter ≥ 18 mm) and in particular intra-abdominal bowel dilatation (IABD). Perinatal data included birth age, gestational age, sex, and birth weight. Surgical records included presence of intestinal atresia, necrosis, perforation, strictures, and method of closure. Outcome data included duration of mechanical ventilation, duration of total parenteral nutrition, pseudoobstruction, sepsis (central line infection), reoperations, length of hospital stay, and mortality rates.

We defined patients with complex gastroschisis as cases with gastroschisis and one or more of the following anomalies: intestinal perforation, intestinal atresia, strictures, and ischemic bowel. Total length of hospital stay was defined as the number of days from first admission to first discharge or transfer to another hospital.

2.1. Data analyses

We compared the incidence of simple gastroschisis (defined as gastroschisis with intact bowel that is not compromised) and complex gastroschisis (defined as gastroschisis with presence of one or more of the following criteria: intestinal atresia, perforation or intestinal necrosis or strictures), in fetuses with gastroschisis with and without evidence of bowel dilatation.

Also, we compared outcomes in infants with simple gastroschisis and those with complex gastroschisis using nonparametric methods. An outcome analysis was performed regarding antenatal bowel dilatation (bowel diameter ≥ 18 mm) and in particular intra-abdominal bowel dilatation (IABD), birth weight, gestational age, sex, mode of the closure of the defect, presence of intestinal necrosis or perforation, pseudoobstruction, reoperation, duration of mechanical ventilation, and total parenteral nutrition. Outcome data included presence of sepsis, total length of hospital stay, and mortality rates. We used χ^2 test and Mann-Whitney U test for data analysis; p values <0.05 were considered significant. SPSS version 12 was used for carrying out all analyses.

3. Results

We identified 70 patients with gastroschisis between 2001 and 2017. Five patients were excluded from study (babies with birth weight less of 1500 g and premature infants (<34 weeks of gestation)), so that 65 patients were analyzed. The characteristics of all analyzed patients are presented in **Table 1**. There were 15 patients (23.07%) with complex gastroschisis. Statistically significant difference was not identified between the simple and the complex gastroschisis groups in gestational age (36.1 ± 1.4 versus 36.16 ± 1.6 ; $p = 0.173$) and birth weight (2248.4 ± 507.6 versus 2351.33 ± 633.8 ; $p = 0.319$). There were 39 males and 26 female patients (65 in total). In both groups, majority of patients were males: 54% and 80% in simple and complex gastroschisis group, respectively.

Forty-four patients (67.69%) received primary fascial repair (primary closure). Twenty-one patients (32.30%) received delayed fascial closure using silastic bag. All the patients with complex gastroschisis ($n = 15$) were treated with primary fascial repair.

The overall incidence of intestinal atresia was 7.69% ($n = 5$) in our patient population. Ischemic complications such as stenosis, strictures, necrosis, and perforation were the main complication in nine cases (60%) of the complex gastroschisis group. Closing gastroschisis was presented in one case (6.66%) with circumferential closure of the ring around the protruding bowel associated with midgut necrosis.

N Gender	Simple; n (%)	Complex; n (%)	p
	Mean \pm SD (n = 50)	Mean \pm SD (n = 15)	
Male	27 (54%)	12 (80%)	p = 0.071
Female	23 (46%)	3 (20%)	
Gestational age (wk)	36.1 \pm 1.4	36.16 \pm 1.6	p = 0.173
Birth weight (g)	2248.4 \pm 507.6	2351.33 \pm 633.8	p = 0.319
Primary closure	29 (58%)	15 (100%)	p = 0.0032
Performed spring-loaded silo	21 (42%)	0	
TPN duration (d)	13.64 \pm 10.8	53.1 \pm 42.6	p = 0.000019; p < 0.001
Ventilation support duration (d)	7 \pm 6.54	24 \pm 14.2	p = 0.000003; p < 0.001
Hospital stay (d)	32 \pm 15	91 \pm 64	p = 0.000198; p < 0.001
Sepsis (n)	19 (38%)	12 (80%)	p = 0.0043
Reoperation (n)	10 (20%)	10 (66.7%)	p = 0.00122
Pseudoobstruction (n)	9 (18%)	12 (80%)	p = 0.00067; p < 0.001
Neonatal death (n)	4 (8%)	3 (20%)	p = 0.338

Table 1. Patient characteristics of simple and complex gastroschisis groups.

Antenatal IABD (including stomach dilatation) was detected at any time during pregnancy in 55 patients, resolving in 4 after 1 ultrasound scan. In 27 patients IABD persisted until the last ultrasound scan in 32% of simple and 73% of complex cases. In these 27 patients, there were cases in both groups (simple and complex) where IABD was present earlier than 30 gestational weeks. All intra-abdominal bowel dilatation (IABD) are summarized in **Tables 2** and **3**. IABD was never present in seven simple cases and in three complex cases (2 atresia and 1 perforation).

All extra-abdominal bowel dilatation (EABD) are summarized in **Table 4**. There were 55 patients with extra-abdominal bowel dilatation (with precise EABD diameter). We have not identified statistically significant difference in EABD between the group of patients with complex gastroschisis [15 (15–31) mm] and the group of patients with simple gastroschisis [40 (13–50) mm], p = 0.91. EABD with the diameter \geq 18 mm was documented in 72% of patients with simple gastroschisis as well as in 82% of patients with complex gastroschisis.

Patients with simple gastroschisis were put on enteral feeding earlier than patients with complex gastroschisis and received less parenteral nutrition: [(13.64 \pm 10) vs. (53.1 \pm 42.6) days; p = 0.000019 (p < 0.001)]. Also, they had shorter duration of ventilation support: [(7 \pm 6.54) vs. (24 \pm 14.2) days; p = 0.000003 (p < 0.001)]. Patients with simple gastroschisis had a shorter hospital stay: [(32 \pm 15) vs. (91 \pm 64) days; p = 0.000198 (p < 0.001)].

In complex gastroschisis group, the finding always dictated the method of closure, and all of these patients (n = 15) were closed primarily. In the simple gastroschisis group primary fascial closure was performed in 29 patients (58%). Our data show that the way of treatment of these

Complexity group (n = total in group)	Simple (n = 50)	Complex (n = 15)
IABD at last scan		
Number (% of complexity group)	16 (32%)	11 (73%)
IABD at ≥30 weeks to ≤34 GA		
Number (% of complexity group)	7 (14%)	10 (66%)
IABD at <30 weeks GA		
Number (% of complexity group)	4 (8%)	6 (40%)
Resolved IABD		
Number (% of complexity group)	3 (6%)	1 (7%)
Never had IABD		
Number (% of complexity group)	7 (14%)	3 (20%)

Table 2. All intra-abdominal bowel dilatation (IABD).

IABD diameter (mm)	Complex gastroschisis, n = 15	Simple gastroschisis, n = 50
	Number (% in group)	Number (% in group)
<10	0	4 (5%)
10 to <18	7 (47%)	10 (20%)
≥18	11 (73%)	16 (32%)

Table 3. Degree of intra-abdominal bowel dilatation (IABD).

EABD diameter (mm)	Complex gastroschisis n = 15	Simple gastroschisis n = 50
	Number (% in group)	Number (% in group)
<10	0	0
10 to <18	3 (20%)	11 (27.5%)
≥18	12 (82%)	29 (72%)

Table 4. Degree of extra-abdominal bowel dilatation (EABD).

patients depended primarily on characteristics of each case, which were quite heterogeneous. Routine silastic bag closure was performed in 21 patients (42%) with simple gastroschisis, and 19 patients (90.47%) of them had no complications.

Four patients with simple gastroschisis (8%) did not survive to be discharged. We identified gangrene of the bowels which were placed into silastic bag in two patients. Abdominal compartment syndrome was documented in two patients who were treated with primary closure. The need for repeated laparotomies was a result of various complications: sepsis, persistent metabolic acidosis, respiratory compromise, low urine output, and poor perfusion.

Three patients with complex gastroschisis (20%) did not survive to be discharged. We identified one patient (6.66% of complex gastroschisis and 1.53% of all gastroschisis) with closing gastroschisis—a boy born in 34th gestational week with birth weight of 1900 g. The abdominal wall defect was located to the left side of the umbilicus. This patient had jejunal atresia 20 cm distal to the ligament of Treitz. We identified midgut volvulus progressing to complete midgut necrosis of entire extra-abdominal bowel mass in the first day of life. We performed a midgut resection, jejunocolic anastomosis, and abdominal fascial closure. The procedure was successful. However, the baby died due to multiple organ dysfunction caused by sepsis in the 20th day of life.

Additional complications were identified in 21 (32.3%) of the 65 patients. A bowel pseudoobstruction and feeding problems were most frequent gastrointestinal complications: 9 (18%) of the patients with simple gastroschisis vs. 12 (80%) patients with complex gastroschisis ($p = 0.00067$). In 10 (20%) patients with simple gastroschisis and in 10 (66.7%) patients with complex gastroschisis ($p = 0.00122$) reoperation was necessary. Sepsis was the most common extraintestinal complication: in 19 (38%) and 12 (80%) patients with the simple and complex gastroschisis, respectively ($p = 0.0043$).

Forty-six (92%) patients with simple gastroschisis survived to be discharged and four (8%) patients died in the hospital. Twelve (80%) patients with complex gastroschisis survived to be discharged and three (20%) patients died in the hospital ($p = 0.338$).

4. Discussion

Recent studies have shown significant increase in the incidence of gastroschisis during the past 20 years [19]. The incidence of gastroschisis is as high as 4.4 per 10,000 live births, and it is proved that it depends on the mother's age [1, 20]. In fact, the incidence is several times higher in women younger than 20 years than in women 25–29 years old [1].

In our study, we classified gastroschisis cases into simple and complex, according to the presence of associated bowel damage such as atresia, perforation, and necrosis, as these factors may have influence on the way of treatment and outcomes. Reviews in large national databases in Great Britain and the United States have shown that complex gastroschisis represents 11.5% and 10.9% of all cases, respectively [21]. The prevalence of complex gastroschisis in recent publications has been reported as 11–31% [21, 22]. In our cohort study, 77% of infants had simple gastroschisis, in other words almost 1 in 4 patients had complex gastroschisis. Researchers have proved that the only factor that has been consistently shown to predict poorer outcomes of this anomaly is the presence of complex gastroschisis [23, 24]. The results we obtained in our study show the same. Also, the presence of complex gastroschisis could lead to prolonged duration of total parenteral nutrition, ventilation support, and hospital stay. On the other hand, in our study, as well in some others, mortality did not differ significantly between simple and complex gastroschisis [9, 10, 22]. Some previous researches, on contrary, claim that intestinal complications are associated with higher mortality, as high as 28% [10, 11].

We also try to investigate possible relationship between intra-abdominal and extra-abdominal bowel dilatation with poor outcome. Some studies have shown that antenatal bowel dilatation (bowel diameter ≥ 18 mm) and in particular intra-abdominal bowel dilatation (IABD) is a useful predictor for impending necrosis or atresia and for bad outcome [25, 26]. On the other hand, one study shows [12] that 19% of complex patients never had IABD and the other one shows [27] that 75% never had extra-abdominal bowel dilatation (EABD). Therefore, the absence of bowel dilatation cannot fully exclude complex patients with gastroschisis. However, combined IABD/EABD or IABD/collapsed extra-abdominal bowel is highly suggestive to complex gastroschisis [28].

Neonates with gastroschisis have delayed beginning of enteral feeding and prolonged time to achieve full enteral feeding (FEF), possibly due to bowel exposure to amniotic fluid. The research done by Yang et al. shows that IABD is associated with prolonged time to achieve full enteral feeding (FEF) and prolonged length of hospital stay (LHS) [25]. On the other hand, systematic review of isolated gastroschisis reported by Helen Carnaghan et al. [12] does not support those results; this study data on contrary show that neither EABD nor IABD could be predictors of increased poor neonatal outcomes [29]. However, it is proved that if the IABD and collapsed extra-abdominal bowel or both IABD/EABD are identified earlier than 30 weeks of gestation that could be more accurate predictor of poor outcome. Our study has shown that antenatal bowel dilation does not predict the poor outcome in infants with gastroschisis.

A PubMed literature search revealed fetal gastroschisis cases with intrauterine eviscerated bowel or stomach perforation in five reports [25, 27, 28, 30, 31]. There was one case with gastric perforation identified in prenatal period [28] and the other one where the gastric perforation was diagnosed during surgical repair of complex gastroschisis [27]. Two cases of gastroschisis had bowel perforation and intestinal atresia at the same time [25, 31].

The prenatal sonographic findings of bowel or gastric perforation are variable. According to literature, prenatal sonographic findings depend on the extent of meconium leakage, time when the bowel or gastric perforation occurred, the underlying bowel disorder, the stage of the disease, and the site of perforation [32]. The mechanism of gastric and bowel perforation in gastroschisis is multifactorial. Firstly, an amniotic fluid has got toxic effect on the muscle cells of bowel and stomach. Secondly, the amniotic fluid exerts negative effects on the vascular structures of mesentery causing mesenteric shortening which then leads to bowel ischemia. Besides, the lack of blood supply may be additionally caused by previously occurred vascular insult, as well as by constriction of the abdominal wall defect [33, 34]. All this could result in muscle layer thinning and interruption. Furthermore, if the perforation occurs, chemical irritation caused by dissipated meconium leads to an inflammatory reaction which initiates bowel mural thickening (causing stenosis) and adhesions creation (causing external bowel obstruction).

Grundy et al. presented a case of an infant with gastroschisis and intrauterine bowel perforation. The suspicion of fetal bowel perforation was indicated by the presence of calcifications on the surface of the extra-abdominal bowel as well as by the presence of the extra-abdominal intramesenteric pseudocyst. Unfortunately, the neonate died third day after birth [27]. Another case was presented by Haberman et al.: a neonate with gastroschisis associated with bowel

atresia who developed a terminal ileum perforation. The echogenic material spillage at the margin of a bowel loop near the site of the abdominal wall defect led to diagnosis of an acute intrauterine bowel perforation. The perforation has been identified proximal to an atretic segment of ileum. Finally, the patient was treated by resection of the 14 cm of bowel and ileostomy, which were followed by primary fascial repair. The operation outcome was favorable [28]. Furthermore, a case of child with gastroschisis and fetal eviscerated gastric perforation was reported by Tseng and Chou. The antenatal sonography identified a mural thickening of the triple layered gastric segment, a concave deformity of the inner layer, and a small nodule on the outer surface. Firstly, the small perforation over the greater curvature of the stomach was repaired and then staged operations were performed in the aim to reduce the exposure of the bowel loops out of the abdominal cavity [31]. Next case was published by Yang et al.: a patient where the gastric perforation was diagnosed during surgical repair of complex gastroschisis (associated with colon atresia) [25]. Marinović et al. reported case of gastroschisis with gastric perforation and intestinal stenosis in male newborn. Prenatal sonographic findings were inconclusive. Large gastric perforation was diagnosed during surgical repair of gastroschisis [30].

Having diagnosed some of above-mentioned factors prenatally may lead to consideration of an early delivery with the aim to salvage necrotic bowel, although these antenatal findings may indicate that the bowel damage has already occurred. On the other hand, early delivery is associated with prolonged time to achieve a full enteral feeding (FEF) and prolonged length of hospital stay (LHS), suggesting that elective delivery earlier than 37 weeks of gestation is not beneficial.

Closing gastroschisis is rare, but potentially extremely complicated type of this anomaly. Houben et al. [35] published a research with the largest series of infants born with various stages of closing gastroschisis where 6% of infants present with closing abdominal ring. Recent literature shows low survival rate of an infant with closing gastroschisis [36–39]. In our research one patient (6.66%) presented with closing gastroschisis. Identifying progressive intra-abdominal bowel dilatation using prenatal ultrasonography could be indicative of a presence of closing abdominal ring complication. If there is a suspicion of a closing ring, early delivery must be urgently considered [37].

There are many different methods of surgical treatment of gastroschisis. Reducing the evaporative and thermal loss is crucial primary goal. This could be accomplished by primary closure or staged closure using a silastic bag [15]. We found that the only factor that has been shown to predict poorer outcomes of gastroschisis is the presence of complex gastroschisis. Therefore, the strategy of surgical treatment should be focused on management of gastroschisis-associated conditions such as perforation, necrosis, stenosis, atresia, and short bowel syndrome. Our experience confirms the safety of an early restoration of bowel continuity and primary fascial closure. We found that much better outcome is associated with this way of treatment. Others have reported both early and late primary anastomosis as the safe options for treatment of gastroschisis associated with atresia [40]. By experience, surgeons may identify which patients have fascial defects more amenable to primary closure [30]. Our study favored primary closure because it is associated with significant reduction in length of hospital stay, total parenteral

nutrition, and days with ventilation support. On the other hand, primary closure may cause abdominal hypertension and abdominal compartment syndrome which then could lead to an ischemia and necrosis of the bowel, renal failure, respiratory distress, and sepsis [41]. Abdominal hypertension is defined as prolonged or repeated increase in intraperitoneal pressure above 12 mmHg [42]. In fact, when the bowels are reduced into the non-sufficiently developed abdominal cavity, the raise of intraperitoneal pressure leads to compression of the blood vessels causing mesenteric ischemia and bowel necrosis. This kind of ischemia occurs very fast because the bowels in gastroschisis have got, in most cases, primarily lower perfusion than the bowels of a healthy infant [43]. Besides, an increased intra-abdominal pressure reduces the blood flow in big veins leading to diminished heart preload which then causes lower cardiac output and global hypoperfusion. This has an influence on renal blood flow making the renal hypoperfusion, anuria, and renal failure. We identified two patients in our study who received primary fascial repair and had abdominal compartment syndrome (**Figure 5**). So, it is very important that surgeon considers many different parameters when making the decision regarding the way of treatment of various cases of gastroschisis. In case when the primary closure without risk of abdominal compartment syndrome is not possible, surgeon should perform stage closure using a silastic bag which use becomes routine in many healthcare centers around the world. The criterion which strictly indicates that the silastic bag treatment should be performed is the presence of antenatal type of gastroschisis. Regarding to the duration of the exposure of the eviscerated bowels to amniotic fluid and the degree of abdominal cavity development, Moore classified gastroschisis into antenatal and prenatal types [44]. In antenatal type, the abdominal wall defect appears in early pregnancy so the bowels are exposed to negative influence of the amniotic fluid for a long time. Postnatally, the bowels are covered with gelatinous matrix, with a lot of adhesions and shortened mesentery. This type is also characterized by non-sufficiently developed abdominal cavity and the fascial defect which tends to become smaller and more tight during the intrauterine development. The closing of the fascial defect leads to an intrauterine bowel ischemia, which causes thickening of the intestinal wall, creating of the intestinal peel, stenosis, necrosis, and perforation. On the other hand, surgeon is not allowed to apply silastic bag if there is a possibility that tight fascial defect



Figure 5. Massive necrosis of the bowel due to abdominal compartment syndrome.



Figure 6. Necrosis of the bowel placed into silastic bag.

could compromise eviscerated organs' blood flow. In that case, it is very important that surgeon performs an urgent fasciotomy before placing the eviscerated organs into silastic bag. The bad evaluation of fascial defect size and skipping the urgent fasciotomy may lead to bowel ischemia and necrosis. In our study, we identified two patients who had developed gangrene of the bowels placed in the silastic bag without having fasciotomy previously performed (**Figure 6**). On contrary, in prenatal type of gastroschisis, the abdominal wall defect appears later in pregnancy, so the bowels are not as damaged as in antenatal type, and the abdominal cavity is much more developed. This type of gastroschisis could be treated by the primary closure.

Finally, the length of hospital stay in patients with complex gastroschisis is in most cases based on additional intestinal complications they have, so it is often prolonged, regardless to way of closure [9].

5. Conclusions

The only factor that has been shown to predict poorer outcomes of gastroschisis is the presence of complex gastroschisis. Therefore, the strategy of surgical treatment should be focused on the management of gastroschisis-associated conditions such as perforation, necrosis, stenosis, atresia, and short bowel syndrome. Our experience confirms the safety of an early restoration of bowel continuity and primary fascial closure. We found that much better outcome is associated with this way of treatment. More researches should be focused on finding of complex gastroschisis predictors, improvement of prenatal diagnosis, and postnatal management.

Current available evidence suggests that antenatal bowel dilatation is not associated with increased risk of adverse perinatal outcome in infants with gastroschisis. Also, the absence of bowel dilatation cannot fully exclude complex patients. However, a randomized controlled trial is urgently needed.

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