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Contemporary trends in the use of primary repair for gastroschisis in surgical infants

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Abstract

BACKGROUND—Gastroschisis is a newborn anomaly requiring emergent surgical intervention. We review our experience with gastroschisis to examine trends in contemporary surgical management.

METHODS—Infants who underwent initial surgical management of gastroschisis from 1996 to 2014 at a pediatric hospital were reviewed. Closure techniques included primary fascial repair using suture or sutureless umbilical closure, and staged repair using sutured or spring-loaded silo (SLS). Data were separated into 3 clinical eras: pre-SLS (1996 to 2004), SLS (2005 to 2008), and umbilical closure (2009 to 2014).

RESULTS—In the pre-SLS era, 60% (34/57) of infants with gastroschisis underwent primary repair. With the advent of SLS, there was a decrease in primary repair (15%, 10/68, $P < .0001$). Following introduction of sutureless umbilical closure, 61% (47/77) of infants have undergone primary repair. On multivariate regression, primary repair was associated with shorter intensive care unit stays ($P < .001$) and time to initiate enteral nutrition ($P < .01$).

CONCLUSIONS—Following introduction of a less invasive technique for gastroschisis repair, most infants with gastroschisis were able to be repaired primarily. Primary repair should be considered in all babies with gastroschisis and favorable anatomy.

Keywords

Gastroschisis; Umbilical sutureless closure; Spring-loaded silo; Complicated gastroschisis

Gastroschisis is a congenital defect in the abdominal wall through which bowel and other intra-abdominal structures protrude. The condition requires urgent surgical management immediately after birth because of the potential for significant fluid and heat losses from the

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exposed bowel. The goals of surgical intervention in gastroschisis are (1) to minimize the evaporative and thermal losses, (2) reduce the bowel back into the abdominal cavity, and (3) repair the abdominal wall defect. Different surgical strategies exist to care for babies with gastroschisis including reduction with upfront primary closure and handsewn or prefabricated silastic silos to protect the bowel thereby allowing for delayed fascial closure. Recently, the suture-less umbilical closure—an innovative form of primary gastroschisis repair—has been widely adopted.^{1,2} In this novel procedure, the herniated bowel is reduced into the abdomen, and the umbilical cord itself is used to plug the abdominal wall defect. The procedure may be performed at the bedside in the neonatal intensive care unit (NICU) and, in some cases, does not require endotracheal intubation. Multiple case series in the pediatric surgical literature have described the safety and successful long-term outcomes from this technique.²⁻⁴

As the sutureless umbilical closure has become more widely adopted, there is anecdotal evidence that the use of the silo technique with delayed primary closure has declined. Given these recent changes, the aim of this study was to evaluate the trends in gastroschisis closure techniques to define contemporary surgical management of this condition. We hypothesized that the majority of children born in the modern era with gastroschisis can be repaired with primary closure techniques.

Methods

Data collection

After approval from our institutional review board (SCH IRB# 15006), a retrospective review of all infants diagnosed with gastroschisis from 1996 to June 2014 was performed at a single, tertiary-care, free standing children's hospital. Patients with gastroschisis were identified using the International Classification of Diseases, 9th Revision codes for gastroschisis, and subjects' electronic and paper medical records were reviewed. Information pertaining to the hospital course was recorded to include overall length of stay (LOS), NICU LOS, and the time until enteral feeds were initiated. Reliable NICU LOS data were only accessible at our institution since November 2008. To obtain a longer time series, we queried the Pediatric Health Information System database using our institutional identifier to retrieve our center's NICU LOS data from 2003 to May 2014. A quality check indicated good agreement between the two data sources.

Cases of complicated gastroschisis were defined as infants with gastroschisis and one or more of the following diagnoses: intestinal atresia, intestinal perforation, ischemic bowel, strictures, and midgut or segmental volvulus. For purposes of analyses, prematurity was defined as estimated gestational age less than 34 weeks. Total hospital LOS was defined as the period of time from the date of first admission to the date of first discharge or transfer to another hospital.

Surgical closure methods were categorized into 3 distinct historical eras based on the introduction within our institution of the prefabricated silo and sutureless umbilical closure technique: pre-spring-loaded silo era (pre-SLS, 1996 to 2004), spring-loaded silo (SLS, 2005 to 2008), and sutureless umbilical closure (2009 to present). From our chart review, we

identified the years in which the first SLS (2005) and primary umbilical closure (2009) were performed at our institution and then incorporated these years to separate our data into the 3 eras.

In general, at our institution, babies with gastroschisis were managed primarily by the attending surgeon of record with input by the neonatology team while the patient remained in the NICU. Our institution implemented a clinical standard work pathway for newborns with gastroschisis in 2011 that guided the feeding advancement protocol.

Data analysis

Descriptive statistics using medians for continuous variables and percentages to describe the frequency of different procedures were used to describe the study population. A multivariate linear regression model was fitted with the gastroschisis repair type as the covariate of interest while adjusting for gestational age, sex, a linear time trend, and complicated gastroschisis. In this model, outcome variables such as LOS and time to enteral feeds were log transformed. Therefore, model effects should be interpreted as relative change represented by percent increase or decrease compared with the reference value. The statistical modeling and analyses were performed using R 3.1.0 software.

Results

A total of 202 infants with gastroschisis were identified, and demographic data for this cohort are summarized in Table 1. Thirty-seven (18%) children met the study criteria for complicated gastroschisis. Primary closure, defined as upfront primary fascial repair or sutureless umbilical closure, was performed in 91 (45%) patients. Delayed fascial closure, using either sutured silastic silo or SLS, was used in 111 (55%) patients. In the pre-SLS era, 60% (34/57) of infants with gastroschisis underwent primary repair. After the advent of the SLS in 2005, there was a significant decrease in primary repair during the SLS era (15%, 10/68 infants, $P < .0001$). Since the introduction of the sutureless umbilical closure technique in 2009, 61% (47/77) of infants with gastroschisis have undergone primary repair, and 80% of these primary repairs have used sutureless umbilical closure (Fig. 1). The use of primary repair continues to increase in the current era; since 2012, 81% (29/36) of infants have undergone primary repair (Fig. 2). Of the 7 staged repairs in the last 3 years, 6 procedures were performed for either suspected intestinal atresia or bowel contents fused to the skin. We identified 16 cases of complicated gastroschisis in the most recent era, and 44% (7/16) of these children were able to be closed primarily. Of these complicated cases, 5 infants were closed with primary fascial repair and 2 infants with sutureless umbilical closure.

A multivariate linear regression model was constructed to explore the relationship between gastroschisis closure technique and clinical outcomes (Table 2). After controlling for complicated gastroschisis, prematurity, and year of admission, infants who underwent staged fascial repair using either SLS or handsewn silo had significantly longer NICU LOS compared with primary repair ($P < .001$). This pattern was observed with the analysis of chart review data from 2009 to 2014 and Pediatric Health Information System data from 2003 to 2014. The pattern of longer NICU duration with staged repair was still seen when

complicated cases of gastroschisis were excluded from analysis (Table 3); in this subanalysis, staged repair with the SLS and handsewn silo techniques was associated with 169% and 430% increases, respectively, in NICU LOS compared with primary repair. Staged gastroschisis repair was also associated with a longer time to initiation of enteral nutrition ($P < .01$) on multivariate analysis (Table 2). There were no significant changes in total hospital LOS when analyzed by procedural era or type of repair.

As expected, both complicated gastroschisis and prematurity were associated with increased total hospital LOS ($P = .01$) and increased NICU LOS ($P < .001$). This pattern persisted when controlling for gastroschisis closure technique. Complicated gastroschisis was also associated with a prolonged duration to initiation of enteral nutrition ($P < .001$).

Comments

Gastroschisis is a newborn surgical emergency that mandates immediate operative intervention. As the infant presents with exposed viscera through the gastroschisis defect, surgical options are needed to either reduce the bowel contents and close the defect or at least provide a temporary covering over the exposed bowel to limit injury and thermal loss. Classically, surgical options in this scenario have included upfront primary fascial repair or handsewn silo placement followed by staged fascial repair several days later.⁵ Both procedures are performed under general anesthesia in the operating room or at the bedside in the NICU. Beginning in 2005 at our institution, an SLS became available for use in babies with gastroschisis. Using this technique, the pediatric surgeon could place the silo without suture fixation at the bedside in the NICU, and often the procedure could be performed in an awake infant.⁶ The SLS technique quickly became widely adopted nationwide and replaced the handsewn silo in most cases.⁷⁻⁹ Finally, in 2009, we began using a novel and less invasive technique termed the sutureless umbilical closure. In this method of immediate primary repair, the herniated abdominal contents are reduced at the bedside, and the umbilical cord is used to cover the gastroschisis defect. In select cases, this technique may avoid the need for paralysis and intubation as the procedure can be performed with minimal sedation. Adhesive dressings are changed over the umbilical cord closure every other day for 2 weeks, and the wound quickly epithelializes during this time. The result is a small, skin-covered umbilical hernia that may close spontaneously over the ensuing years. Previous studies have attempted to compare these various surgical techniques but have found no consistent differences in long-term clinical outcomes.^{3,10}

Because of the evolution in surgical options for gastroschisis over the past decade, we sought to evaluate trends in utilization of closure techniques for infants with gastroschisis. In this study, we report marked differences in the use of surgical techniques for gastroschisis that reflect the different chronological eras of gastroschisis management. Before the advent of the SLS, we found that 60% of infants with gastroschisis were able to be reduced and closed using primary fascial repair. However, during the SLS era, only 15% of infants with gastroschisis were closed primarily presumably because the SLS now afforded the pediatric surgeon an initial nonoperative technique to temporize the defect and reduce the risk to the exposed viscera. After introduction of the sutureless umbilical closure at our institution in 2009, a majority of infants with gastroschisis are again undergoing primary repair.

Moreover, the frequency of primary repair—and in particular the use of sutureless umbilical closure—seems to be increasing. Our data suggest that the preferred method for initial surgical management of gastroschisis has changed considerably over time. As the analysis includes over 200 patients and spans nearly 2 decades, these trends are unlikely to be related to anatomic differences or other patient-specific factors.

The initial surgical plan for babies with gastroschisis has important implications. Infants who undergo silo placement must subsequently wait several days before staged fascial closure is attempted while the bowel slowly reduces into the intra-abdominal cavity. In some cases, the waiting period between silo placement and delayed primary closure may last upwards of 7 days. These infants remain in the ICU setting while they await delayed fascial repair because they have an open abdominal cavity; indeed, some of these babies may remain intubated until final closure. Hence, the additional time before definitive fascial closure likely contributes to the increased LOS in the NICU observed in our data analysis. Our data also demonstrate that infants treated with initial silo placement experience an increased time to initiation of enteral nutrition. This observation is likely secondary to the fact that these babies cannot be fed enterally before fascial closure. Infants with gastroschisis treated with an initial silo placement, then, may require longer durations of parenteral nutrition. Thus, there may be distinct clinical and cost benefits associated with primary repair of gastroschisis. It is interesting to note that, in the current era of management, primary repair was used to close nearly half of the complicated cases of gastroschisis as well.

The renewed focus on primary fascial repair at our institution corresponds to the introduction of the sutureless umbilical closure for gastroschisis. The technique is less invasive in that it involves reduction of the herniated viscera and then plugging of the fascial defect with the umbilical cord itself. In this way, the procedure can easily be performed at the bedside in the NICU and, in many cases, does not require sedation or general anesthesia. This procedure has been shown to reduce patient days on the mechanical ventilator, but has not been associated with decreased hospital stays or quicker return of bowel function in prior studies.⁵ Currently, in our institution, infants with uncomplicated gastroschisis who undergo sutureless umbilical closure may stay for only 1 or 2 days in the ICU setting; indeed, several recent patients have not required preoperative intubation before the procedure.

Clearly, there are infants with gastroschisis in which primary repair of the defect is not possible and, in some cases, contraindicated. In our series, we identified 7 (19%) infants within the last 3 years who still underwent delayed fascial closure despite the trend toward primary repair during this time period. In 6 of these patients, intestinal atresia was suspected or the exposed bowel was fused to the abdominal wall skin thereby necessitating additional dissection before any type of closure could be attempted. In addition, the majority of complicated gastroschisis patients in our series were not closed primarily even in the recent era. On multivariate regression analysis, complicated gastroschisis was associated with significantly longer NICU and total LOS as well as time to initiation of enteral nutrition. Based on these data, there are some infants with gastroschisis in whom primary repair simply may not be feasible or safe.

There are several limitations to this study. It is a retrospective review over many years that is dependent on the accuracy of coding and completeness of medical records, some of which were present before implementation of the electronic medical record at our institution. Furthermore, in this series, the decision on the method of surgical closure was based on the attending surgeon's judgment, and objective criteria for different closure techniques were not prospectively defined. Finally, because these patients were cared for over many years, a more detailed analysis evaluating duration of parenteral nutrition and hospital costs was outside the scope of the present study.

Our data help to define the changing trends in the surgical management of gastroschisis. We have identified a distinct shift toward the renewed use of primary gastroschisis repair using the sutureless umbilical closure at our institution. In the current era of gastroschisis management, the exposed bowel can be reduced on initial presentation thereby allowing for primary closure in a majority of patients. Utilization of the SLS or handsewn silo seems to occur predominantly in the complicated gastroschisis patient. As it may afford clinical benefit to infants with gastroschisis, primary repair should be considered in all babies with gastroschisis and favorable anatomy.

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Figure 1.
Percent of primary versus delayed closure by era.

Figure 2.

In the most recent clinical era, the majority of babies with gastroschisis have been repaired with primary closure and the frequency of primary closure continues to increase.

Table 1

General demographics

	Total	Percent
Male	105	52
Female	97	48
Uncomplicated	166	82
Complicated*	36	18
	Median	Range
Gestational age (weeks)	36 1/7	27 3/7–40 1/7
Birthweight (kg)	2.47	.96–3.80

* Complicated defined as gastroschisis with atresia, perforation, intestinal ischemia, volvulus, and strictures.

Table 2

Results of the multivariate regression model controlling for repair type, sex, prematurity, complicated gastroschisis, and year of admission

Effect	Percent change	Confidence interval	P value
NICU LOS 2009 to 2014 (reference value = primary repair)			
Spring-loaded silo	229.7	(125.5–382)	<.001
Handsewn silo	408.7	(201.3–758.9)	<.001
Male (vs female)	–13.3	(–36.2–17.8)	.36
Prematurity	140.9	(47.3–293.9)	<.001
Complicated gastroschisis	99.4	(33.2–198.4)	.001
Secular time trend (% increase per year)	8.2	(–2.6–20.1)	.14
NICU LOS 2003 to 2014 PHIS data (reference value = primary repair)			
Spring-loaded silo	163.7	(106–237.6)	<.001
Handsewn silo	458.3	(294–691.2)	<.001
Male (vs female)	–14.4	(–31–6.4)	.16
Prematurity	77.8	(27.2–148.6)	.001
Complicated gastroschisis	94.5	(48.5–154.7)	<.001
Secular time trend (% increase per year)	1.1	(–2.8–5.1)	.58
Time to enteral feeding 2009 to 2014 (reference value = primary repair)			
Spring-loaded silo	45.9	(10.4–92.8)	.008
Handsewn silo	110.5	(43.3–209.4)	<.001
Male (vs female)	–12	(–29.7–10.3)	.27
Prematurity	10.5	(–23–58.5)	.59
Complicated gastroschisis	141.6	(79.6–224.9)	<.001
Secular time trend (% increase per year)	3.5	(–4.2–11.7)	.38

The percent change is relative to data for primary repair which is used as the reference value.

LOS = length of stay; NICU = neonatal intensive care unit; PHIS = Pediatric Health Information System.

Table 3

Multivariate regression results for NICU LOS when complicated gastroschisis cases were excluded from analysis

NICU LOS 2003 to 2014 PHIS data (reference value = primary repair)			
Effect	Percent change	Confidence interval	P value
Spring-loaded silo	169	(111.1–242.7)	<.001
Handsewn silo	430.4	(259.1–683.4)	<.001
Male (vs female)	–16	(–31.7–3.2)	.10
Prematurity	81.3	(29.4–154.1)	.001
Secular time trend (% increase per year)	–1.1	(–4.9–2.9)	.60

LOS = length of stay; NICU = neonatal intensive care unit; PHIS = Pediatric Health Information System.