Gastroschisis—Primary Fascial Closure

The Goal for Optimal Management

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Since Raffensperger and Jona reported an 80% success rate with primary skin closure including a 16% rate of complete fascial closure in 24 patients with gastroschisis in 1974, primary fascial closure has been the author's preferred method. It has been possible to achieve complete fascial and skin closure in 17 of the last 21 patients (81%). Four infants in this series, one of whom was initially managed by another surgeon, were treated with brief application of a silon prosthesis with subsequent reduction and closure. The two keys to success of this method are thorough wash out of the meconium from the entire intestine and vigorous stretching of the abdominal wall. Assisted ventilation may be needed for 24 to 48 hours after operation and has been well tolerated. Transposition of an umbilical artery for cannulation and blood gas monitoring has been an important adjunct. The one death (5% mortality) resulted from prolonged bowel dysfunction and liver failure three months after operation. Other complications have been few and mild. Since some recent reports have indicated that primary closure is not being widely used in the treatment of gastroschisis, this series is presented to emphasize that this method can be used in most infants and with a very low complication rate.

IN THE LAST ten years gastroschisis has been clearly defined as a clinical entity distinct from omphalocele and is being recognized with increasing frequency.[1-5] Because of its infrequent association with other congenital anomalies, mortality from the lesion usually represents the loss of an otherwise intact individual. Reports in the literature document considerable improvement in survival rates with a number of different treatment approaches and combinations thereof.[3,6-13] This series is presented to support the efficacy of primary fascial closure in the context of modern neonatal ventilatory support as the optimal method.

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Submitted for publication: September 7, 1982.

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Materials and Methods

The patient population consists of 21 newborns, ranging in age from 32 to 41 weeks of gestation and in weight from 1675 to 3820 g, referred to the Duke University Medical Center from distances of 45 minutes to three hours away. A formal transport system was not available in most cases, and the babies were transported by local ambulance, usually with a nurse attendant and with resuscitation efforts performed by the referring physician under the direction of the Duke neonatal housestaff. The referring physician was instructed to place an intravenous line, administer 20 ml/kg of 5% dextrose in lactated Ringer's solution (D_5%/LR) as a rapid "push" infusion, continue D_5%/LR administration at two to three times maintenance volume (100 ml/kg/day), begin Ampicillin and Gentamicin intravenously, place warm moist saline soaked gauze over the bowel enwrapping it in such a fashion as to protect it from vascular occlusion by mesenteric obstruction, and place the infant in a bowel bag[14] or other plastic equivalent from the neck or axilla down in an effort to offset the major evaporative fluid losses that otherwise would occur. The need for temperature control was emphasized. These resuscitative directions were adhered to in widely varying degrees by the referring physicians. Many of the infants arrived in severely hypoperfused and hypothermic states, a fact attested to by their prolonged postoperative metabolic acidosis, "leaky" capillary membranes, and need for high levels of positive end expiratory pressure (PEEP) to counter pulmonary interstitial edema. Some were among the sickest infants in the high-risk, intensive care nursery.

Upon arrival at Duke University Medical Center, those facets of this resuscitation program that had not

0003-4932/83/0300/0260 $01.05

been accomplished were completed and additional volumes of D_5%/LR were given to achieve a urine output of 1.5 to 2.0 ml/kg/hr. The bowel was inspected and further protected as necessary and once blood pressure and temperature were normal, the infant was taken to the operating room.

The preferred method of treatment was primary fascial closure, and all efforts were directed toward this end until it was clearly untenable. The infant was placed on the operating table under a warming radiant heater and was temporarily draped with sterile towels. Utilizing sterile gloves, a large bore (22 French) rectal tube was passed into the anus and guided up through the bowel loops by direct manipulation as far proximally as possible. Warm saline solution was then used to irrigate the meconium from the bowel and as much meconium was milked out through the anus as was possible (Fig. 1). An assistant held the anus open with a blunt-ended clamp to facilitate the expulsion of the meconium. The bowel was then compressed around the rectal tube to prevent the saline from washing distally and additional volumes of saline were instilled with a syringe, forcing fluid proximally and thus by hydrostatic pressure pushing the meconium from the proximal bowel loops retrograde into the stomach whence it was suctioned out through the orogastric tube. Bowel contents occasionally refluxed up the esophagus and were suctioned from the hypopharynx. The endotracheal tube and the muscle relaxant anesthetic technique prevented aspiration of intestinal contents during these procedures.

Removal of contents from the lumen usually resulted in soft, pliable, collapsed bowel loops that were much more easily reduced into and distributed within the peritoneal cavity than were the overdistended, easily ruptured loops prior to the washout.

Formal preparation of the skin and bowel with dilute warm povodine iodine solution was then accomplished and the actual operative procedure commenced. Attention was first directed to the umbilicus where the individual vessels were separated from the cord matrix. The umbilical vein and one umbilical artery were doubly ligated with chromic catgut. The other umbilical artery was dissected between the peritoneum and fascial layers and cannulated through a stab wound incision in the lower abdomen for maintenance of an umbilical artery catheter. Details of the technique have been presented previously.[15] Any urachal remnant was ligated with chromic catgut and inverted into a small purse-string chromic suture in the bladder dome. It was seldom necessary to enlarge the size of the defect if primary fascial closure proved to be successful.

Allis clamps were then placed along each side of the defect holding the entire full thickness abdominal wall within the clamp, and the abdominal cavity was enlarged by stretching the tissues of the abdominal wall from the paraspinous region around the flanks and up onto the anterior abdominal wall. The stretching technique was employed twice on each side in the manner described by Raffensperger and Jona.[13] Any adhesions or gelatinous peel among the bowel loops were then removed, but dissection of dense adhesions that might lead to injury to the serosa of the bowel or significant bleeding was avoided. Complete dissection of all adhesions and gelatinous peel that could be removed was an important step, however, since it allowed better distribution of the bowel loops throughout the enlarged peritoneal cavity. The bowel loops were then individually returned to the peritoneal cavity distributing them throughout each of the four quadrants and orienting the mesentery carefully without twisting.

When the bowel was completely returned to the peritoneal cavity, the anesthesiologist was asked to judge the

FIG. 1. Infant with gastroschisis. Rectal tube inserted for warm irrigations to evacuate meconium both anally and retrograde through the nasogastric tube.

TABLE 1. *Gastroschisis Patients Comparison by Treatment Method*

	Silon Pouch	Primary Fascial Repair
Number	4	17
Survival	4 (100%)	16 (94%)
Weight		
Mean	2762 g	2506 g
Range	2049–3300 g	1675–3820 g
TPN Duration		
Mean	30 days	27 days
Range	14–42 days	8–103 days
Hospital Stay		
Mean	45 days	39 days
Range	21–71 days	20–103 days
Sepsis (bacteremia)	1 (25%)	4 (24%)

degree of change in compliance and to report whether any extreme difficulty in ventilation had been produced. In general, if the bowel loops could be returned to the peritoneal cavity without undue pressure or excessive packing, persistence with primary fascial closure was acceptable. When primary closure was abandoned, it was either impossible to reduce the last several loops of bowel, or the degree of force required was obviously excessive and was reflected in an almost impossible ventilatory pressure requirement. Final fascial closure was usually accomplished with figure-of-eight mattress sutures in a transverse fashion and the skin was either closed in a linear transverse fashion or, in several instances, umbilication of the skin was achieved with a skin edge subcuticular purse-string suture of fine chromic catgut.

One patient initially treated elsewhere had a gastrostomy placed along with application of a Silon pouch. No other gastrostomies were used and orogastric tubes were perfectly adequate for intestinal decompression. Fixation of the stomach by the gastrostomy reduces the volume of peritoneal cavity available for reduction of the eviscerated intestines.

On completion of the procedure, a central line was placed percutaneously in the left subclavian vein[16] and the infant was returned to the Intensive Care Nursery with the endotracheal tube still taped securely in place.

TABLE 2. *Gastroschisis—Respiratory Support*

	Silon Pouch	Primary Repair
ET CPAP only	0	2
Ventilated	3/4	12/17
Pressure		
Mean	32/6	26/6
Range	23/3–40/10	18/4–37/9
Duration		
1–2 day	1	7
3 day	0	1
>3 day	2	4
Umb. Art. Transpos.	2	16

The infant was placed on a ventilator in the Intensive Care Nursery until fully recovered from the anesthetic and then weaned as rapidly as possible from the ventilator and the tube, utilizing careful blood gas monitoring through the umbilical artery catheter as the major guide.

In the few instances when the silon pouch technique was utilized, it was sutured to the full thickness abdominal wall, but the skin was not included in the sutures. All of the steps discussed above for the primary fascial closure technique were undertaken and as much of the bowel as could be comfortably reduced was placed within the peritoneal cavity. The defect was enlarged in the superior midline when necessary to avoid a funnel-shaped pouch with a narrow base.

The goal when the silon pouch was utilized was for as rapid reduction and removal of the pouch as possible, so that ventilation was mechanically supported if necessary and the pouches were usually reduced, removed, and primary closure achieved within four to five days.

Fluid administration after operation was managed according to previously described techiques for neonatal fluid management with the goal of maintaining a urine output of 1½ to 2 ml/kg/hr.[17] Positive end expiratory pressure was liberally utilized to offset the fluid shifts resulting from membrane damage in those babies who had sustained hypovolemic and hypothermic stress in the preoperative period.

Most infants were afforded two to three weeks of bowel rest depending upon the degree of preoperative insult, the distortion of the bowel by adhesions and gelatinous peel, and the difficulty of the surgical procedure. Nutritional status was well maintained by central total parenteral nutrition during this period, and enteral feedings were reinstituted with a graded program of administration initially utilizing dilute concentrations of predigested formulas followed by advancement to full enteral nutrition over a two- to three-week period.

Results

Table 1 shows a comparison of the four infants treated by silon pouch and the 17 infants in whom complete fascial and skin closure were possible. One of the infants treated by silon pouch was initially treated elsewhere and transferred to Duke University Medical Center for completion. Silon pouches were electively placed in only three of the 20 patients who were treated initially and who failed the initial attempts at primary closure. Generally, these were infants whose edematous intestines failed to soften and collapse after the washout.

Only one infant in the series died, an overall survival rate of 95%. The infant who died succumbed to infection after 103 days of parenteral nutrition during which time no return of significant bowel function occurred. The child appeared to have sustained the type of bowel dam-

TABLE 3. *Gastroschisis—Recent Series*

Author/Year	Span	Silon Sacs	Survival	Primary Closure Complete/Skin Only	Survival	Total	Total Survival
Mayer et al., 1980[3]	1971–79	33	28 (85%)	14/0	13 (92%)	47	41 (87%)
O'Neill & Grosfeld[6]	1966–72	?	6	?	15	21	15 (71%)
Stringel & Filler, 1979[7]	1967–77	26	16 (62%)	16/2	16 (89%)	44	32 (73%)
Fonkalsrud 1980[8]	1965–79	2	?	3/27	?	32	30 (94%)
Ein & Rubin, 1980[9]	1969–76	29	17 (65%)	15/0	13 (87%)	44	30 (68%)
Hrabovsky et al., 1980[10]	1974–79	22	21 (95%)	6/0	6 (100%)	28	27 (96%)
Klein et al., 1981[11]	1976–80	?	?	?	?	18	13 (72%)
Bower et al., 1982[12]	1975–80	0	?	24/0	21 (88%)	24	21 (88%)
Raffensperger & Jona, 1974[13]	1970–73	5	4 (80%)	5/14	16 (84%)	24	20 (83%)
Present series	1976–82	4	4 (100%)	17/0	16 (94%)	21	20 (95%)

age described initially by O'Neill[6] and subsequently by others.[18] It has been labeled "intestinal pseudo-obstruction." The closure of this infant's abdomen did not appear to be difficult or under undue pressure. This is confirmed by the short need for ventilatory support (<24 hours) and low pressures required (20/4). Ein and Rubin reported prolonged bowel dysfunction in 12 of 29 patients treated with Silon pouches.[9]

Hospital stay and TPN duration were much shorter for infants with primary fascial closure. If the data relating to the infant who died from complications of prolonged bowel dysfunction are eliminated, average TPN duration is only 22 days and average hospital stay 35 days for the infants managed by primary closure.

Complications were few in the entire series. One infant treated with a Silon pouch sustained a bowel perforation in the sac. He recovered from this but subsequently became septic and responded to treatment. Four other cases of bacteremia were noted and responded to antibiotic therapy.

There were no significant associated congenital anomalies in the series except for a patent ductus arteriosus in the infant who died. This had been ligated well prior to his demise.

Table 2 shows the need for ventilation in the two groups. Seventy per cent of the patients treated by primary fascial closure required ventilation, but few of them required support for more than 48 hours. Pressures required to ventilate the infants were quite acceptable. The need for prolonged ventilatory support resulted more from preoperative hypovolemic injury than from intra-abdominal pressure. One infant with meconium aspiration required 21 days of ventilatory support.

Discussion

After Gross'[19] initial contributions to the management of large omphaloceles and Schuster's[20] introduction of prosthetic material in the management of these patients, Allen and Wrenn[21] introduced the use of the temporary silo for reduction of gastroschisis and showed a markedly improved survival rate in a small number of patients. Raffensperger and Jona[13] first emphasized the frequency with which some degree of primary closure could be obtained, although in most instances they failed to achieve complete fascial closure. At the same time the distinction between gastroschisis and omphalocele was clearly emphasized by numerous authors while Shaw's[1] theoretical concepts and subsequent embryologic investigations by deVries[5] and Hoyme[2] provided an acceptable hypothesis for the pathogenesis of this lesion.

Many recent series have documented the improved survival of these infants utilizing a variety of techniques (Table 3).[3,6–13] Fonkalsrud[8] achieved an excellent survival in infants treated by a modified Gross multistaged technique. This is especially commendable when the period spanned by the series (1965–79) is considered. Nonetheless, these infants required two or more major operative procedures over eight or more months. The average *initial* period of hospitalization was 66 days and numerous complications were recorded.

Ein and Rubin[9] compared infants treated by primary closure with those managed with a silo and found a much improved survival (87% *vs.* 65%), a reduced sepsis rate, less bowel dysfunction, and shorter hospitalization in those infants treated by primary closure. The 29 infants treated by the Silon technique required 64 operations.

Several series[3,10,22] recorded a significant incidence of bowel atresias and stenoses in gastroschisis patients. Hrabovsky et al.[10] reported a 25% incidence and they elected to treat these lesions at the time of initial surgery. The author has ignored the many areas of apparent stenoses, has found no atresias in this group of patients, and has experienced no late obstructions. The degree to which the bowel normalizes after reduction makes treatment of most stenoses unnecessary; only unequivocal atresias require enterostomy or resection and primary anastomosis.

Authors favoring staged procedures have denigrated the primary closure technique or utilized it sparingly because of hesitancy to rely on ventilatory support for the infant in the postoperative period.[10]

Bower et al.[12] showed in a series of 24 infants all treated by primary fascial closure that few complications

result from the short-term use of mechanical ventilation in these infants. Mechanical ventilation of infants has reached a high degree of sophistication and safety for even the tiniest prematures, and the short period of ventilation required for most infants treated by primary fascial closure produces little morbidity. The mortality in Bower's series all resulted from damage to the intestine, illustrating that occasional infants cannot be successfully closed primarily.

The average duration of ventilation for these infants was 30 hours and the pressures required were less than those required by those infants in whom silastic pouches were utilized. Although Hrabvosky et al.[10] achieved a remarkably low rate of sepsis utilizing the silon pouch technique, the author's own past experience and that of others has been that sepsis is a significant complication of the prosthetic technique. Primary closure has eliminated much of this risk except as it relates to long-term central TPN. Four instances of late onset bacteremia in this series probably resulted from central line contamination and responded quickly to antibiotic therapy.

Conclusion

The ability to close a high percentage of infants with gastroschisis utilizing a technique of primary fascial and other skin closure with a high survival rate and a very low rate of morbidity leads the author to advocate this method as the preferred treatment. Although some series utilizing staged procedures show similarly favorable survival rates, they do so at the cost of two or more operative procedures, prolonged hospital stays, and morbidity extending well beyond the neonatal period. The short period of ventilatory support required by most of these infants produces little in the way of additional morbidity when principles of modern neonatal ventilatory management are adhered to strictly. There must be a willingness to abandon primary closure when undue pressure upon the intestine would result from complete reduction of the bowel at the initial procedure. The shortened hospital stay, reduced number of operative procedures, and reduced exposure to contamination and subsequent sepsis are all cogent arguments in favor of primary closure for the majority of infants with gastroschisis.

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