Title
Factors Associated With Gastroschisis Outcomes

Journal
Obstetrics and Gynecology, 124(3)

ISSN
1099-3630

Authors
Overcash, Rachael T
DeUgarte, Daniel A
Stephenson, Megan L
et al.

Publication Date
2014-09-01

DOI
10.1097/aog.0000000000000425

Peer reviewed

Published in final edited form as:
Obstet Gynecol. 2014 September ; 124(3): 551–557. doi:10.1097/AOG.0000000000000425.

Factors Associated With Gastroschisis Outcomes

Rachael T. Overcash, MD, MPH[1], **Daniel A. DeUgarte, MD, MS**[2], **Megan L. Stephenson, MD**[3], **Rachel M. Gutkin, MD**[4], **Mary E. Norton, MD**[5], **Sima Parmar, MD**[6], **Manuel Porto, MD**[3], **Francis R. Poulain, MD**[7], **David B. Schrimmer, MD**[6], and **for the University of California Fetal Consortium (UCfC)**

[1]Division of Maternal Fetal Medicine, Department of Reproductive Medicine, University of California San Diego

[2]Division of Pediatric Surgery, Department of Surgery, University of California Los Angeles

[3]Division of Maternal Fetal Medicine, Department of Obstetrics & Gynecology, University of California Irvine

[4]Division of Maternal Fetal Medicine, Department of Obstetrics and Gynecology, University of California Los Angeles

[5]Division of Maternal Fetal Medicine, Department of Obstetrics, Gynecology, & Reproductive Sciences, University of California San Francisco

[6]Division of Maternal Fetal Medicine, Department of Obstetrics and Gynecology, University of California Davis

[7]Division of Neonatology, Department of Pediatrics, University of California Davis

Abstract

Objective—To identify perinatal variables associated with adverse outcomes in infants prenatally diagnosed with gastroschisis.

Methods—A retrospective review was conducted of all inborn pregnancies complicated by gastroschisis within the five institutions of the University of California Fetal Consortium from 2007 to 2012. The primary outcome was a composite adverse neonatal outcome comprising death, re-operation, gastrostomy, and necrotizing enterocolitis. Variables collected included antenatal ultrasound findings, maternal smoking or drug use, gestational age at delivery, preterm labor, elective delivery, mode of delivery, and birth weight. Univariate and multivariate analysis was utilized to assess factors associated with adverse outcomes. We also evaluated the e association of preterm delivery with neonatal outcomes such as total parenteral nutrition (TPN) cholestasis and length of stay.

Corresponding Author: Daniel A. DeUgarte, MD, MS, Division of Pediatric Surgery - UCLA, Box 709818, 10833 Le Conte Avenue, Los Angeles, CA 90095-7098, Phone: 310-206-2429, Fax: 310-206-1120, ddeugarte@mednet.ucla.edu.

For a list of contributing members of the University of California Fetal Consortium, see the Appendix online at http://links.lww.com/xxx.

Financial Disclosure: Mary Norton's institution has received research support on her behalf from Natera (unrestricted research gift to institution/division) and Arisoa (funding for clinical trial related to noninvasive prenatal testing).

Results—There were 191 infants born with gastroschisis in University of California Fetal Consortium institutions at a mean gestational age of 36 3/7 ± 1.8 weeks. Within the cohort, 27 (14%) had one or more major adverse outcomes including three deaths (1.6%). Early gestational age at delivery was the only variable identified as a significant predictor of adverse outcomes on both univariate and multivariate analysis (OR 1.4; 95% CI 1.1-1.8 for each earlier week of gestation). TPN cholestasis was significantly more common in infants delivered < 37 weeks of gestational age (38/115 (33%) compared with 11/76 (15%); p<0.001).

Conclusions—In this contemporary cohort, earlier gestational age at delivery is associated with adverse neonatal outcomes in infants with gastroschisis. Other variables such as antenatal ultrasound findings and mode of delivery did not predict adverse neonatal outcomes.

Introduction

Gastroschisis is an abdominal wall abnormality that results in herniation of bowel and other abdominal contents. In the United States the rate of gastroschisis has increased from 2.32 per 10,000 live births in 1995 to 4.42 per 10,000 live births in 2005 (1). Risk factors for gastroschisis include tobacco and illicit drug use, low socioeconomic status, low body mass index (BMI), and young maternal age (1-3).

While the overall neonatal mortality rate for gastroschisis remains low at 5-10%, pregnancies with gastroschisis have a relatively high incidence of fetal growth restriction, preterm delivery, and neonatal complications such as bowel atresia, perforation, stricture, ischemia, and necrotizing enterocolitis (4,5).

Numerous studies have examined prognostic factors for outcomes of gastroschisis (6-9). It has been hypothesized that prolonged exposure to amniotic fluid may lead to inflammatory changes and damage to the exteriorized bowel (10,11). Researchers have assessed ultrasound findings, including size of abdominal wall defect, bowel wall dilation, and bowel wall thickness (6-9,12,13). While some studies have demonstrated that these findings are predictive of adverse outcomes, others report insufficient evidence to support use in clinical management (8,9,14-16). It is also theorized that elective preterm delivery may improve outcomes by preventing ongoing bowel injury (17-19). However, this theory remains unproven and there is no consensus regarding perinatal management of gastroschisis (20).

Identifying prenatal predictors and optimizing perinatal management could minimize adverse outcomes among infants with gastroschisis. The aim of this study is to identify perinatal variables associated with adverse outcomes in infants prenatally diagnosed with gastroschisis.

Materials and Methods

A retrospective review was conducted on all inborn pregnancies complicated by gastroschisis within the five institutions of the University of California Fetal Consortium from 2007 to 2012. The University of California Fetal Consortium is a multi-institutional collaboration of the UC Medical Centers and includes UC Davis, UC Irvine, UC Los Angeles, UC San Diego, and UC San Francisco. All institutions participating in the

University of California Fetal Consortium are tertiary academic medical centers with a full complement of perinatal, neonatal, and surgical services.

Cases of gastroschisis were initially identified by ICD-9 codes. Maternal and neonatal variables were abstracted through an individual chart review at each institution. All patients included in the analysis received prenatal and postnatal care within the same institution. Infants who were transferred into a University of California Fetal Consortium institution after delivery for post-natal care were excluded. A multi-institutional review board reliance registry approved the study (IRB #10-04093). The primary outcome was a composite adverse neonatal outcome comprising neonatal death, bowel complications (intestinal atresia, stricture, or ischemia) requiring re-operation, gastrostomy, and necrotizing enterocolitis.

Demographic information was collected including maternal age, parity, zip code of residence, smoking, and drug use. Other perinatal variables collected were gestational age at delivery, preterm labor, mode of delivery, and whether delivery was electively scheduled. Findings from the last ultrasound prior to delivery were reviewed, as they were most likely to correlate with neonatal status. The perinatal sonographic variables assessed were presence of fetal bowel dilation (subjectively assessed by a physician and sonographer), intrauterine growth restriction (estimated fetal weight less than the 10^{th} percentile), and oligohydramnios (amniotic fluid index (AFI) less than 5 cm). As gastroschisis is not usually associated with chromosomal abnormalities, genetic testing was not performed routinely in our cohort.

Adverse neonatal outcomes were collected including neonatal death, bowel complications (intestinal atresia, stricture, or ischemia) requiring re-operation, gastrostomy, and necrotizing enterocolitis. Other newborn characteristics including birth weight, small for gestational age (birth weight less than the 10^{th} percentile for gestational age), Apgar score less than 5 at five minutes, presence of meconium at delivery, method of gastroschisis defect closure, neonatal length of stay, ventilator days, days to initiation of feeds and full feeds, total parenteral nutrition (TPN) cholestasis, presence of other neonatal anomalies, and readmission within one month were also collected.

Perinatal and neonatal variables were analyzed to determine whether they were associated with adverse outcomes in infants with gastroschisis. As there is debate regarding the need to deliver infants with gastroschisis preterm, we examined differences in neonatal outcomes based on timing of delivery (preterm <37 weeks or term ≥37 weeks). Univariate analysis was performed using Fisher's exact test for assessing the relationship between categorical variables and Wilcoxon rank sum test for comparing continuous variables between groups. Those predictors with *p*-values <0.20 on univariate analysis were included in the multivariate model. In cases where predictors were clearly associated, we selected only the variable that had the lowest *p*-value on univariate analysis. Potential predictor variables included in the models were gestational age, maternal smoking, maternal drug use, elective delivery, Apgar score less than 5 at five minutes, and institutional site. Forward stepwise regression was then utilized to identify the most significant variables. In order to assess the robustness of our stepwise selected model, a mixed effects logistic regression model was

constructed using institutional site as a random effect. $P<0.05$ was considered statistically significant. Statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC).

Results

There were 191 infants born with gastroschisis at the five University of California Fetal Consortium institutions from 2007 to 2012. Among the cohort, 87% lived in urban areas and 13% in rural areas. Of those who lived in urban areas, 64% were from areas with greater than 99% urban dwellers, while 33% were from mixed urban and rural communities.

Table 1 shows maternal and neonatal demographics of the cohort. The mean gestational age of delivery was 363/7 ± 1.8 weeks. The mean maternal age was 22 ±4.4 years, and the majority of women (66%) were nulliparous. In the cohort, 15% smoked tobacco and 6% reported use of illicit drugs during pregnancy. Based on the last ultrasound prior to delivery, 25% had intrauterine growth restriction (IUGR), 7% had oligohydramnios, and 45% had bowel dilation. Of all the deliveries, 75 (39%) were scheduled electively. The cesarean delivery rate was 34%, of which 19 (29%) were elective cesarean deliveries.

The mean birth weight for all infants was 2,469 ±500 grams;42 (22%) were small for gestational age. Meconium was present in 56% of deliveries, and 4% had Apgar scores less than 5 at five minutes. Primary closure was performed in 42% of patients. The median (interquartile range) length of NICU stay was 31 (24-45) days, ventilator days was 5 (3-9) days, days to initiation of feeds was 15 (11-21)days, and days to full feeds was 24 (21-36) days. Thirteen infants (7%) had other anomalies including cardiac (dextrocardia, pulmonary valve stenosis, atrial septal defect), neurologic (optic nerve hypoplasia, cerebral dysgenesis, absent cavum septum pellucidum, tethered spinal cord), renal (multicystic kidney, vesicoureteral reflux, hydronephrosis), severe combined immunodeficiency, arthrogryposis, and amniotic band syndrome with club feet.

Of the 191 infants in the cohort, 27 (14%; 95% CI 7.9%-17.3%) had one or more major adverse outcomes (Table 2). Three infants (1.6%; 95% CI 0%-3.3%) died after delivery with time to death ranging from two to nine days. Two of the neonatal deaths had entire liver evisceration associated with gastroschisis and pulmonary hypoplasia. The third death was due to an in utero volvulus and resultant short gut syndrome. There were no stillbirths.

Reoperation was required in 26 infants for intestinal atresia or stricture (10%) and bowel ischemia (1%). Thirteen infants (7%) required a gastrostomy tube for oral aversion or prolonged gastrointestinal dysmotility. All infants with gastrostomy were discharged home with tubes in place. Two infants (1%) had necrotizing enterocolitis complicating their hospitalization. Six infants (3%) were discharged home on total parenteral nutrition.

On univariate analysis, gestational age at delivery, spontaneous preterm labor, and birth weight were significantly different between infants without and with adverse outcomes (Table 3). We also identified differences in adverse outcomes between University of California Fetal Consortium institutional sites ($P<0.002$) which was likely attributable to one outlier institution with a 45% adverse outcome rate. When excluding the one outlier

institution, adverse outcomes were not different between institutions (adverse outcomes rate of 7-14%, *P*=0.62).

On multivariate analysis, each earlier week of gestation (OR 1.4; 95% CI 1.1-1.8), maternal smoking (OR 4.3; 95% CI 1.1-10.5), and institutional site (p<0.001) were identified as significant predictors of adverse neonatal outcomes. When site was treated as a random effect to control for site-to-site variation, neonatal outcomes worsened with each earlier week of gestation (OR 1.4; 95% CI 1.1-2.0), and maternal smoking was associated with adverse neonatal outcomes (OR 3.4; 95% CI 1.1-10.5).

The other variables of maternal drug use and mode of delivery did not differ between groups. Antenatal ultrasound findings of intrauterine growth restriction, oligohydramnios, and bowel dilation were also not predictive of adverse neonatal outcomes (Table 3). The presence of meconium, small for gestational age, five minute Apgar score, and other fetal anomalies were similar between those without and with adverse outcomes (Table 3).

In our cohort, 75 (39%) deliveries were elective. Those electively delivered had a later gestational age at delivery compared to those not electively delivered (37 0/7 ±1.4 weeks compared with 36 0/7 ±1.9 weeks, *P*<0.0001). Infants electively delivered had higher birth weights (2,600 ±472 grams compared with 2,384 ±500 grams, *P* <0.01) and lower rates of preterm delivery (40% compared with 73%, *P*<0.0001). However, there was no difference in small for gestational age (21% compared with 22%, P=1.0) and adverse outcomes (9% compared with 17%, P=0.14) between the two groups.

As would be expected, those with adverse outcomes had longer NICU lengths of stay (93 [68-128] days compared with 28.5 [24-39] days, *P*<0.001), more ventilator days (10 [5-16] days compared with 5 [3-9] days, *P*=0.0021), and longer time to initiation of feeds (27 [25-71] days compared with 14 [11-19] days, *P*<0.001). There was no association of adverse outcomes with silo placement (58% of infants without adverse outcomes had silo placement compared to 63% of those with adverse outcomes, *P*=0.83).

As seen in other studies, our cohort had a high rate of preterm birth, with 115 (60%) infants delivered prior to 37 weeks. Table 4 shows the indications for preterm delivery. There were fewer adverse outcomes in infants delivered ≥37 weeks, although this difference was not statistically significant (6 [8%] adverse outcomes with delivery ≥37 weeks compared with 21 [18%] adverse outcomes with delivery <37 weeks, *P*=0.06). A majority of adverse outcomes (46%) occurred in infants delivered <35 weeks compared to infants delivered ≥35 weeks (9%, *P*<0.001). TPN cholestasis was higher in those who delivered prior to 37 weeks (33% with delivery prior to 37 weeks compared with 15% with delivery after 37 weeks, *P*<0.001). The overall rate of TPN cholestasis within the cohort was 26%. Ventilator days, days to initiation of feeds and full feeds was not different in those who delivered before versus after 37 weeks (Table 5).

Discussion

Much investigation on gastroschisis has focused on identifying reliable prenatal predictors to minimize risk of fetal demise and neonatal complications (6-9,12-16,21). In our cohort,

prenatal predictors such as intrauterine growth restriction, oligohydramnios, and bowel dilation on ultrasound were not found to be predictive of adverse neonatal outcomes. Neonatal variables such as the presence of meconium, small for gestational age, five minute Apgar score, and other fetal anomalies were also not predictive of adverse outcomes.

Infants in our cohort experienced bowel complications similar to those reported in other studies. Intestinal problems such as bowel atresia, stricture, or ischemia have been reported to occur in infants with gastroschisis at rates as high as 25% (22). Our adverse outcome rate of 14% comprised neonatal death, bowel complications (intestinal atresia, stricture, or ischemia) requiring re-operation, gastrostomy, and necrotizing enterocolitis. All the infants with adverse outcomes had significantly longer lengths of stay, ventilator days, and time to initiation of feeds. Despite a typical complication frequency, our mortality rate of 1.6% was significantly lower than reported previously (1,4,23). This may reflect advances in medical care. Two of the fetal deaths had liver evisceration, which is consistent with other studies that have demonstrated higher rates of mortality with liver herniation (24).

Gestational age and maternal smoking were found to be predictors of adverse neonatal outcomes. However, 28% of preterm infants were delivered following spontaneous preterm labor. The underlying etiology for spontaneous preterm labor is typically unknown, and may account in part for the worse outcomes observed in lower gestational age infants. Biologic plausibility for an association between smoking and gastroschisis include carbon monoxide exposure, vascular injury, and inflammatory changes (25, 26).

Much debate exists regarding appropriate timing and mode of delivery for the infant with gastroschisis. Proponents of early delivery believe prolonged intra-amniotic bowel exposure increases the risk of complications, and they recommend elective preterm delivery (17-19). Baud et al. found induction at 37 weeks was associated with lower rate of sepsis, bowel damage, and neonatal death compared with pregnancies managed expectantly beyond 37 weeks (27). In contrast, a randomized controlled trial of 42 pregnancies with gastroschisis demonstrated no difference in outcomes between elective delivery at 36 weeks compared to awaiting spontaneous labor (28). Our data found that infants born preterm have a higher rate of TPN cholestasis, and those born before 35 weeks are at most risk for adverse outcomes.

The primary strength of our study is that it is a large multi-institutional cohort of perinatal predictors and neonatal outcomes of gastroschisis. This study includes a large catchment area in California with patients from urban and rural areas. Data were examined within the last seven years, providing a contemporary examination of various management strategies for gastroschisis, and reflecting current advances in perinatal and neonatal technology and care.

Our study is limited in that it is based on a retrospective chart review. There was variation in availability of data, prenatal ultrasonographic surveillance, and obstetric management at each University of California Fetal Consortium institution. Although our initial analysis suggested site was predictive of adverse outcomes, we found that a single outlier site was responsible for these differences. When this site was excluded, site was not predictive of adverse outcomes. Site-specific practices are likely captured with other covariates including

mode of delivery, gestational age at delivery, and method of closure. Finally, while the study size was relatively large, it may be insufficiently powered to assess all predictors.

As the prevalence of gastroschisis continues to increase both globally and domestically, clinicians and families should be aware of potential neonatal complications. During prenatal counseling, families should be aware that infants with gastroschisis are at risk for serious complications including intestinal atresia, stricture, ischemia, necrotizing enterocolitis, feeding intolerance requiring gastrostomy, and prolonged hospital stays. The overall mortality rate for gastroschisis is low, unless liver herniation is present.

In conclusion, our data suggest ultrasound findings of bowel dilation, intrauterine growth restriction, and oligohydramnios do not warrant early delivery as they do not appear to be associated with adverse outcomes. We found no differences in outcomes with vaginal or cesarean delivery suggesting gastroschisis should not be an indication for elective cesarean deliveries. Finally, this study demonstrates an association between earlier gestational age and adverse neonatal outcomes, and it found no evidence to support routine induction of delivery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The UCfC is supported through the UC Research Opportunity Fund through UCOP. This research has been supported NIH/NCRR/NCATS UCLA CTSI Grant Number UL1TR000124.

The authors thank Tristan Grogan and David Elashoff from the UCLA Department of Medicine (Statistics Core) for their assistance with statistical analysis.

References

1. Kirby RS, Marshall J, Tanner JP, Salemi JL, Feldkamp ML, Marengo L, et al. Prevalence and correlates of gastroschisis in 15 states, 1995 to 2005. Obstet Gynecol. 2013; 122:275–81. [PubMed: 23969795]
2. Vu LT, Nobuhara KK, Laurent C, Shaw GM. Increasing prevalence of gastroschisis: population-based study in California. J Pediatr. 2008; 152(6):807–11. [PubMed: 18492521]
3. Laughon M, Meyer R, Bose C, Wall A, Otero E, Heerens A, et al. Rising birth prevalence of gastroschisis. J Perinatol. 2003; 23(4):291–3. [PubMed: 12774135]
4. Holland AJ, Walker K, Badawi N. Gastroschisis: an update. Pediatr Surg Int. 2010; 26:871–878. [PubMed: 20686898]
5. Sydorak RM, Nijagal A, Sbragia L, Hirose S Tsao K, Phibbs RH, et al. Gastroschisis: small hole, big cost. J Pediatr Surg. 2002; 37(12):1669–72. [PubMed: 12483626]
6. Cowan KN, Puligandla PS, Laberge JM, Skarsgard ED, Bouchard S, Yanchar N, et al. The gastroschisis prognostic score: reliable outcome prediction in gastroschisis. J Pediatr Surg. 2012; 47(6):1111–7. [PubMed: 22703779]
7. Bond SJ, Harrison MR, Filly RA, Callen PW, Anderson RA, Golbus MS. Severity of intestinal damage in gastroschisis: correlation with prenatal sonographic findings. J Pediatr Surg. 1988; 23(6): 520–5. [PubMed: 2971103]
8. Piper HG, Jaksic T. The impact of prenatal bowel dilation on clinical outcomes in neonates with gastroschisis. J Pediatr Surg. 2006; 41(5):897–900. [PubMed: 16677878]

9. Badillo AT, Hedrick HL, Wilson RD, Danzer E, Bebbington MW, Johnson MP, et al. Prenatal ultrasonographic gastrointestinal abnormalities in fetuses with gastroschisis do not correlate with postnatal outcomes. J Pediatr Surg. 2008; 43(4):647–53. [PubMed: 18405710]
10. Langer JC, Longaker MT, Crombleholme TM, Bond SJ, Finkbeiner WE, Rupolph CA, et al. Etiology of intestinal damage in gastroschisis. I: effects of amniotic fluid exposure and bowel constriction in a fetal lamb model. J Pediatr Surg. 1989; 24:992–7. [PubMed: 2530329]
11. Guibourdenche J, Berrebi D, Buillard E de LP, Aigrain Y, Oury JF, et al. Biochemical investigations of bowel inflammation in gastroschisis. Pediatr Res. 2006; 60:565–8. [PubMed: 16988188]
12. Nick AM, Bruner JP, Moses R, Yang EY, Scott TA. Second-trimester intra-abdominal bowel dilation in fetuses with gastroschisis predicts neonatal bowel atresia. Ultrasound Obstet Gynecol. 2006; 28(6):821–5. [PubMed: 17029299]
13. Heinig J, Muller V, Schmitz R, Lohse K, Klockenbusch W, Steinhard J. Sonographic assessment of the extra-abdominal fetal small bowel in gastroschisis: a retrospective longitudinal study in relation to prenatal complications. Prenat Diagn. 2008; 28(2):109–14. [PubMed: 18186152]
14. Davis RP, Treadwell MC, Drongowski RA, Teitelbaum DH, Mychaliska GB. Risk stratification in gastroschisis: can prenatal evaluation or early postnatal factors predict outcome? Pediatric Surg Int. 2009; 25(4):319–25.
15. Mears AL, Sadiq JM, Impey L, Lakhoo K. Antenatal bowel dilatation in gastroschisis: a bad sign? PediatrSurg Int. 2010; 26(6):581–8.
16. Alfaraj MA, Ryan G, Langer JC, Windrim R, Seaward PG, Kingdom J. Does gastric dilation predict adverse perinatal or surgical outcome in fetuses with gastroschisis? Ultrasound Obstet Gynecol. 2011; 37(2):202–6. [PubMed: 21264982]
17. Serra A, Fitze G, Kamin G, Dinger J, Koning IR, Roesner D. Preliminary report on elective preterm delivery at 34 weeks and primary abdominal closure for the management of gastroschisis. Eur J Pediatr Surg. 2008; 18:32–7. [PubMed: 18302067]
18. Hadidi A, Subotic U, Goeppl M, Waag KL. Early elective cesarean delivery before 36 weeks vs late spontaneous delivery in infants with gastroschisis. J Pediatr Surg. 2008; 43:1342–6. [PubMed: 18639693]
19. Gelas T, Gorduza D, Devonec S, Gaucherand R, Downham E, Claris O, et al. Scheduled preterm delivery for gastroschisis improves postoperative outcome. Pediatr Surg Int. 2008; 24:1023–9. [PubMed: 18668252]
20. Grant NH, Dorling J, Thornton JG. Elective preterm birth for fetal gastroschisis. The Cochrane database of systematic reviews. 2013; 6:CD009394–23737031. [PubMed: 23737031]
21. Payne NR, Pfleghaar K, Assel B, Johnson A, Rich RH. Predicting the outcome of newborns with gastroschisis. J Pediatr Surg. 2009; 44(5):918–23. [PubMed: 19433170]
22. Abdullah F, Arnold MA, Nabaweesi R, Fischer AC, Colombani PM, Anderson KD, et al. Gastroschisis in the United States 1988-2003: analysis and risk categorization of 4344 patients. J Perinatol. 2007; 27(1):50–5. [PubMed: 17036030]
23. Skarsgard ED, Claydon J, Bouchard S, Kim PC, Lee SK, Laberge JM, et al. Canadian Pediatric Surgical Network: a population-based pediatric surgery network and database for analyzing surgical birth defects. The first 100 cases of gastroschisis. J Pediatr Surg. 2008; 43(1):30–4. [PubMed: 18206451]
24. McClellan EB, Shew SS, Lee SS, Funn JC, Deugarte DA. Liver herniation in gastroschisis: incidence and prognosis. J Pediatr Surg. 2011; 46(11):2115–8. [PubMed: 22075341]
25. Feldkamp ML, Alder SC, Carey JC. A case control population-based study investigating smoking as a risk factor for gastroschisis in Utah, 1997-2005. Birth Defects Res A Clin Mol Teratol. 2008; 82(11):768–75. [PubMed: 18985693]
26. Lam PK, Torfs CP. Interaction between maternal smoking and malnutrition in infant risk of gastroschisis. Birth Defects Res A Clin Mol Teratol. 2006; 76(3):182–6. [PubMed: 16498669]
27. Baud D, Lausman A, Alfaraj MA, Seaward G, Kingdom J, Windrim R, et al. Expectant management compared with elective delivery at 37 weeks for gastroschisis. Obstet Gynecol. 2013; 121(5):990–8. [PubMed: 23635735]

28. Logghe HL, Mason GC, Thornton JG, Stringer MD. A randomized controlled trial of elective preterm delivery of fetuses with gastroschisis. J Pediatr Surg. 2005; 40:1726–31. [PubMed: 16291160]

Table 1

Maternal and Neonatal Demographics

Variable	n=191
Maternal age (y)	22.2 ±4.4
Nulliparous	126 (66%)
Smoking	29 (15%)
Drug use	12 (6%)
Gestational age at delivery (wk)	36 3/7 ± 1.8
Birthweight (g)	2,469 ±500
Delivery <37 weeks	115 (60%)
Cesarean delivery	65 (34%)
Preterm labor	54 (28%)
Other fetal anomalies* (n=190)	13 (7%)
Male Gender	107 (56%)

Data are mean ± standard deviation or n (%) unless otherwise specified.

* Data are missing.

Table 2

Adverse Neonatal Outcomes

Outcome	Adverse outcome
Infants with adverse outcome	27 (14%)
Specific adverse outcomes*	
Intestinal atresia or stricture	19 (10%)
Insertion of gastrostomy tube	13 (7%)
Intestinal ischemia prior to closure	2 (1%)
Necrotizing enterocolitis	2 (1%)
Death	3 (1.6%)

Data are incidents and % of total study population (n=191).

*Some infants had more than one adverse outcome.

Table 3

Univariate Analysis of Perinatal and Neonatal Predictors of Composite Adverse Outcomes

Variable	Total n=191	No adverse outcome n=164	Adverse outcome† n=27	P‡
Perinatal Predictors				
Gestational age (wk)	36 3/7 ±1.8	36.5 ± 1.7	35.4 ±2.1	0.004
Maternal smoking	29 (15%)	22 (13%)	7 (26%)	0.14
Maternal drug use	12 (6%)	8 (5%)	4 (15%)	0.07
Intrauterine growth restriction (<10%ile)* (n=186)	46 (25%)	39 (24%)	7 (27%)	0.81
Oligohydramnios (AFI <5cm)* (n=190)	13 (7%)	10 (6%)	3 (11%)	0.40
Bowel dilation* (n=190)	86 (45%)	71 (44%)	15 (56%)	0.30
Cesarean delivery	65 (34%)	54 (33%)	11 (41%)	0.51
Elective Delivery	75 (39%)	68 (41%)	7 (26%)	0.14
Spontaneous Preterm Labor	54 (28%)	40 (24%)	14 (52%)	0.01
Neonatal Predictors				
Delivery <37 weeks	115 (60%)	94 (57%)	21 (78%)	0.06
Meconium	106 (56%)	92 (56%)	14 (52%)	0.68
5-minute Apgar score less than 5* (n=188)	7 (4%)	4 (2%)	3 (11%)	0.06
Birthweight (g)	2,469 ±500	2,498 ±478	2,294 ±593	0.04
Small for gestational age	42 (22%)	36 (22%)	6 (22%)	1.00
Other anomalies	13 (7%)	11 (7%)	2 (7%)	0.69
Primary closure* (n=190)	79 (42%)	69 (42%)	10 (38%)	0.83

Data are mean ±standard deviation or n (%) unless otherwise specified.

*Data are missing.

†Adverse outcomes includes death, bowel complications (intestinal atresia, stricture, or ischemia) requiring re-operation, gastrostomy, and necrotizing enterocolitis.

‡Comparison between no adverse outcome group and adverse outcome group by Fisher's exact test or Wilcoxon rank sum test.

Table 4

Indications for Preterm Delivery

Indication	n=115
Spontaneous Preterm Labor	54 (47%)
Non-reassuring fetal heart tracing	19 (17%)
Intrauterine growth restriction	10 (9%)
Oligohydramnios	6 (5%)
Compromised bowel*	13 (11%)
Other	4 (3%)
Unknown	9 (8%)

Data are n (%) unless otherwise specified.

*Compromised bowel is defined as ultrasonographic findings concerning for dilated bowel, bowel infarct, bowel perforation, or herniation of other abdominal viscera.

Table 5
Neonatal Outcomes Based on Gestational Age at Delivery

Outcome	Total n=191	Delivery <37 weeks (n=115)	Delivery ≥37 weeks (n=76)	*P*‡
Adverse outcome	27 (14%)	21 (18%)	6 (8%)	0.06
Length of stay (days)	31 (24-45)	32.5 (23-47)	29 (24-44)	0.73
Ventilator days	5 (3-9)	5.5 (3-9)	5 (3-10)	0.89
Days to initiation of feeds	15 (11-21)	15 (11-75)	14 (11-19)	0.25
Days to full feeds	24 (21-36)	25 (19-37)	23.5 (21-75)	0.84
TPN Cholestasis	49 (26%)	38 (33%)	11 (15%)	<0.001

Data are median (interquartile range) or n (%) unless otherwise specified.

‡Comparison between no adverse outcome group and adverse outcome group by Fisher's exact test or Wilcoxon rank sum test.