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Anatomical location of small bowel atresia independently predicts preterm delivery: A two-center study in southern Japan

Toshio Harumatsu
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Yudai Tsuruno
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Ayaka Nagano
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Koshiro Sugita
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Yumiko Tabata
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Nanako Nishida
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Chihiro Kedoin
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Masakazu Murakami
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Keisuke Yano
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

Tomonori Kurimoto
Kagoshima City Hospital

Asataro Yara
Kagoshima City Hospital

Hiroki Otsuka
Kagoshima City Hospital
Shun Onishi
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University
Koji Yamada
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University
Waka Yamada
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University
Eiji Hirakawa
Kagoshima City Hospital
Takafumi Kawano
Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University
Motofumi Torikai
Kagoshima City Hospital
Takuya Tokuhisa
Kagoshima City Hospital
Satoshi Ieiri
sieiri@m.kufm.kagoshima-u.ac.jp

Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University

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Abstract

Purpose

Small bowel atresia (SBA) presents with variable clinical features depending on anatomical location. We investigated the relationship between atresia location and preterm delivery.

Methods

We retrospectively reviewed 58 patients who underwent surgery for SBA at two institutions between April 2000 and March 2024. Patients were divided into preterm (< 37 weeks, n = 28) and term (≥ 37 weeks, n = 30) groups. Clinical characteristics, prenatal findings, anatomical location, and surgical outcomes were compared. A logistic regression analysis identified independent predictors of preterm delivery.

Results

Preterm infants showed lower birth weight (1988 ± 731 g vs. 3062 ± 395 g, $p < 0.001$) and higher rates of prenatal diagnosis (85.7% vs. 60.0%, $p = 0.040$), polyhydramnios (42.9% vs. 13.3%, $p = 0.018$), and bowel dilatation (78.5% vs. 50.0%, $p = 0.031$). The distance from the ligament of Treitz was shorter in preterm infants (31.6 ± 31.5 cm vs. 103.6 ± 39.9 cm, $p < 0.001$). Jejunal atresia was more common in preterm infants (71.4% vs. 6.7%; $p < 0.001$). A strong correlation was observed between birth weight and atresia distance ($r = 0.63$, $p < 0.001$). In a multivariable analysis, proximal atresia was an independent predictor of preterm delivery (adjusted OR 0.79 per 10 cm, 95% CI 0.65–0.96, $p = 0.018$).

Conclusion

Proximal SBA was independently associated with preterm delivery. Prenatal identification may facilitate appropriate perinatal management and parental counseling.

Introduction

Small bowel atresia presents with variable clinical features depending on the anatomical location. Despite advances in neonatal care, this condition remains associated with significant morbidity, particularly short bowel syndrome and feeding difficulties [1, 2].

The anatomical location of intestinal atresia may influence perinatal outcomes, including delivery timing. The currently accepted vascular accident theory, first confirmed by Louw and Barnard, is supported by various clinical presentations, ranging from isolated atresia to extremely rare cases of near-complete jejunoileal absence [3]. However, the precise relationship between atresia location and gestational age at delivery has not been thoroughly investigated as a continuous variable.

Advances in prenatal ultrasonography have improved the diagnostic accuracy of small bowel atresia [4, 5]. However, whether these prenatal findings can predict delivery timing and facilitate appropriate

perinatal management planning remains unclear.

This study aimed to investigate the relationship between the anatomical location of small bowel atresia and preterm delivery and identify independent predictors of preterm birth in this patient population.

Materials and methods

1.1. Study design and patient population

This was a retrospective observational study of patients with small-bowel atresia who underwent surgical treatment at two institutions (Kagoshima University Hospital and Kagoshima City Hospital) between April 2000 and March 2024.

Inclusion criteria were all consecutive patients with surgically confirmed small bowel atresia (jejunal or ileal atresia) during the study period. Patients with duodenal atresia or colonic atresia were not included in this study. There were no other specific exclusion criteria.

A total of 58 patients with small-bowel atresia were enrolled. Patients were classified into two groups based on gestational age at delivery: preterm (< 37 weeks, n = 28) and term (≥ 37 weeks, n = 30). The patients were further categorized based on the anatomical location of the atresia relative to the ligament of Treitz. Cases of multiple atresia were classified according to the most proximal atretic site.

The mode of delivery was determined by obstetricians based on maternal and fetal indications. Cesarean section was performed for standard obstetric indications including non-reassuring fetal status, breech presentation, and other maternal or fetal complications. The diagnosis of small bowel atresia itself was not considered an absolute indication for cesarean delivery.

1.2. Definition of jejunal and ileal atresia

The small bowel is anatomically divided into jejunum and ileum based on the total length of the small intestine [6]. Jejunal atresia was defined as atresia located within the proximal two-fifths of the total small-bowel length from the ligament of Treitz. Ileal atresia was defined as atresia located in the distal three-fifths of the small bowel.

1.3. Data collection

Patient demographics, prenatal findings, delivery characteristics, anatomical characteristics of intestinal atresia, surgical procedures, and short-term outcomes were collected from the medical records. Prenatal findings included the prenatal diagnosis status, gestational age at the diagnosis, polyhydramnios, bowel dilatation on ultrasonography, and fetal ascites. Anatomical characteristics included the distance from the ligament of Treitz to the atresia site and classification as jejunal or ileal atresia. Surgical data included the age at surgery, type of surgical procedure performed (primary anastomosis, stoma creation, or membrane excision), and in-hospital mortality.

1.4. Surgical management

All patients underwent surgical intervention for small-bowel atresia. The surgical approach was determined based on the anatomical characteristics of atresia, bowel condition, and overall clinical status. Primary anastomosis was performed when the bowel ends were viable with adequate blood supply and the luminal diameter discrepancy was manageable. Stoma creation was selected in cases of multiple atresia, questionable bowel viability, severe contamination, or extremely low birth weight. Membrane excision was performed for type I atresia with a membranous obstruction.

1.5. Statistical analyses

Continuous variables were expressed as the mean ± standard deviation (SD) or median with interquartile range (IQR), as appropriate. Categorical variables are presented as numbers and percentages. Comparisons between the preterm and term groups were performed using the Mann-Whitney U test for continuous variables with non-normal distribution, Student's t-test for normally distributed continuous variables, and Fisher's exact test or chi-square test for categorical variables.

Univariable and multivariable logistic regression analyses were performed to identify independent predictors of preterm delivery. Variables with $p < 0.1$ in the univariate analysis were included in the multivariable model. Results are expressed as odds ratios (ORs) with 95% confidence intervals (CIs). The correlation between the distance from the ligament of Treitz and birth weight was evaluated using the Spearman's rank correlation coefficient.

For the dose-response analysis, patients were divided into three gestational age groups: early preterm (< 34 weeks), late preterm (34–36 weeks), and term (≥ 37 weeks). The Kruskal-Wallis test was used for overall comparison among the three groups, followed by post-hoc pairwise comparisons using Dunn's test with Bonferroni correction.

All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (R Foundation for Statistical Computing, Vienna, Austria). More precisely, it is a modified version of the R commander designed to add statistical functions frequently used in biostatistics [7]. Statistical significance was set at $p < 0.05$. All tests were two sided.

1.6. Ethical approval

A retrospective chart review and data collection were performed after institutional review board approval was received in accordance with the Ethical Guidelines for Medical and Health Research Involving Human Subjects by the Ministry of Health, Labor, and Welfare of Japan in 2014. This study complied with the 1964 Declaration of Helsinki (revised in 2013) and was approved by the Research Ethics Committee of Kagoshima University Hospital (registration number: 210329). All participants and their parents provided informed consent for registration in this study.

Results

2.1. Patient characteristics

The clinical characteristics of the preterm and term groups are presented in Table 1. The preterm group had a significantly lower birth weight than the term group (1988 ± 731 g vs. 3062 ± 395 g, $p < 0.001$). Male sex was significantly less common in the preterm group than in the term group (25.0% vs. 70.0%, $p < 0.001$).

Regarding prenatal findings, prenatal diagnoses were made more frequently in the preterm group than in the term group (85.7% vs. 60.0%, $p = 0.040$). The gestational age at the diagnosis in patients with a prenatal diagnosis was significantly earlier in the preterm group (29.0 ± 4.1 weeks vs. 32.5 ± 4.1 weeks, $p = 0.011$). Polyhydramnios was more frequently observed in the preterm group (42.9% vs. 13.3%, $p = 0.018$). Bowel dilatation on ultrasonography was also detected more frequently in the preterm group (78.5% vs. 50.0%, $p = 0.031$). There was no significant difference in the incidence of fetal ascites between the two groups (10.7% vs. 6.7%, $p = 0.67$).

Cesarean delivery was performed significantly more frequently in the preterm group than in the term group (46.4% vs. 13.3%, $p = 0.009$). The incidence of umbilical cord ulcers did not differ between groups (3.6% vs. 3.3%, $p = 1.000$).

2.2. Anatomical characteristics of intestinal atresia

The anatomical characteristics stratified by gestational age at delivery are shown in Table 2. The distance from the ligament of Treitz to the atresia site was significantly shorter in the preterm group compared to the term group (mean: 31.6 ± 31.5 cm vs. 103.6 ± 39.9 cm, $p < 0.001$; median: 18 cm [IQR 5.0–57.5] vs. 100 cm [IQR 80.25–126.5]).

Regarding anatomical classification, jejunal atresia was significantly more common in the preterm group (71.4% vs. 6.7%, $p < 0.001$), while ileal atresia was predominant in the term group (28.6% vs. 93.3%).

The Spearman correlation coefficient between the distance from the ligament of Treitz and birth weight was 0.63 ($p < 0.001$), indicating a strong positive correlation. As illustrated in Figure 1, proximal atresia was associated with lower birth weight.

2.3. Multivariable analysis for preterm delivery

The results of the logistic regression analysis are presented in Table 3. In the univariate analysis, the distance from the ligament of Treitz (per 10 cm increase) was significantly associated with reduced odds of preterm delivery (crude OR 0.78, 95% CI 0.65–0.94; $p = 0.009$). Polyhydramnios was also associated with increased odds of preterm delivery (crude OR 4.74, 95% CI 1.18–23.74, $p = 0.018$).

In the multivariable analysis adjusted for both variables, the distance from the ligament of Treitz remained an independent predictor of preterm delivery (adjusted OR 0.79, 95% CI 0.65–0.96, $p = 0.018$).

This OR of 0.79 indicates that each 10 cm increase in the distance from the ligament of Treitz is associated with an approximately 21% reduction in the odds of preterm delivery, meaning that proximal atresia substantially elevates preterm birth risk in a dose-dependent manner. However, the association between polyhydramnios and preterm delivery was not significant after adjustment (adjusted OR 1.33, 95% CI 0.19–9.46, $p = 0.774$).

2.4. Surgical procedures and short-term outcomes

Table 4 presents the surgical and clinical outcomes of the patients. The median age at operation did not differ significantly between the groups (1 day [IQR 0–2.25] in the preterm group vs. 1 day [IQR 1–2.0] in the term group, $p = 0.310$).

The distribution of surgical procedures differed significantly between the two groups ($p = 0.0024$). Primary anastomosis was performed in 53.6% and 90.0% of the preterm and term groups, respectively. Stoma creation was required in 25.0% and 10.0% of the preterm and term groups, respectively. Membrane excision was performed exclusively in the preterm group (21.4% vs 0%).

In-hospital mortality occurred in 2 patients (3.4%) in the preterm group (9.5% vs. 0%, $p = 0.229$). Both deaths were associated with short bowel syndrome caused by multiple intestinal atresia in one case and intrauterine midgut volvulus in the other.

2.5. Dose-response relationship across gestational age groups

Figure 2 illustrates the dose-response relationship by comparing the three gestational age groups. The Kruskal-Wallis test showed significant differences among the three groups ($p < 0.001$). A post-hoc analysis using Dunn's test with Bonferroni correction revealed significant differences between the early preterm and term groups ($p < 0.001$), and between the late preterm and term groups ($p = 0.005$). However, no significant difference was observed between the early and late preterm groups ($p = 0.22$).

Discussion

In the present study, we retrospectively reviewed our two institutions' experiences with patients with small bowel atresia and investigated the relationship between the anatomical location of atresia and preterm delivery to identify independent predictors of preterm birth. The major findings of this study were as follows: (1) the distance from the ligament of Treitz to the atresia site was an independent predictor of preterm delivery in the multivariable analysis; (2) polyhydramnios showed a significant association with preterm delivery in the univariate analysis but became non-significant after adjusting for the atresia location; (3) a dose-response relationship was observed across the three gestational age groups, with progressively shorter distances from the ligament of Treitz in the earlier gestational age groups; (4) a strong positive correlation was found between the distance from the ligament of Treitz and birth weight.

This study demonstrated that the anatomical location of small bowel atresia, measured as the distance from the ligament of Treitz, is an independent predictor of preterm delivery. These findings have several important clinical implications. First, prenatal identification of the atresia location could serve as a prognostic marker for the preterm delivery risk, allowing clinicians to implement appropriate monitoring and prepare for premature birth. Second, our results indicate that the relationship between the atresia location and gestational age is continuous rather than categorical, indicating that even small differences in the atresia location may influence the timing of delivery.

Our analysis revealed that polyhydramnios was not significant after adjusting for atresia location. This statistical finding suggests that polyhydramnios is not an independent cause of preterm delivery but rather a consequence of proximal obstruction. This distinction is clinically meaningful because it implies that treating polyhydramnios alone may not effectively reduce preterm delivery risk unless underlying mechanical obstruction is addressed. The fundamental driver of preterm birth appears to be the anatomical position of atresia. Nakamura et al. demonstrated that elevated bile acid concentrations in the amniotic fluid (≥10 μmol/L) were strongly associated with umbilical cord ulcers and intrauterine fetal death in intestinal atresia [8]. Recent histological studies have supported this hypothesis. Garg et al. demonstrated that light microscopy failed to detect major abnormalities in the proximal dilated bowel in 84% of jejunoileal atresia cases, contradicting previous reports of extensive histological damage. They concluded that bowel plication rather than massive resection should be preferred, as the dilated bowel retains its structural integrity [9].

The dose-response relationship we observed strengthens the causal inference between proximal atresia and preterm delivery. When patients were stratified into three gestational age groups, the distance from the ligament of Treitz showed a progressive stepwise pattern. This gradient effect supports a biological mechanism rather than a mere association, suggesting that the degree of fetal swallowing impairment increases proportionally with the proximity of the obstruction.

Previous studies have documented an association between jejunal atresia and adverse perinatal outcomes. Vecchia et al. reported that jejunal atresia was associated with higher complication rates and poorer long-term outcomes than more distal lesions [1]. Fung et al. found that the distance from the ligament of Treitz was significantly shorter in preterm infants [10]. However, their analysis primarily used categorical comparisons rather than examining distance as a continuous variable in a dose-response analysis.

Our study extends these observations by demonstrating a quantitative dose-response relationship using continuous variables, providing more granular prognostic information. Furthermore, our multivariate analysis revealed that polyhydramnios acts as a mediating factor rather than an independent predictor, a distinction not previously reported in the literature. Regarding feeding difficulties, Wang et al. identified several predictors of prolonged time to full enteral nutrition [2], which is relevant because infants with proximal atresia and preterm birth face compounded nutritional risks.

Our results have direct implications for prenatal counseling. When a fetal ultrasound examination identifies proximal small-bowel atresia with associated polyhydramnios, obstetricians can estimate preterm delivery risk based on the estimated distance from the ligament of Treitz. This allows for proactive planning, including delivery at tertiary centers with both neonatal intensive care and pediatric surgical expertise. Specifically, prenatal identification of proximal atresia enables consideration of antenatal corticosteroids for fetal lung maturation, enhanced surveillance of amniotic fluid volume and fetal well-being, and early preparation of the neonatal and surgical teams for a complex surgical newborn requiring prompt intervention. Increased fetal surveillance may be warranted in cases of proximal atresia, particularly given the risks highlighted by Nakamura et al. regarding umbilical cord ulceration [8].

The strong correlation between atresia location and birth weight raises the question of whether our findings simply reflect fetal size. However, the distance from the ligament of Treitz remained significant even after adjusting for confounding factors, suggesting that anatomical position exerts an effect independent of fetal size. Biological plausibility supports a causal mechanism whereby proximal obstruction leads to impaired fetal swallowing, which in turn results in polyhydramnios, subsequently causing uterine overdistension, and ultimately triggering preterm labor [11,12].

The combination of proximal atresia and preterm birth may have confounding effects on the long-term outcomes. When combined with a potentially shorter residual bowel length after surgical correction, these patients face elevated risks of short bowel syndrome and intestinal failure. In our series, both deaths occurred in the preterm group and were attributable to short bowel syndrome resulting from multiple intestinal atresia and intrauterine midgut volvuli. As emphasized by Fung et al., bowel length preservation is paramount [10].

Limitations

This study had several limitations. First, the retrospective design limits causal inferences. Second, the relatively small sample sizes of the two institutions may limit generalizability. Third, we observed an unexpected higher proportion of female infants in the preterm group (75.0% vs. 30.0%), which contradicts the generally recognized male predominance in preterm births. This finding may reflect the small sample size and possible selection bias in our cohort. The relationship between proximal intestinal atresia and sex distribution has not been previously reported and warrants further investigation in larger studies. Fourth, the long-term outcomes, including neurodevelopmental status, were not evaluated. Future prospective multicenter studies with larger cohorts are needed to validate our findings and to develop clinical prediction models. Finally, the retrospective design precluded systematic distinction between spontaneous and iatrogenic preterm delivery; confounding by obstetric decision-making, such as elective early delivery for maternal or fetal indications unrelated to the atresia itself, cannot be entirely excluded. Future prospective studies should systematically record the indication for delivery to allow for this distinction.

Conclusions

This study demonstrated that proximal small bowel atresia, measured by the distance from the ligament of Treitz, is an independent predictor of preterm delivery. Polyhydramnios acts as a mediating factor rather than an independent cause. The dose-response relationship observed across gestational age groups strengthens the evidence for causality. Prenatal identification of the atresia location may facilitate appropriate perinatal management and parental counseling, enabling delivery planning at tertiary centers equipped with neonatal intensive care and pediatric surgical expertise. Future prospective studies are warranted to validate these findings and develop clinical prediction models.

Declarations

Author contributions

T.H., A.N., and K.S. wrote the manuscript. S.O. and K.Y. prepared the tables and reviewed the literature. Y.T., Y.T., N.N., and C.K. collected data based on medical records, and A.Y., H.O., T.K., E.H., T.K., M.T., and T.T. provided conceptual advice. S.I. critically reviewed the manuscript and supervised the data-collection process. All authors have reviewed the manuscript.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest

The authors declare no conflicts of interest in association with the present study.

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Tables

Table 1

Patient characteristics and perinatal findings stratified by gestational age at delivery

Characteristic	Overall (n = 58)	Preterm (n = 28)	Term (n = 30)	p value	OR (95% CI)
Patient demographics					
Birth weight (g), mean ± SD	2571 ± 778	1988 ± 731	3062 ± 395	< 0.001	-
Male gender, n (%)	28 (48.3)	7 (25.0)	21 (70.0)	< 0.001	0.14 (0.03–0.52)
Prenatal findings					
Prenatal diagnosis, n (%)	42 (72.4)	24 (85.7)	18 (60.0)	0.040	3.9 (0.97–19.44)
Gestational age at diagnosis (weeks), mean ± SD	31.2 ± 4.5	29.0 ± 4.1	32.5 ± 4.1	0.011	-
Polyhydramnios, n (%)	16 (27.6)	12 (42.9)	4 (13.3)	0.018	4.74 (1.18–23.74)
Bowel dilatation on ultrasound, n (%)	37 (63.8)	22 (78.5)	15 (50.0)	0.031	3.58 (1.02–14.05)
Fetal ascites, n (%)	5 (8.6)	3 (10.7)	2 (6.7)	0.67	1.67 (0.18–21.45)
Delivery characteristics					
Cesarean delivery, n (%)	17 (29.3)	13 (46.4)	4 (13.3)	0.009	5.46 (1.37–27.27)
Umbilical cord ulcer, n (%)	2 (3.4)	1 (3.6)	1 (3.3)	1.000	1.07 (0.01–87.12)

OR, odds ratio; CI, confidence interval; SD, standard deviation.

Table 2

Anatomical characteristics of intestinal atresia and correlation with gestational age at delivery

Characteristic	Overall (n = 58)	Preterm (n = 28)	Term (n = 30)	p value
Location of atresia				
Distance from Treitz ligament (cm), mean ± SD	67.3 ± 45.2	31.6 ± 31.5	103.6 ± 39.9	< 0.001
Distance from Treitz (cm), median (IQR)	60.0 (9.5-91.75)	18 (5.0-57.5)	100 (80.25–126.5)	
Anatomical classification				
Jejunal atresia, n (%)	22 (37.9)	20 (71.4)	2 (6.7)	< 0.001
Ileal atresia, n (%)	36 (62.1)	8 (28.6)	28 (93.3)	
Correlation with birth weight				
Spearman correlation coefficient (TL distance vs birth weight)	r = 0.63	-	-	< 0.001
*Per 10 cm increase in distance from ligament of Treitz				
SD, standard deviation; IQR, interquartile range; TL, Treitz ligament.				

Table 3

Multivariable logistic regression analysis for preterm delivery: parsimonious model accounting for sample size constraints

Variable	Univariate analysis			Multivariable analysis		
	Crude OR	95% CI	p value	Adjusted OR*	95% CI	p value
Distance from Treitz ligament (per 10 cm)	0.78	0.65–0.94	0.009	0.79	0.65–0.96	0.018
Polyhydramnios (present vs absent)	4.74	1.18–23.74	0.018	1.33	0.19–9.46	0.774
OR, odds ratio; CI, confidence interval.						

Table 4

Surgical procedures and short-term outcomes stratified by gestational age at delivery

Outcome	Overall (n = 58)	Preterm < 37 weeks (n = 28)	Term ≥ 37 weeks (n = 30)	P value
Surgical characteristics				
Age at operation (days), median (IQR)	1 (0–2)	1 (0-2.25)	1 (1–2.0)	0.310
Surgical procedure, n (%)				0.0024
- Primary anastomosis	42 (72.4)	15 (53.6)	27 (90.0)	-
- Stoma creation	10 (17.2)	7 (25.0)	3 (10.0)	-
- Membrane excision	6 (10.3)	6 (21.4)	0 (0)	-
Clinical outcomes				
In-hospital mortality, n (%)	2 (3.4)	2 (9.5)	0 (0)	0.229
IQR, interquartile Range.				

Figures

Figure 1: Correlation between birth weight and site of atresia

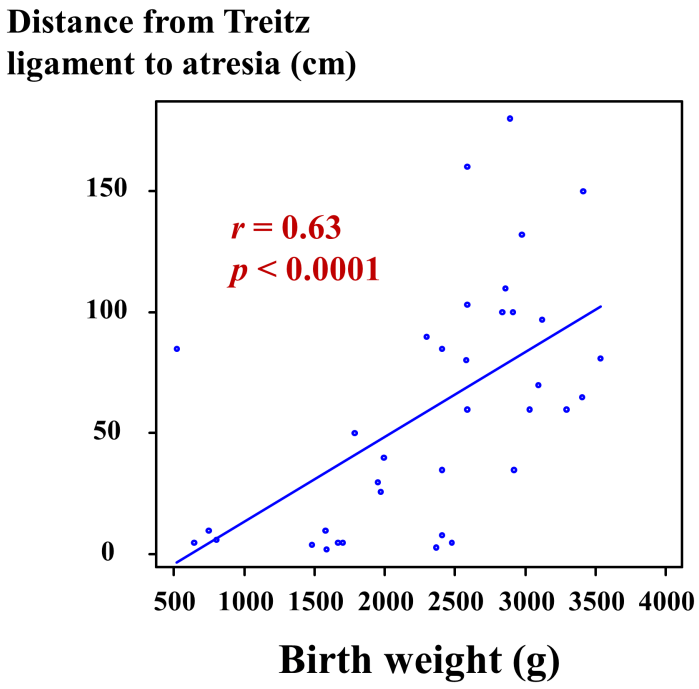


Figure 1

Correlation between birth weight and atresia location

r, Spearman's rank correlation coefficient.

Figure 2: Dose-response relationship between atresia location and gestational age groups

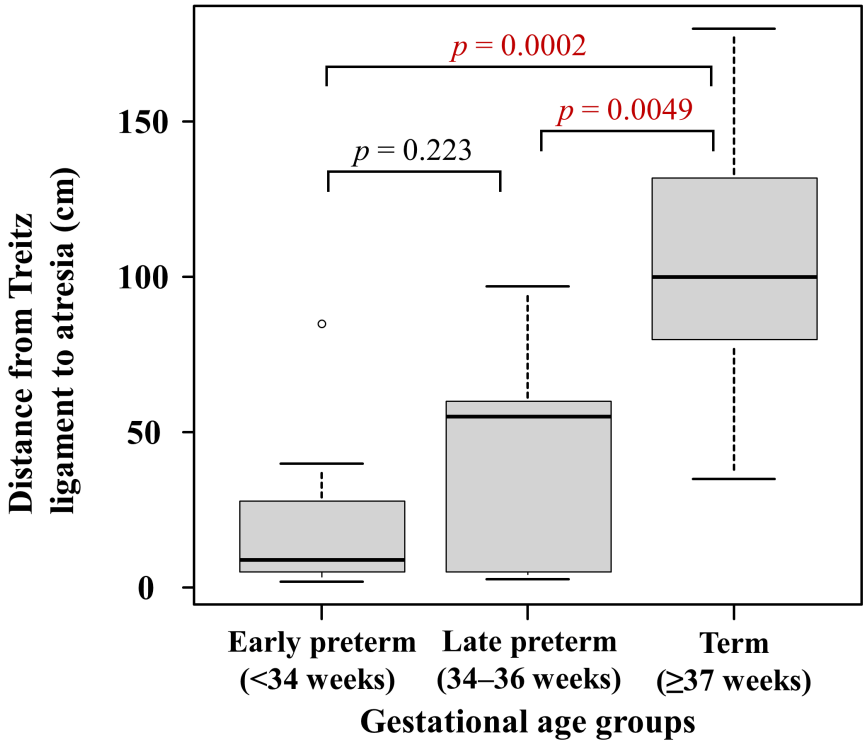


Figure 2

Dose-response relationship between atresia location and gestational age groups

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