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Retrospective Analysis of Neonatal Surgery at Tottori University over the Past Ten Years

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ABATRACTS

Background In recent years, the number of neonatal surgeries has been on the rise despite the decline in the number of births, and we examined the actual trends and problems at Tottori University Hospital located in the Sanin region.

Methods Medical records were retrospectively searched for patients who underwent major surgery during the neonatal period (within 30 days of age) at the Tottori University Hospital over the past 10 years (Jan. 2011 to Dec. 2020).

Results Sixty-five cases were included. Early birth infants (< 37 gestational weeks) comprised 15 cases (23%) and low birth weight (< 2500 g) infants involved 27 cases (42%). In the latter half (2016–2020), early birth and low birth weight infants were significantly less than in the first half (2011–2015). The common diseases were anorectal malformation (14 cases), esophageal atresia (10), duodenal atresia (10), and diaphragmatic hernia (9). Prenatal diagnosis was obtained in 26 cases (40%), with high diagnostic rate obtained in duodenal atresia (100%), abdominal wall defect (100%), ileal atresia (75%), meconium peritonitis (67%), and diaphragmatic hernia (67%). Fifty-five cases (85%) were operated on within 7 days of age. Other major malformations were associated in 23 cases (35%). There were 6 deaths (9%), of which 3 cases were low birth weight infants with gastrointestinal perforation, 2 cases with severe chromosomal abnormalities (esophageal atresia, omphalocele), and 1 case with diaphragmatic hernia with severe pulmonary hypertension. Home medical care has been required with gastrostomy tube in 2 cases.

Conclusion Neonatal surgery at Tottori University has been well performed as required with acceptable results along with the progression of other perinatal care. However, further investigation for improvements in premature delivery or organ hypoplasia may be required.

Key words intestinal perforation; low birth-weight infant; Nationwide Japanese Surveillance; neonatal surgery; premature delivery; prenatal diagnosis

Neonatal surgery is a particularly important field in perinatal medicine and pediatric surgery. Great strides have been made in clinical aspects of neonatal surgery over the last 50 years in Japan and the environment has changed significantly.[1, 2] While the number of births and birthrate is decreasing in recent years, the neonates requiring surgeries are on the contrary increasing. According to a Nationwide Japanese surveillance (NJS) program aggregated by the Japan Society of Pediatric Surgeons (JSPS) every five years since 1960, the average number of cases counted is about 3,500 per year, and in 2018 it was 2,828 cases. The population of Japan increased to 127.4% and the number of births decreased to 53.5% in 2018 compared to those in 1964. On the contrary, the number of neonatal surgeries increased to 485.7%.[2] The background is related to high-risk pregnancy and birth associated with elderly pregnancy and birth, causing the increased number of premature infants by premature delivery.[3] These babies tend to have increased chance of undergoing operations.[1, 2] Another factor of increasing neonatal surgeries may be the increased number of diseases diagnosed before birth. Despite the recent progress in the neonatal surgical field, new problems such as an increase of severely disabled children receiving home medical care have risen.[4]

In this paper, we collected the medical records of neonatal surgeries performed at Tottori University

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Abbreviations: CoA, coarctation of aorta; CPAM, congenital pulmonary airway malformation; DORV, double outlet right ventricle; ECMO, extracorporeal membrane oxygenation; EXIT, ex-utero intrapartum treatment; ELBW, extremely low birth weight; FETO, fetoscopic endoluminal tracheal occlusion; JSPS, Japan Society of Pediatric Surgeons; LBW, low-birth weight; NCD, National Clinical Database; NCDP, NCD-Pediatric; NEC, necrotizing enterocolitis; NJS, Nationwide Japanese surveillance; PDA, patent ductus arteriosus; STEP, serial transverse enteroplasty; VSD, ventricular septal defect

Hospital during the previous 10 years and analyzed the trends and problems of the actual situation.

SUBJECTS AND METHODS

Participants

In 2011, the National Clinical Database (NCD) registration system started.[5] We collected the data of patients undergoing major surgery within 30 days after birth who were admitted to Tottori University Hospital during the past 10 years (Jan. 2011 to Dec. 2020) included in NCD registration. One exclusion was a case of diaphragmatic hernia predicted to have severe pulmonary hypoplasia who was transferred to a high-volume center in another prefecture for treatment with extracorporeal membrane oxygenation (ECMO). Cases suspected to have been fetal diagnosis or after birth but not requiring surgery during the neonatal period were not included in this review. These diseases were ovarian cyst, congenital biliary dilatation, biliary atresia, hydronephrosis, hydrocephalus. Cases were chronologically divided into early period (Jan. 2011 to Dec. 2015) and late period (Jan. 2016 to Dec. 2020).

Methods

By a retrospective search of the medical records, the numbers of babies of low birth weight (LBW) < 2500 g, very low birth weight (VLBW) < 1500 g, extremely low birth weight (ELBW) < 1000 g, were counted. In addition, chromosomal abnormalities, other major malformations, surgical timing (early surgery within 7 days after birth, late surgery between 7 and 30 days), delayed discharge (more than 60 days after surgery), and survival rate were determined. The prognosis was determined at 90 days after surgery. Follow-up was conducted for more than two years until 2022 with a mean of 80.5 months and long-term outcomes were examined. Mortality cases were examined separately.

Statistical analysis

Chi-square tests were conducted to examine the differences of the data between early period and late period. When *p*-value was less than 0.05, difference was considered significant.

Ethical considerations

The Institutional Review Board of our institution approved this study (23A026). The need for informed consent requirement was waived because of the retrospective nature of this study. All procedures were performed according to the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Table 1. Overall patients in the early and late period

	2011–2015	2016–2020
Gender		
Female	18	13
Male	17	17
Gestational age (weeks)*		
Preterm (< 37)	14	3
Term (> 38)	21	27
Birth weight (g)		
ELBW < 1000g	5	1
VLBW < 1500g	1	1
LBW < 2500g	12	8
Prenatal diagnosis*	10	16
Survival	30	29
Total	35	30

*$P < 0.05$ between 2 groups.

RESULTS

Overall patients

Sixty-five cases were included as shown in Table 1. Thirty-five patients were in the early period and 30 in the late period. There were 31 female and 34 male patients.

Prenatal diagnosis

Prenatal diagnosis was obtained in 26 cases (40%), as shown in Table 1. Prenatal diagnosis was obtained in 53% in the late period, higher rate than in the early period ($P < 0.05$). The diagnostic rate was obtained in abdominal wall defect (100%), duodenal atresia (90%), ileal atresia (75%), diaphragmatic hernia (67%), meconium peritonitis (67%) and esophageal atresia (40%) as shown in Table 2.

Maternal transport

Maternal transport was planned in 33 cases (51%) (Table 2). The reason was the intended postnatal intensive treatment following prenatal diagnosis or other reason in abdominal wall defects (100%), meconium plug syndrome (100%), duodenal atresia (90%), bowel perforation (80%), diaphragmatic hernia (67%), meconium peritonitis (67%), esophageal atresia (50%) and ileal atresia (25%).

Premature delivery

Premature delivery was significantly higher in the early period (40%) as shown in Table 1 ($P < 0.05$). Premature delivery was associated with bowel perforation (100%), meconium plug syndrome (100%), meconium peritonitis

Table 2. Perinatal events in neonatal surgical patients

Disease	No of cases	Prenatal Diagnosis	Maternal transport	Premature delivery	Cesarean or transvaginal induced delivery	ELBW/VLBW/ LBW (Total)
Esophageal Atresia	10	4 (40)	5 (50)	2 (20)	8 (80)	1/0/6 (70)
Diaphragmatic Hernia	9	6 (67)	6 (67)	2 (22)	8 (89)	0/0/3 (33)
Gastric Rupture	1	0 (0)	0 (0)	0 (0)	1 (100)	0/0/1 (100)
Duodenal Atresia	10	9 (90)	9 (90)	4 (40)	6 (60)	0/1/3 (40)
Malrotation of the Intestine	3	0 (0)	0 (0)	0 (0)	2 (67)	0/0/0 (0)
Ileal Atresia	4	3 (75)	1 (25)	0 (0)	2 (50)	0/0/1 (25)
Meconium Peritonitis	3	2 (67)	2 (67)	2 (67)	3 (100)	0/0/1 (33)
Bowel Perforation	5	0 (0)	4 (80)	5 (100)	3 (60)	3/1/1 (100)
Meconium Plug Syndrome	2	0 (0)	2 (100)	2 (100)	2 (100)	2/0/0 (100)
Bowel Obstruction	1	0 (0)	0 (0)	0 (0)	0 (0)	0/0/1 (100)
Anorectal Malformation	14	0 (0)	1 (7)	0 (0)	4 (29)	0/0/2 (14)
Abdominal Wall Defect	3	3 (100)	3 (100)	0 (0)	3 (100)	0/0/1 (33)
Total	65	26 (40)	33 (51)	17 (26)	41 (63)	6/2/20 (40)

(% to total cases in each disease)

(67%), duodenal atresia (40%), diaphragmatic hernia (22%) and esophageal atresia (20%) as shown in Table 2.

Caesarean or transvaginal induced delivery

Caesarean or transvaginal induced delivery was performed in 41 cases (63%) (Table 2). After the delivery, postnatal intensive treatment following prenatal diagnosis was conducted for the babies with abdominal wall defects (100%), meconium peritonitis (100%), diaphragmatic hernia (89%), esophageal atresia (80%), duodenal atresia (60%). Others were maternal and fetal reasons such as premature delivery.

Birth weight

Lower birth weight was seen in the same patients at gestational age. Especially, ELBW was seen in esophageal atresia (1) bowel perforation (3) and meconium plug syndrome (2).

Disease and classification

The most common disease was anorectal malformation (imperforate anus, 14 patients), including low type (6), intermediate type (4) and high type (4) as shown in Table 2. The next was esophageal atresia (10), all of which were Gross type C. Ten cases were duodenal atresia, including complete separation (7) and membranous atresia (3). Diaphragmatic hernia was in 9 cases, left (7) and right side (2). Ileal atresia was in 4 cases, complete separation (2), fibrous cord (1) and membranous atresia (1). Bowel perforation was in 4, including focal intestinal perforation (1), NEC (necrotizing enterocolitis) (1), ileal atresia (1), multiple ileal ulcer (1). Abdominal wall defect was in 3 cases, cloacal extrophy (1), omphalocele (1), hernia into the umbilical cord (1). The other diseases were malrotation of the Intestine (3), meconium peritonitis (3), meconium plug syndrome (3) and bowel obstruction (2).

Chromosmal abnormalities

Table 3 shows chromosomal abnormalities. Eighteen-trisomy was associated in esophageal atresia (1), 21-trisomy was in duodenal atresia (1), meconium peritonitis (1) anorectal malformation (1) and 13-trisomy was in hernia into the umbilical cord (1).

Major other anomalies

Twenty-two patients (34%) were associated with other major anomalies. The most common was cardiovascular anomalies in 14 patients. The second most common ailment was cerebral anomaly in 5 cases (spina bifida, hydrocephalus). The other gastrointestinal anomalies were in 4 cases (malrotation of the intestine, Meckel's diverticulum, duodenal atresia, ileal atresia, omphalomesenteric duct). The urinary anomalies were in 2

Table 3. Operations and outcomes

	No of cases	Chromosomal abnormality	Major other anomalies	Early operation (< 7days)	Prolonged discharge	Survival
Esophageal Atresia	10	1 (10) 18 Trisomy	6 (60)	10 (100)	4 (40)	9 (90)
Diaphragmatic Hernia	9	0 (0)	3 (33)	9 (100)	3 (33)	8 (89)
Gastric Rupture	1	0 (0)	0 (0)	1 (100)	1 (100)	1 (100)
Duodenal Atresia	10	1 (10) 21 Trisomy	4 (40)	8 (80)	2 (20)	10 (100)
Malrotation of the Intestine	3	0 (0)	0 (0)	0 (0)	0 (0)	3 (100)
Ileal Atresia	4	0 (0)	1 (25)	4 (100)	1 (25)	4 (100)
Meconium Peritonitis	3	1 (33) 21Trisomy	1 (33)	2 (67)	3 (100)	3 (100)
Bowel Perforation	5	0 (0)	1 (33)	3 (60)	4 (80)	2 (40)
Meconium Plug Syndrome	2	0 (0)	0 (0)	1 (50)	2 (100)	2 (100)
Bowel Obstruction	1	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
Anorectal Malformation	14	1 (7) 21 Trisomy	4 (29)	14 (100)	1 (7)	14 (100)
Abdominal Wall Defect	3	1 (33) 13 Trisomy	2 (67)	3 (100)	2 (67)	2 (67)
Total	65	5 (8)	22 (34)	55 (85)	23 (35)	59 (91)

(% to total cases in each disease)

cases (hydronephrosis, horseshoe kidney, vesicoureteral reflux).

Operations

Operations within 7 days after birth were undergone in 55 cases (85%), including esophageal atresia (100%), diaphragmatic hernia (100%), gastric rupture (100%), ileal atresia (100%), anorectal malformation (100%), abdominal wall defect (100%), duodenal atresia (80%), meconium peritonitis (67%), bowel perforation (60%) and meconium plug syndrome (50%) (Table 3). Later operations after 7 days postnatally were performed in the other 30 cases with malrotation of the intestine, duodenal atresia, or bowel obstruction.

For esophageal atresia, 7 cases underwent one-stage radical surgery on days 1–3, and ELBW cases underwent gastrostomy and esophageal banding on day 5, and esophageal radical surgery at 4 months. In patients associated with duodenal atresia, gastrostomy and duodenoduodenostomy were performed on the day of birth, and esophageal radical surgery was performed on the 2nd day. In a case of 18-trisomy with microcephaly and cardiac malformation, gastrostomy and esophageal banding were performed on the day of birth, but the patient died 10 months later.

Seven cases of left diaphragmatic hernia and a case of right diaphragmatic hernia with sac underwent direct suture on the day of birth, and a case on the right side had severe lung hypoplasia and only chest tube drainage was performed. In patients associated with meningocele, meningocele closure was performed on the day of birth followed by diaphragmatic closure the next day.

Gastric suture was performed for a case of gastric rupture. In duodenal atresia, membrane resection was performed in one case of membranous type and diamond-type duodenoduodenostomy was performed in the other nine cases with separate type at 0–15 days after birth. Three cases of intestinal malrotation underwent untwisting and Ladd's operation on the 7th to 8th day after birth. Ileal resection was performed on 0–2 days after birth in all 4 cases of ileal atresia. For meconium peritonitis, initial surgery (drainage, ileostomy) was performed 0–9 days after birth, followed by radical surgery. STEP (serial transverse enteroplasty) was added in one case due to residual short bowel syndrome. Five cases of bowel perforation underwent drainage or enterostomy and small bowel resection on days 5–13. Two cases of meconium plug syndrome underwent ileostomy on 6–12 days, followed by closure of the ileostomy.

Six cases of low anorectal malformation underwent anoplasty on day 0–1 and eight cases of high or intermediate type underwent colostomy on day 0–1, followed by radical surgery and colostomy closure. One patient underwent Kasai surgery at the age of one month due to associated biliary atresia, and a patient with double outlet right ventricle (DORV) underwent radical surgery at another hospital.

Three cases of abdominal wall defect underwent abdominal wall closure on days 0–6.

Table 4. Mortality cases

Patient	Main disease	Associated abnormalities	Gender	Gestational weeks)/ Birth weight (grams)	Operation	Cause of the death
#1	Esophageal Atresia	18 trisomy, VSD, CoA, PDA, microcephaly	Female	37/ 1594	Esophageal banding	Pneumonia
#2	Diaphragmatic Hernia (Right sided)		Female	31/ 2148	Thoracic drainage	Respiratory failure
#3	Ileal Atresia with perforation		Female	27/ 409	Ileostomy	Respiratory failure
#4	Multiple intestinal ulcer with perforation		Male	34/ 2032	Ileal resection	Sepsis
#5	Necrotizing Enterocolitis		Male	23/ 596	Abdominal darainage	Sepsis
#6	Omphalocele	13 trisomy, DORV, PDA, Cleft palate	Male	37/ 2560	Abdominal closure	Heart failure

CoA, coarctation of aorta; DORV, double outlet right ventricle; PDA, patent ductus arteriosus; VSD, ventricular septal defect.

Outcomes

Overall survival was obtained in 59 cases (91%) (Table 3). There was no significant difference in the survival rate between the early and late period. The worst disease was bowel perforation (survival rate, 40%), followed by abdominal wall defect (67%), diaphragmatic hernia (89%) and esophageal atresia (90%).

Mortality cases

Six cases (9%) died (Table 4). The main disease was bowel perforation in 3 cases. Two of the 3 cases were associated with ELBW presenting with ileal atresia (#3) and NEC (#4). Another case of bowel perforation was LBW infant with multiple intestinal ulcer (#4). The other cause of death was chromosomal abnormalities (#1: 18-trisomy, #6: 13-trisomy) and associated other major anomalies especially cardiac defects in patient #1 (esophageal atresia) and #6 (omphalocele). Patient #2 with right-sided diaphragmatic hernia died of severe lung hypoplasia.

Prolonged complications

Respiratory disorders requiring postoperative intratracheal intubation management were observed in 15 cases (diaphragmatic hernia in 8, esophageal atresia in 2, gastrointestinal perforation in 2, gastrointestinal rupture in 1, ileal obstruction in 1, meconium peritonitis in 1). Liver dysfunction was observed in 2 cases of diaphragmatic hernia and 1 of ileal atresia. Twenty-three cases (35%) were discharged from the hospital more than 60 days after surgery. Home medical care required with gastrostomy tube in 2 cases (esophageal atresia and ileal atresia). During the follow-up period up to 2022, no major complications due to the primary disease have been identified for the other cases.

DISCUSSION

The observation period of this study was the previous 10 years from January 2011 when the NCD started,[5] and the long-term prognosis was evaluated at the end of 2022 after more than 2 years after the end of our review had passed.

In Table 5, the present data were compared with the NJS data published in 2020.[2] The most common 4 diseases are anorectal malformation, intestinal atresia, diaphragmatic hernia, and esophageal atresia both in NJS and our series. The frequency of fetal diagnosis was almost comparable between NJS (35%) and our series (40%). The overall survival rate was equivalent between NJS (92%) and our series (91%).

Regarding the prenatal diagnosis, the diseases with the highest diagnosis rate were abdominal wall defect, duodenal atresia, small intestine obstruction, diaphragmatic hernia, and meconium peritonitis, which was almost the same as NJS.[2] The significance of fetal diagnosis is that selection of maternal transport, delivery time and mode can be made according to the severity of fetal condition and is beneficial in cases with a tendency for premature birth due to polyhydramnios. In the present series, surgery was performed in the early neonatal period in good condition in most of the cases. However, the series also includes severe cases that cannot be accessed at surgical facilities, which may actually reduce treatment results, and may not necessarily lead to good results overall.

At our facility, there were many early deliveries of less than 37 gestational weeks and the high frequency of premature infants especially in the early period. Polyhydramnios tended to result in preterm birth. On the other hand, in NJS, the number of premature babies increased by year.[2] Decrease of premature babies in our hospital may have been attributed to improved perinatal

Table 5. Comparison of the present data with Nationwide Japanese Surveillance

	Present series	Nationwide Japanese Surveillance
Common disase	1 Intestinal Atresia	1 Anorectal Malformation
	2 Anorectal Malformation	2 Intestinal Atresia
	3 Diaphragmatic Hernia	3 Diaphragmatic Hernia
	4 Esophageal Atresia	4 Esophageal Atresia
Prenatal diagnosis	40%	35%
Total survival rate	91%	92%
High mortality	1 Bowel Perforation	1 Bowel perforation
	2 Omphalocele	2 Esophageal Atresia
	3 Diaphragmatic Hernia	3 Omphalocele
	4 Esophageal Atresia	4 Diaphragmatic Hernia

management.

Bowel perforation, esophageal atresia, omphalocele, and diaphragmatic hernia are listed as the top four diseases with poor prognosis. These mortality rates have been high in past NJS records,[1] but recent mortalities of premature infants are decreasing due to advances in perinatal care.[6, 7] However, complications caused by the immaturity of various organs are a major issue. Particularly, gastrointestinal disease such as NEC, focal intestinal perforation, and meconium-related intestinal obstruction are serious complications seen in premature infants and affect the early and long-term prognosis.[2] Development of these problems is due to the involvement of perinatal factors such as infection and stress based on the background of immaturity of the intestinal tract. All of them usually develop from a few days to 1–2 weeks after birth, and there are various symptoms such as intestinal inflammation, intestinal obstruction, and sudden intestinal perforation. NEC has been reported to be caused by fetal/neonatal asphyxia, apneic attacks, IRDS, patent ductus arteriosus, and artificial milk. On the other hand, focal intestinal perforation is a sudden perforation with no sign of preceding infection, the general condition is maintained, there are few inflammatory findings, and there is only a local abnormality in the intestinal tract. Meconium-related intestinal obstruction is due to viscous meconium and may respond to gastrografin enema.[8, 9] If conservative treatment such as fasting, antibiotics is ineffective or if perforation occurs, urgent operation is required. Drainage and intestinal stoma construction are performed.[10, 11] In our series, 7 cases of gastrointestinal perforation were LBW infants, 5 cases were ELBW, and 1 case was VLBW. Sixty percent of the patients died despite aggressive treatment. To prevent perforation and improve surgical results, administration of steroids to mothers with predicted premature birth,[12–14] administration of breast milk[15, 16] or probiotics[17–19] may help premature babies succeed.

Regarding chromosomal abnormalities, 21-trisomy is the most common and duodenal atresia and anorectal malformations often occur in pediatric surgery; the prognosis is usually good. On the other hand, since 18-trisomy had been recognized as having very poor outcome, invasive treatment was limited.[20] However, recently long-term survival cases have been reported and surgical interventions such as heart surgery have been performed frequently.[21] The effectiveness of aggressive surgical intervention even for often associated esophageal atresia has been demonstrated with a 1-year survival rate of 27%.[22] Actually in the recent NJS reports, there are an increasing number of cases where radical surgery has been performed for esophageal atresia associated with 18-trisomy, and we would like to consider whether this can be done in our hospital as well.

Thoracotomy has been conventionally performed by the posterior lateral incision even in the neonatal period and caused thoracic deformity, scapula elevation and scoliosis, resulting in exercise, learning, and employment restriction, and bullying, mental stress, after growing older, and a decrease in quality of life by conspicuous large scars. Nowadays, we use axillary incision instead. For abdominal laparotomy, the trans-umbilical approach has been selected instead of large incision. Furthermore, endoscopic surgery has been applied even for newborn babies and is becoming widespread for esophageal atresia, diaphragmatic hernia, cystic lung disease, duodenal atresia and ovarian cys.[23–28] Regarding endoscopic surgery in the pediatric field, there is a system for technically certified doctors, but there are still few people who have obtained

certification nationwide as in our hospital. So we are in the process of training young surgeons who will receive training at a high volume center, etc.

Intervention of the fetus has been attempted for very compromised cases. For diaphragmatic hernia with severe lung hypoplasia, fetoscopic tracheal occlusion (FETO) is performed.[29, 30] In addition, ex-utero intrapartum treatment (EXIT) is performed in upper airway obstruction syndrome (CHAOS) such as fetal giant cervical mass or tracheal atresia to secure the airway while maintaining placental circulation prior to delivery of the fetus at the time of caesarean section.[31–33] In addition, uterine opening surgery, abnormal vascular ablation, and shunt surgery have been performed for large or severe cases of meningocele, sacrococcygeal teratoma, congenital pulmonary airway malformation (CPAM), urinary tract obstruction, and fetal pleural effusion.[34–36]

Although direct data showing the results of neonatal surgery in each country has not been published, Japan's results in infant mortality rates are extremely good compared to Europe and the United States. Because infant mortality is dependent on the treatment of neonatal surgical diseases, Japan's neonatal surgical outcomes may be good. However, as for advanced medical care, the introduction of endoscopic surgery including robotic surgery for infants and newborns, and the introduction of fetal surgery have been made from an early stage.

Regarding the long-term prognosis, the increase in the number of children with severe physical and mental disabilities due to the complication of brain damage in premature infants will be a future problem. In addition, short bowel syndrome, which occurs mostly after massive, small bowel resection during the neonatal period, requires parenteral nutrition. NEC, abdominal wall defect, small intestinal obstruction, and midgut volvulus are common candidates causing short bowel syndrome.[37] Liver damage has the greatest impact on prognosis when parenteral nutrition is prolonged.[38]

From the above-mentioned retrospective analysis of neonatal surgical cases performed at Tottori University Hospital during the past 10 year period, except for cases of extreme organ hypoplasia, fetal surgery, and organ transplantation, diagnostic methods, perinatal management, and surgical treatment have been conducted appropriately according to the needs of local medical care and are comparable to the national level.

A limitation of this study is that it is a retrospective study of neonatal surgery at a single institution, and future studies that match the observation period and various conditions for surgery are necessary for comparative studies with other institutions.

In conclusion, neonatal surgery at Tottori University has been well performed as required with acceptable results along with the progression of the other perinatal care. However, further investigation for the improvement of premature delivery or organ hypoplasia may be required.

The authors declare no conflict of interest.

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