Neonatal gastric perforation: A single center experience

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AIM: To determine the etiology and prognostic factors for neonatal gastric perforation (NGP), a rare but life-threatening disease.

METHODS: Between 1980 and 2011, nine patients underwent surgical intervention for NGP at Seoul National University Children’s Hospital. The characteristics and prognosis of the patients were retrospectively analyzed.

RESULTS: Among the nine patients, three (33.3%) were preterm babies and five (55.5%) had associated anomalies, which included diaphragmatic eventration (n = 2), congenital diaphragmatic hernia, esophageal atresia with tracheoesophageal fistula, and antral web. Three (33.3%) patients were born before 1990 and three (33.3%) had a birth weight < 2500 g. Pneumoperitoneum was found on preoperative images in six (66.7%) patients, and incidentally in the other three (33.3%) patients. Surgery was performed within 24 h after the onset of symptoms in seven (77.8%) patients. The overall mortality rate was 22.2% (2/9). The time between symptoms and surgical intervention was the only prognostic factor for survival, whereas premature birth and birth weight were not.

CONCLUSION: Early detection and advances in neonatal intensive care may improve the prognosis of NGP.

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Key words: Neonate; Gastric perforation; Etiology; Prognosis; Surgical intervention

Core tip: Neonatal gastric perforation (NGP) is an extremely rare condition and very few cases have been reported to date. We determined the etiology and prognostic factors for NGP in nine cases who were treated at a single center. Early detection and prompt surgical intervention are essential to improve the outcomes of NGP.

INTRODUCTION

Neonatal gastric perforation (NGP) accounts for approximately 7% of all gastrointestinal perforations in neonates, and has a poor prognosis with a high mortality rate[1,2]. Factors associated with NGP include prematurity, asphyxia, congenital anomalies, stress at birth, vigorous respiratory resuscitative measures, increased intragastric pressure caused by distal obstruction, and anatomic abnormalities of the stomach[3-5]. Male gender, metabolic acidosis, premature birth, and low birth weight are associated with worse outcomes[6,7]. However, the etiology and prognostic factors of NGP are still widely debated. Here, we describe our experience of treating nine patients with NGP at a single center. The aim of this study was to review patients with NGP and discuss its etiology and...
Table 1  Patient characteristics

| Patient | Gender | Date of birth | GA (wk) | Term | BW (g) | Delivery | Symptom onset (d) | Time from symptoms to surgery (d) | pH | NG tube |
|---------|--------|---------------|---------|------|--------|----------|------------------|----------------------------------|----|---------|
| A       | F      | 1983-02-24    | 40      | Full term | 3500  | Natural | 5                 | 1                               | N.D. | Yes     |
| B       | F      | 1987-07-09    | 40      | Full term | 2950  | Natural | 2                 | 2                               | 7.13 | Yes     |
| C       | M      | 1990-09-05    | 35      | Preterm  | 2190  | Natural | 2                 | 2                               | 7.03 | Yes     |
| D       | M      | 1993-06-03    | 38      | Full term | 2950  | C-sec   | 4                 | 0                               | 7.19 | No      |
| E       | M      | 1999-05-13    | 36      | Full term | 2860  | Natural | 2                 | 0                               | 7.43 | No      |
| F       | F      | 2003-05-10    | 32      | Preterm  | 1960  | C-sec   | 2                 | 0                               | N.D. | Yes     |
| G       | M      | 2009-02-03    | 38      | Full term | 3620  | Natural | 0                 | 1                               | 7.086| Yes     |
| H       | M      | 2011-08-03    | 24      | Preterm  | 730   | Natural | 4                 | 1                               | 7.058| Yes     |
| I       | F      | 2011-12-27    | 39      | Full term | 4040  | Natural | 2                 | 0                               | 7.391| Yes     |

GA: Gestational age; BW: Birth weight; F: Female; M: Male; NG: Nasogastric; C-sec: Cesarean section.

Table 2  Preoperative conditions

| Initial symptom                  | Diet | Ventilator | O₂ therapy | Pneumoperitoneum on X-ray | Associated anomaly | Maternal problem |
|----------------------------------|------|------------|------------|---------------------------|--------------------|-----------------|
| High fever, vomiting, dyspnea    | Yes  | Yes        | Yes        | No                        | Diaphragmatic eventration | None            |
| Vomiting dyspnea                 | Yes  | Yes        | Yes        | No                        | Diaphragmatic eventration | None            |
| Hematemesis                      | Yes  | No         | Yes        | No                        | No                 | PROM            |
| Abd. dist, vomiting, fever       | Yes  | No         | No         | Yes                       | Yes                | None            |
| Abd. dist                        | Yes  | No         | No         | Yes                       | No                 | None            |
| Abd. dist                        | No   | No         | No         | Yes                       | Yes                | TEF             |
| Abd. dist                        | No   | Yes        | Yes        | Yes                       | Yes                | CDH             |
| Metabolic acidosis, Abd. dist    | No   | Yes        | Yes        | Yes                       | Yes                | Antral web      |
| Abd. dist                        | Yes  | No         | No         | Yes                       | Yes                | PROM            |

PROM: Premature rupture of membranes.

RESULTS

The clinical features of the nine patients are described in Table 1. There were five boys and four girls; three were born before 1990 and six after 1991. The mean gestational age was 38 (range, 24-40) wk and the mean birth weight was 2950 g (range, 730-4040 g). Three patients were preterm and six were full term. Two patients had a low birth weight (LBW: < 2500 g) and one had an extremely LBW (ELBW; < 1000 g). Seven were born via natural delivery and two via cesarean section. Two patients were born after premature rupture of the membranes, of whom one was a twin. The mean maternal age at delivery was 32 years (range, 25-32 years). In one patient, Apgar score was 1 and 4 at 1 and 5 min, respectively. In another patient, Apgar score was 2 and 7 at 1 and 5 min, respectively.

Preoperative conditions are described in Table 2. Preoperative serum pH was < 7.30 in five patients and > 7.30 in two patients, and was not determined in the other two patients. A nasogastric tube was used preoperatively in seven patients. Six were on a specialist diet, four were on ventilators, and six received supplemental O₂.

All nine patients presented with mild to severe abdominal distention. Patient A initially presented with high fever, vomiting, and dyspnea. Congenital diaphragmatic hernia was initially suspected, but the final diagnosis was diaphragmatic eventration. Gastric perforation was found during surgery. Patient B initially presented with vomiting and dyspnea. Abdominal exploration was performed because of suspected congenital diaphragmatic hernia,

prognosis, in order to improve patient outcomes.

MATERIALS AND METHODS

Data collection

Between 1983 and 2011, nine neonates (five males and four females) who underwent surgical treatment for NGP at a single center were identified using written and electronic medical records.

Variables

We focused on preoperative and intraoperative characteristics that are known or thought to be prognostic factors for NGP. The characteristics retrieved from medical records included gender, year of birth, gestational age, birth weight, method of delivery, maternal gestational problems, maternal age at delivery, Apgar score, initial symptoms, time from birth to initial symptoms after birth, time between symptom onset and surgery, serum pH, serum pCO₂, use of a nasogastric tube, ventilator therapy, O₂ therapy, diagnostic method, associated anomalies, site of perforation, length of perforation, type of surgical procedure, and postoperative complications.

Statistical analyses

Statistical analyses were performed using SPSS 19.0 software for Windows (IBM Inc., Armonk, NY, United States). Descriptive data are reported as percentage of patients or as mean (range). The χ² test was used to identify possible prognostic factors.
which was ultimately diagnosed as diaphragmatic eventration. Gastric perforation was also found intraoperatively. Patient C initially presented with dyspnea and was intubated at birth. At 3 d of age, the patient exhibited hematemesis and severe abdominal distension. Paracentesis revealed bloody ascites, and explorative surgery was performed 2 d after the onset of symptoms. All of the patients, except for Patients B and C, underwent surgery within 24 h of the onset of symptoms. The mean age of symptom onset was 3 d (range, 0.5-5 d). Five patients had associated anomalies, which included diaphragmatic eventration, congenital diaphragmatic hernia, esophageal atresia with a tracheoesophageal fistula, and antral web.

The intraoperative and postoperative findings are summarized in Table 3. The mean size of the perforation was 4.5 cm (0.5-10 cm). The body (n = 5, 55.5%) of the stomach was the most common site of perforation. The perforation was located in the greater curvature in four patients and in the lesser curvature in three patients. Primary repair was performed in six patients, while resection and anastomosis were performed in three patients. Postoperative complications occurred in five patients (55.6%), which included wound problems in two patients and recurrence in one patient. The other four patients were discharged without any complications.

Patient H, who had recurrence, was male and was born at a gestational age of 24 wk with a birth weight of 730 g. He presented with pneumoperitoneum on infantogram and underwent surgery at 5 d old. A 5 cm long laceration on the lesser curvature and pyloric thickening were found during explorative surgery. Therefore, primary repair was done. However, the postoperative infanto-gram and sonogram revealed an increase in free air. Small bowel series suggested obstruction of the gastric outlet. Three days after initial surgery, the patient underwent a second operation that revealed another perforation of the upper body of the anterior wall and prepyloric antral web. Primary repair and Heineke-Mikulicz pyloroplasty were performed, and an ileostomy was formed because of enteritis of the entire small bowel. Ileostomy repair was done 3 mo after surgery.

The overall mortality rate was 22.2% (2/9). Patient B was born at a gestational age of 40 wk and the birth weight was 2950 g. The patient was diagnosed with Bochdalek hernia at another hospital and was transferred to our institute for surgery. On surgical exploration, the anterior portion of the diaphragm was eventrated, and a 2.5 cm long laceration was found in the posterior wall of the stomach. Diaphragm repair and primary suturing of the stomach were done. The patient died 5 d after surgery because of septic shock. Patient C was born at a gestational age of 35 wk and with a birth weight of 2190 g. Hematemesis and hematochezia were found at 3 d of age. The patient received conservative therapies, including transfusion for 24 h. Diagnostic paracentesis performed at 4 d of age revealed bloody ascites. Explorative laparotomy was done to evaluate the patient’s hemoperitoneum and gastrointestinal bleeding. On exploration, a 10 cm long laceration with a necrotic margin was found on the greater curvature of the stomach, and primary repair was performed. Fifteen days later, the patient suffered from abrupt onset of abdominal distension and vomiting, and an erythematous discoloration was found on the left flank. Necrotizing enterocolitis was suspected based on infantogram, and the patient underwent surgery to repair multiple small bowel perforations. Gross fecal spillage into the abdominal cavity and multiple perforations of the small bowel were found, and approximately 20 cm of the ileum was resected. Despite intensive postoperative care, the patient’s septic condition, hepatic dysfunction, and renal dysfunction resulted in death 29 d after the second surgery.

When we performed analyses to identify factors associated with survival, the time between symptoms and surgical intervention was the only prognostic factor for survival (P < 0.05) (Table 4). However, factors that appeared to show some association with survival included the presence of pneumoperitoneum on preoperative imaging (P = 0.083) and the year of birth (P = 0.083). Prematurity and birth weight were not associated with survival (P = 1.000 for both).

### DISCUSSION

Since Herbut first suggested that the congenital absence of muscular structures of the stomach may result in perforation, multiple theories have been proposed to describe the etiology of NGP. High gastric acid produc-

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**Table 3 Intraoperative and postoperative outcomes**

| Patient | Surgical procedure | Perforated site | Length (cm) | NEC | Complications | Hospital stay (d) | Survival |
|---------|-------------------|----------------|-------------|-----|---------------|------------------|----------|
| A       | RA                | Body, LC, PW   | 4           | Yes | Wound problem | 18               | Alive    |
| B       | RA                | Body, PW       | 2.5         | No  | Sepsis        | 4                | Deceased |
| C       | Primary repair    | Whole, GC      | 10          | Yes | Sepsis        | 46               | Deceased |
| D       | Primary repair    | Whole, GC      | 10          | No  |               | 11               | Alive    |
| E       | RA                | Body, GC       | 5           | Yes |               | 28               | Alive    |
| F       | Primary repair    | LC             | 3           | No  |               | 40               | Alive    |
| G       | Primary repair    | Body, GC       | 1           | No  |               | 24               | Alive    |
| H       | Primary repair    | (1) LC (2) body, AW | 5     | No  |               | 131              | Alive    |
| I       | Primary repair    | Antrum, AW     | 0.5         | No  | Wound problem | 11               | Alive    |

NEC: Necrotizing enterocolitis; RA: Resection and anastomosis; LC: Lesser curvature; PW: Posterior wall; GC: Greater curvature; AW: Anterior wall.
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| Table 4 Prognostic factor analysis |  |
|-----------------------------------|--|
| Survival (n = 7) Deceased (n = 2) | P-value |
| Male | 4 | 1 | 1.000 |
| Birth before 1990 | 1 | 2 | 0.083 |
| Birth before 2000 | 3 | 2 | 0.444 |
| Preterm | 2 | 1 | 1.000 |
| BW < 2500 g | 2 | 1 | 1.000 |
| pH < 7.30 | 3 | 2 | 1.000 |
| NG tube | 5 | 4 | 1.000 |
| Diet | 5 | 5 | 0.500 |
| Ventilator | 3 | 1 | 1.000 |
| O2 therapy | 3 | 3 | 0.464 |
| Pneumoperitoneum | 6 | 4 | 0.083 |
| Associated anomaly | 5 | 1 | 1.000 |
| Time from symptom onset to surgery > 24 h | 0 | 2 | < 0.001 |
| Length > 2 cm | 5 | 2 | 1.000 |
| Primary repair | 5 | 1 | 1.000 |
| NEC | 2 | 1 | 1.000 |

BW: Body weight; NG: Nasogastric; NEC: Necrotizing enterocolitis.

In conclusion, early detection and prompt surgical intervention are essential to improve the outcomes of infants with NGP. The survival outcomes of preterm

paining disorders, especially disorders that may increase intragastric pressure. Although the greater curvature is thought to be the most common site of perforation\[6,20], the distribution of perforation sites was fairly even.

Factors predicting the survival of NGP have not been extensively examined. Lin et al\[8] reported that the mortality rate was significantly higher in premature infants and in those with a low birth weight. Chung et al\[9] reported that male gender and metabolic acidosis (pH < 7.5) were associated with poor prognosis. In the present patients, prematurity was not associated with survival; of three premature patients, only one died (because of septic shock) and the \( \chi^2 \) test yielded a \( P \)-value of 1.000. Likewise, low birth weight was not associated with survival. There were two LBW and one ELBW patient, and only one LBW patient died. Furthermore, male gender was not associated with survival. There were five boys and four girls, and gender was not associated with survival. Five patients had preoperative metabolic acidosis, of whom two died because of postoperative septic shock. In both of these patients, the preoperative serum pH was < 7.30, but the association between preoperative pH and survival was not significant.

The time between symptoms and surgical intervention was the only prognostic factor for survival, with a \( P \)-value of < 0.05. However, because the study group was small, involving just nine patients, there is the possibility of type II error. We considered the \( P \)-value as a factor of relativity and extended its interpretation criteria. Even though several other factors were not statistically significant, they may be clinically relevant in terms of survival outcomes. The factor with the lowest \( P \)-value was the year of birth. Of note, two of three patients born before 1990 died. There is a great difference between the clinical and mechanical environments of the neonatal intensive care unit in the 1980s compared with those today. It is likely that clinical and technical developments in pre- and postoperative intensive care have improved the survival outcome of NGP patients. Another factor with a low \( P \)-value was preoperative pneumoperitoneum on plain X-ray. Notably, two of three patients who did not undergo preoperative infantography died. Had intestinal perforation been detected or suspected based on preoperative radiographs, earlier intervention may have been possible, increasing the likelihood of survival. Interestingly, all three patients who did not undergo infantography were treated before 1990. Thus, the lack of a diagnostic protocol and diagnostic tools probably contributed to the poor prognosis before 1990 in particular.

Limitations of our paper are that it was performed retrospectively and the number of patients was too small to achieve statistical significance. However, NGP is extremely rare and very few cases have been reported to date. Therefore, our findings should help clinicians and surgeons with their decisions.

In conclusion, early detection and prompt surgical intervention are essential to improve the outcomes of infants with NGP. The survival outcomes of preterm...
infants or LBW infants were not inferior to those of other patients. NGP can accompany other significant anomalies. Therefore, careful examination of the patient, together with imaging studies, may lead to early detection and improve the outcomes of NGP.

**COMMENTS**

**Background**

Neonatal gastric perforation (NGP) is a very rare but life-threatening disease.

**Research frontiers**

Because of its rarity, the etiology and prognostic factors of NGP are debated.

**Innovations and breakthroughs**

The time between symptoms and surgical intervention was the only prognostic factor for survival; premature birth and birth weight were not associated with the survival of patients with NGP.

**Applications**

Early detection and advances in neonatal intensive care may improve the prognosis of NGP.

**Terminology**

NGP: Neonatal gastric perforation; LBW: Low birth weight; ELBW: Extremely low birth weight.

**Peer review**

This is an important case series to publish as it deals with a rare but important neonatal emergent disorder. The abstract, introduction, methods and results are all well written.

**REFERENCES**

1. St-VII D, LeBouthillier G, Luks FI, Bensoussan AL, Blanchard H, Youssf S. Neonatal gastrointestinal perforations. J Pediatr Surg 1992; 27: 1340-1342 [PMID: 1403517 DOI: 10.1016/0022-3468(92)90292-4]
2. Rosser SB, Clark CH, Elechi EN. Spontaneous neonatal gastric perforation. J Pediatr Surg 1982; 17: 390-394 [PMID: 7120006 DOI: 10.1016/s0022-3468(82)80496-x]
3. Holgersen LO. The etiology of spontaneous gastric perforation of the newborn: a reevaluation. J Pediatr Surg 1981; 16: 608-613 [PMID: 7277163 DOI: 10.1016/0022-3468(81)9014-2]
4. Tan CE, Ikely EM, Agrawal M, Berreton RJ, Spitz L. Neonatal gastrointestinal perforation. J Pediatr Surg 1989; 24: 888-892 [PMID: 2674391 DOI: 10.1016/s0022-3468(89)80589-5]
5. Kara CS, Ileç, Z, Celayir S, Sarimurat N, Erdogan E, Yeker D. Neonatal gastric perforation: review of 23 years' experience. Surg Today 2004; 34: 243-245 [PMID: 14999537 DOI: 10.1007/s00595-003-2675-3]
6. Leone RJ, Krasna IH. ‘Spontaneous’ neonatal gastric perforation: is it really spontaneous? J Pediatr Surg 2000; 35: 1066-1069 [PMID: 10917298 DOI: 10.1016/j.pedsurg.2000.07.0773]
7. Jawad AJ, Al-Rabie A, Hadi A, Al-Sowaimel A, Al-Rawaf A, Abu-Touk B, Al-Karfi T, Al-Sammarai A. Spontaneous neonatal gastric perforation. Pediatr Surg Int 2002; 18: 396-399 [PMID: 12415364 DOI: 10.1007/s00383-002-0749-8]
8. Chung MT, Kuo CY, Wang JW, Hsieh WS, Huang CB, Lin JN. Gastric perforation in the neonate: clinical analysis of 12 cases. Zhonghua Min Guo Xueyi Xueyuan Za Zhi 1994; 35: 460-465 [PMID: 7942035 DOI: 10.1002/ccd.20116]
9. Lin CM, Lee HC, Kao HA, Hung HY, Hsu CH, Yeung CY, Sheu JC, Wang NL. Neonatal gastric perforation: report of 15 cases and review of the literature. Pediatr Neonatol 2008; 49: 65-70 [PMID: 18947001 DOI: 10.1016/s1875-9572(08)60015-7]
10. Herbut PA. Congenital defect in musculature of stomach with rupture in newborn Infant. Arch Pathol 1943; 36: 91
11. Kiesewetter WB. Spontaneous rupture of the stomach in the newborn. AMA J Dis Child 1956; 91: 162-167 [PMID: 13282628 DOI: 10.1001/archpedi.1956.0260020164013]
12. Arnold GG. Perforation of the stomach in the neonatal period; report of a survival in a premature infant. J Pediatr 1955; 46: 276-279 [PMID: 14354581 DOI: 10.1016/s0022-3467(55)80281-8]
13. Touloukian RJ, Posch JN, Spencer R. The pathogenesis of ischemic gastroenterocolitis of the neonate: selective gut mucosal ischemia in asphyxiated neonatal piglets. J Pediatr Surg 1972; 7: 194-205 [PMID: 5023196 DOI: 10.1016/s0022-3468(72)90496-4]
14. Houck WS, Griffin JA. Spontaneous linear tears of the stomach in the newborn infant. Ann Surg 1981; 193: 763-768 [PMID: 7247521 DOI: 10.1097/00000658-198106000-00012]
15. Ohshiro K, Yamataka A, Kobayashi H, Hirai S, Miyahara K, Sueyoshi N, Suda K, Miyano T. Idiopathic gastric perforation in neonates and abnormal distribution of intestinal pacemaker cells. J Pediatr Surg 2000; 35: 673-676 [PMID: 10813320 DOI: 10.1053/j.peds.2000.5940]
16. Yamataka A, Yamataka T, Kobayashi H, Sueyoshi N, Miyano T. Lack of C-KIT+ mast cells and the development of idiopathic gastric perforation in neonates. J Pediatr Surg 1999; 34: 34-37; discussion 37-38 [PMID: 10022139 DOI: 10.1016/s0022-3468(99)90224-5]
17. Touloukian RJ. Gastric ischemia: the primary factor in neonatal perforation. Clin Pediatr (Phila) 1973; 12: 219-225 [PMID: 4701092]
18. Meyer JL. Congenital defect in the musculature of the stomach resulting in spontaneous gastric perforation in the neonatal period; a report of two cases. J Pediatr 1957; 51: 416-421 [PMID: 13476323 DOI: 10.1016/s0022-3467(57)80126-7]
19. Amadeo JH, Ashmore HW, Aponte GE. Neonatal gastric perforation caused by congenital defects of the gastric musculature. Surgery 1960; 47: 1010-1017 [PMID: 13793066]
20. Shaw A, Blanc WA, Santulli TV, Kiser G. Spontaneous rupture of the stomach in the newborn: A clinical and experimental study. Surgery 1965; 58: 561-571 [PMID: 14338551]
21. Gryboski JD. The swirling mechanism of the neonate. i. esophageal and gastric motility. Pediatrics 1965; 35: 445-452 [PMID: 14260304]
22. Jones TB, Kirchner SG, Lee FA, Heller RM. Stomach rupture associated with esophageal atresia, tracheoesophageal fistula, and ventilatory assistance. AJR Am J Roentgenol 1980; 134: 675-677 [PMID: 6672350 DOI: 10.2243/ajr.134.4.675]
23. Saracil T, Mann M, French DM, Booker CR, Scott RB. Rupture of the stomach in the newborn infant. Report of three cases and review of the world literature. Clin Pediatr (Phila) 1967; 6: 583-588 [PMID: 6077501 DOI: 10.1177/0009922867060104]
24. Bruce J, Bianchi A, Doig CM. Gastric perforation in the neonates. Pediatr Surg Int 1993; 8: 17-19 [DOI: 10.1007/bf02352993]
25. Young AE, Sury MR. Spontaneous neonatal gastric perforation. Paediatr Anaesth 1996; 6: 143-145 [PMID: 8846280 DOI: 10.1111/j.1460-9592.1996.tb00378.x]
26. Hood JH. Clinical considerations of intestinal gas. Ann Surg 1966; 163: 359-366 [PMID: 5907560 DOI: 10.1097/00000658-196608000-00006]

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