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Gastrointestinal Conditions

Enhanced recovery after surgery for the treatment of congenital duodenal obstruction☆,☆☆

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ABSTRACT

Background: Enhanced recovery after surgery (ERAS) has been widely used in adult surgery. However, ERAS has not been reported in neonatal surgery. The present prospective study explored the application value of ERAS in treating congenital duodenal obstruction (CDO).
Methods: A total of 68 cases of CDO were collected from October 1, 2017 to July 31, 2019. We divided patients with a prenatal diagnosis of congenital duodenal obstruction into the ERAS group and those who were diagnosed the disease after birth into the control group. The ERAS group adopted ERAS-related measures, and the control group followed the usual measures. The study compared the differences in the gestational age, birth weight, length of hospital stay (LOS), complications, feeding intolerance, and weight one month after surgery between the two groups.
Results: A total of 49 patients were included in the analysis, including 23 who were allocated to the ERAS group and 26 to the control group. The LOS was 9.696 ± 1.222 days in the ERAS group and 12.654 ± 1.686 days in the control group, resulting in a significantly shorter LOS in the ERAS group than in the control group ($p<0.001$). One month after surgery, the neonates in the ERAS group weighted significantly more than those in the control group. No differences were observed in birth weight, gestational age, and the incidence of complications or feeding intolerance between the two groups.
Conclusion: In this single-center study, the implementation of neonate-specific ERAS for CDO surgery was feasible and safe and led to a shorter LOS without increasing the incidence of complications or feeding intolerance.
Type of study: Treatment Study
Level of evidence: Level III

The enhanced recovery after surgery (ERAS) approach refers to a series of measures to reduce the response to psychological and physical traumatic stress in patients to achieve rapid recovery and reduce medical costs [1]. ERAS has been accepted by adult surgeons, and the application of ERAS in pediatric surgery is gradually expanding. An increasing number of pediatric surgical teams are exploring the ERAS approach for children [2]. However, there have been no reports of ERAS for newborns.

Congenital duodenal obstruction (CDO) is one of the most common digestive malformations in newborns, and surgery is the only treatment. At present, only large children's hospitals in China can perform this operation. Newborns with CDO are transferred to large children's hospitals for surgery within a few days after birth, and some may develop electrolyte disorders, severe infections and even shock [3]. Some hospitals are unable to perform laparoscopic surgery, and excessive anesthesia in newborns causes serious trauma and stress to the newborn. Ignoring the management of neonatal pain and long-term fasting after the operation is not conducive to the recovery of newborns. Therefore, we designed a prospective study to explore the effects of ERAS on the treatment of newborns with CDO.

1. Methods

1.1. Patients and ethical consideration

This study was reviewed by the Ethics Committee of the Guangdong Women and Children Hospital. A total of 68 cases of CDO were collected

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from the Guangdong Women and Children Hospital Neonatal Surgery Department from October 1, 2017 to July 31, 2019. All surgeries were performed by laparoscopy, and a doctor with more than three years of experience in laparoscopic surgery served as the surgeon.

1.2. Study design

This study is a prospective non-randomized controlled study. All cases were strictly selected the inclusion and exclusion criteria.

Inclusion criteria:

The prenatal B-mode ultrasound or postnatal plain film of the abdomen (KUB) showed a double-bubble sign in the abdomen.

Exclusion criteria:

1. The presence of other serious diseases that could affect recovery;
2. The presence of genetic metabolic diseases and chromosomal abnormalities;
3. Gestational age <35 weeks;
4. Birth weight <2.5 kg;
5. Congenital intestinal malrotation.

We have found that prenatal diagnosis is critical to the implementation of ERAS. We classified patients with a double-bubble sign in the abdomen during prenatal fetal B-mode ultrasound into the ERAS group, and those with a double-bubble sign on a postnatal KUB who did not undergo fetal B-mode ultrasound or who had no double-bubble sign during the prenatal B-mode ultrasound were included in the control group.

The ERAS group adopted ERAS-related measures, and the control group followed the usual measures (Table 1).

ERAS-related parent education was provided after prenatal diagnosis and before birth.

The ERAS group was transferred to the neonatal surgery ward immediately after birth and immediately underwent abdominal X-ray, upper gastrointestinal radiography and gastroduodenal B-mode ultrasound to further confirm the diagnosis. This group underwent laparoscopic surgery at 1 day after birth. The newborns underwent ERAS-related anesthesia management during surgery, and resuscitation was performed in the operating room after surgery. The patients were returned to the ward after successful resuscitation. On the first day after surgery, the newborns began feeding with a small amount of 5% glucose water (GS); then, the next day, the newborns began feeding with a small amount of milk, gradually increasing the amount of milk per day. If all went well, the newborn would be discharged from the hospital on the eighth day after the operation.

The patients in the control group were admitted to the hospital after the appearance of bloating and vomiting and were then transferred to the neonatal surgery ward. The newborns were operated on approximately 2–7 days after birth. Some newborns might develop dehydration, infections, electrolyte disorders, and even shock. The newborns were under usual anesthesia management during surgery. They were transferred to the neonatal intensive care unit (NICU) with tracheal intubation immediately after surgery. Ventilator-assisted ventilation was usually required for approximately 2-8 hours in the NICU. After the operation, the patient fasted for 5 days. On the sixth day, a small amount of 5% GS was given, and the amount was gradually increased. The patient would be discharged approximately 10 days after surgery.

1.3. Data collection and statistical analysis

The study compared the differences in gestational age, birth weight, length of hospital stays (LOS), complications, feeding intolerance, and weight one month after surgery. Data were collected and stored through an internal hospital database. The weight one month after surgery was collected through a telephone follow-up. Statistical analyses were performed using SPSS 22.0, and the data were analyzed according to the per protocol principle. A Mann-Whitney U test was used to compare gestational age, birth weight, and LOS; a *t*-test was used to compare weight one month after surgery; and a χ^2 test was performed to compare complications and feeding intolerance.

Table 1
ERAS-related measures and usual measures.

Group	ERAS group	Control group
Preoperative	Prenatal diagnosis ERAS related parent education Transfer to the neonatal surgery ward immediately after birth	Postpartum diagnosis No parent education Go to hospital after the appearance of bloating and vomiting, then transfer to the neonatal surgery ward
Intraoperative	1 day after birth Laparoscopic duodenal anastomosis With tracheal intubation and caudal anesthesia and maintain sevoflurane until 10 minutes before surgery	About 2–7 days after birth Laparoscopic duodenal anastomosis With tracheal intubation and intermittent addition of muscle relaxants and sufentanil and maintain sevoflurane until the end of the operation
	Resuscitation in the operating room after surgery and return to the ward after successful resuscitation	Sent to the NICU with tracheal intubations immediately after surgery
Postoperative	Day 1: 2 ml.kg^{-1} 5% GS nasal feeding at 2 ml.kg^{-1}/h every 3 hours	Day 1-5: fasting
	Day 2: 2 ml.kg^{-1} proteolytic milk nasal feeding at 2 ml.kg^{-1}/h every 3 hours	Day 6: 5% GS oral feeding 2 ml. kg-^{1} every 3 hours
	Day 3: 4 ml.kg^{-1} proteolytic milk nasal feeding at 4 ml.kg^{-1}/h every 3 hours	Day 7: formula milk oral feeding 4 ml.kg-^{1} every 3 hours
	Day 4: 6 ml.kg^{-1} proteolytic milk nasal feeding at 6 ml.kg^{-1}/h every 3 hours	Day 8: formula milk oral feeding 8 ml.kg-^{1} every 3 hours
	Day 5: 8 ml.kg^{-1} proteolytic milk nasal feeding at 8 ml.kg^{-1}/h every 3 hours	Day 9: formula milk oral feeding 12 ml.kg-^{1} every 3 hours
	Day 6: 10 ml.kg^{-1} proteolytic milk nasal feeding at 10 ml.kg^{-1}/h every 3 hours	Day 10: discharge from hospital
	Day 7: 10 ml.kg^{-1} proteolytic milk oral feeding every 3 hours	
	Day 8: discharge from hospital	

ERAS-enhanced recovery after surgery
GS-glucose water

1.4. Outcomes

A total of 68 patients who were diagnosed with CDO from October 2017 to July 2019 were enrolled. Among these patients, 19 patients were excluded, 23 patients were assigned to the ERAS group, and 26 patients were assigned to the control group (Fig. 1) (Table 2). All patients were followed until 1 month after the operation.

The gestational age was 38.300 ± 1.869 weeks in the ERAS group and 37.620 ± 1.627 weeks in the control group. No significant differences were found in gestational age between the two groups ($p = 0.143$). The birth weight was 3.040 ± 0.435 kg in the ERAS group and 2.891 ± 0.387 kg in the control group. No significant differences were found in birth weight between the two groups ($p = 0.202$). The LOS was 9.696 ± 1.222 days in the ERAS group and 12.654 ± 1.686 days in the control group, resulting in a significantly shorter LOS in the ERAS group than in the control group ($p < 0.001$), which was mainly because newborns in the ERAS group stopped fasting earlier after surgery. One month after surgery, the weight of the newborns in the ERAS group was 4.627 ± 0.616 kg and that in the control group was 4.306 ± 0.482 kg. The newborns in the ERAS group gained weight

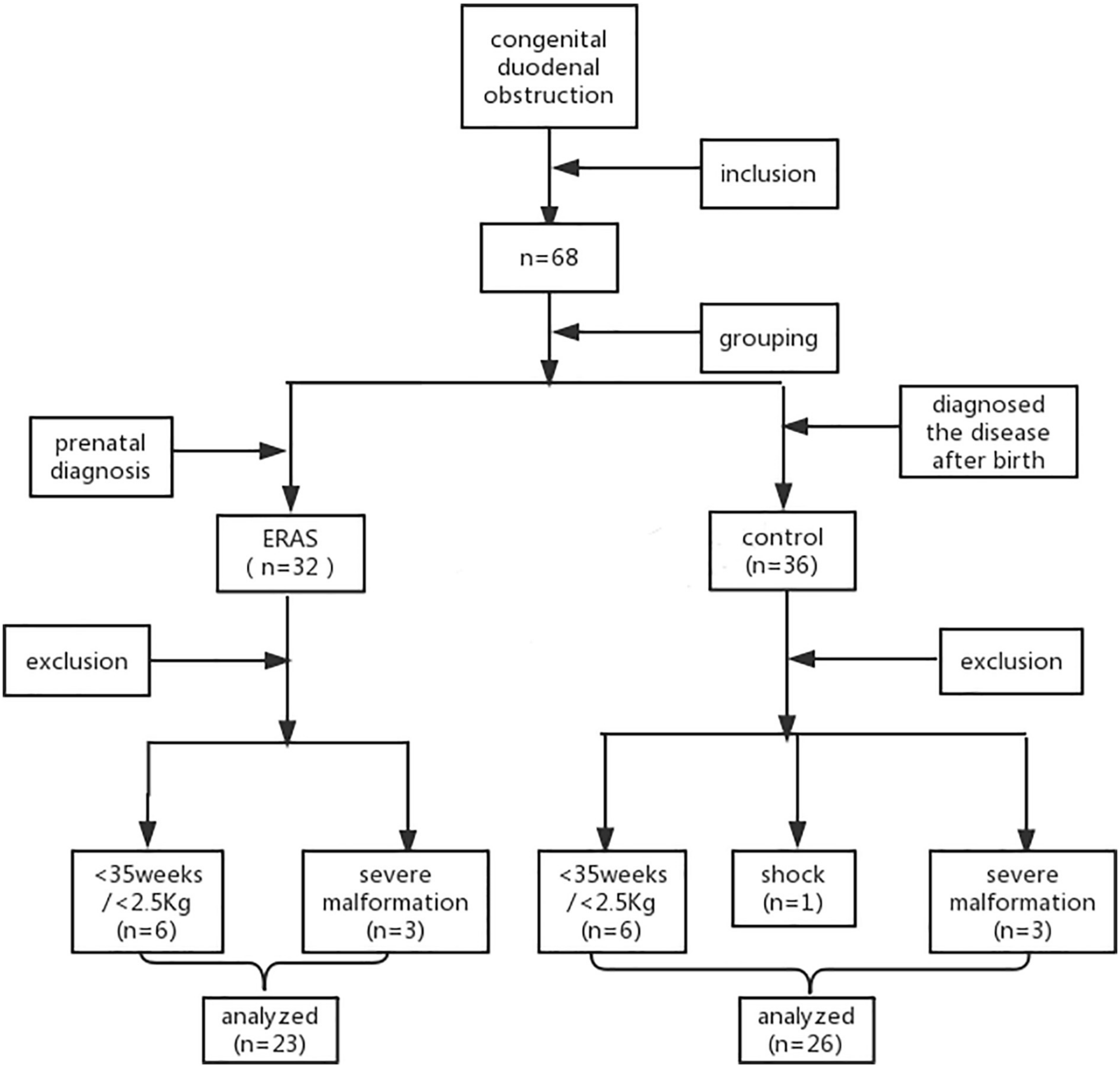

Fig. 1. Screening flow chart of this study.

faster than those in the control group one month after the operation (($p=0.047$) (Table 3).

Except for feeding intolerance, one patient developed a complication of enteritis in the ERAS group that led to a prolonged LOS. In the control group, two patients developed sepsis after surgery, and one patient developed pneumonia, thus prolonging the LOS. There was no statistically significant difference in the incidence of complications between the two groups ($p=0.693$). Seven patients in the ERAS group had feeding intolerance, and 5 patients in the control group had feeding intolerance. No significant differences were found in feeding intolerance between the two groups ($p=0.363$) (Table 3).

2. Discussion

Current research on ERAS focuses on fields related to adult surgery. However, progress in the field of pediatric surgery is slow [4]. All ERAS studies in pediatric surgery currently exclude neonatal surgery patients. Because of their incomplete development, neonates are significantly

Table 2
General information of the patients.

ERAS (n=32)		Control (n=36)	
Inclusion (n=23)	Exclusion (n=9)	Inclusion (n=26)	Exclusion (n=10)
Duodenal atresia (n=9)	Gestational age <35 weeks or birth weight <2.5kg (n=6)	Duodenal atresia (n=9)	Gestational age <35 weeks or birth weight< 2.5kg (n=6)
Duodenal stenosis (n=1)	Shock (n=0)	Duodenal stenosis (n=2)	Shock (n=1)
Duodenal septum (n=6)	With jejunal atresia (n=1)	Duodenal septum (n=6)	With severe ventricular septal defect (n=1)
Annular pancreas (n=7)	With congenital intestinal malrotation (n=1)	Annular pancreas (n=9)	With trisomy 21 syndrome (n=1)
	With esophageal atresia (n=1)		With anal atresia (n=1)

Table 3
Gestational age, birth weight, LOS and weight one month after surgery, complications and feeding intolerance in the two groups.

	ERAS	Control	p
Gestational age (weeks)	38.300 ± 1.869	37.620 ± 1.627	0.143
Birth weight (kg)	3.040 ± 0.435	2.891 ± 0.387	0.202
LOS (days)	9.696 ± 1.222	12.654 ± 1.686	<0.001
Weight 1 month after surgery	4.627 ± 0.616	4.306 ± 0.482	0.047
Complications	1	3	0.693
Feeding intolerance	7	5	0.363

Data are presented as the mean and standard deviation. $p<0.05$ indicated a significant difference between the 2 groups.
ERAS, enhanced recovery after surgery.
LOS, length of hospital stay.

different from children in terms of anatomy, physiology, and pharmacology [5].

The tolerance of neonates to anesthesia and surgical trauma is significantly lower than that of children. Neonatal surgery is usually associated with more complications and perioperative stress, and the damage caused by the stress response to traditional perioperative treatment is also more serious for neonates than for children. With the advancements in neonatal laparoscopic surgery techniques, neonatal anesthesia techniques, and neonatal care, we have seen the use of ERAS in neonatal surgery. In this study, the application of ERAS for neonatal CDO can effectively reduce the level of surgical trauma and stress responses, thereby accelerating recovery, reducing the LOS, and reducing the incidence of complications. ERAS requires the consideration of a multitude of factors. Rather than focusing on a single intervention, ERAS improves outcomes through multiple, incremental steps that act synergistically throughout the entire surgical journey (preoperative, perioperative, and postoperative phases of care) [1].

CDO is one of the most common diseases that requires neonatal surgery, and most of these patients can be diagnosed before delivery. CDO appears as a double-bubble sign in the abdomen of the fetus during the prenatal B-mode ultrasound. Newborns who are prenatally diagnosed with CDO are transferred to neonatal surgery for treatment on the first day after birth. Newborns with an unclear prenatal diagnosis often vomit after feeding and then go to the hospital for treatment [6]. A delay in the diagnosis of CDO can lead to dehydration, acid-base disorders, weight loss, and even shock, all of which are conditions that could compromise the newborn during the postoperative period and possibly increase the incidence of complications and mortality [7]. Before surgery, infections need to be controlled, and water and electrolyte disorders need to be corrected since these conditions will affect the treatment and postoperative recovery of the newborn. Therefore, we believe that prenatal diagnosis is one of the important measures for managing CDO with ERAS in neonates.

The development of laparoscopic surgery has significantly decreased the surgical trauma of CDO compared with traditional open surgery, and this effect has been confirmed by many studies [8,9]. ERAS requires the depth of anesthesia to be reduced as much as possible and requires rapid recovery after surgery, which is a substantial challenge for neonatal anesthesia [2]. To ensure the safety of the surgical procedure, a standardized anesthesia program should be adopted to control the dose of the anesthetic drugs as closely as possible so that the patient can wake up from anesthesia as soon as possible after surgery and return to the ward after recovering in the operating room [10,11]. The setup of the operating room should be suitable for newborns, such as the temperature of the room, and the operating room available equipment should be suitable for neonatal use [12]. Fortunately, many neonatal surgeons are beginning to realize the importance of these measures and are gradually creating an operating room environment that is more suitable for newborns [13,14]. The incidence of intestinal fistula after congenital duodenal surgery is low, and there is no need to place an abdominal drainage tube after surgery [15]. In the past three years, no cases of intestinal fistula complications occurred after any procedures to treat CDO in our hospital. Tracheal intubation should be indwelled during the operation but can be removed as soon as the patient recovers from anesthesia. Early after the operation, the newborns need to be fed through the orogastric tube; therefore, this tube needs to be retained after surgery [16].

The changes to the fasting concept and nutritional support strategy are some of the earliest measures proposed by ERAS. Almost all ERAS studies have measures related to early postoperative feeding. Long-term fasting can lead to increased discomfort associated with thirst and hunger [17,18]. Additionally, long-term fasting may delay postoperative recovery and wound healing, impair immune function and increase the likelihood of infection and risk for energy deficiency [19]. Early feeding in small amounts can actually maintain intestinal nutrient absorption and strengthen bowel movements [20,21]. Early feeding after congenital duodenal surgery has been reported but was achieved through a jejunal feeding tube that crosses the duodenal anastomosis [22]. This study started feeding with micro-nasal feeding through the stomach tube within 24 hours, which is more in line with the physiological function of the gastrointestinal tract.

Our study demonstrates the earliest application of ERAS in neonatal surgery, although there are still many deficiencies. In this study, despite the limited ERAS measures, neonates achieved good results by these measures, including a shorter time of hospitalization, lower hospitalization costs and greater weight gain one month after the operation, without an elevated surgical risk or increased incidence of postoperative complications. The results of this study show that the application of ERAS is safe and effective for CDO.

2.1. Limitations

This study had some limitations. The ERAS measures included were limited, and further research is needed in the future. In addition to the ERAS measures taken in this study, some measures are still worth promoting and investigating in further research. Analgesia after surgery can effectively reduce the anxiety caused by postoperative pain and other discomforts and can include drug analgesia and medical staff comfort [10]. In addition, research on the involvement of parents in newborn care has shown that parents can increase the pleasure of newborns and promote recovery [23]. Newborns with CDO often have infections, and the use of antibiotics is necessary, but long-term antibiotic use can easily affect liver function, kidney function and the distribution of intestinal flora, leading to indigestion and other symptoms [24,25]. The best approach to using antibiotics is also part of the application of ERAS for CDO.

3. Conclusion

In this single-center study, the implementation of neonate-specific ERAS in CDO surgery was feasible and safe and led to shorter LOS without increasing the incidence of complications or feeding intolerance. Further studies are needed to validate these findings and to provide guidance on how ERAS can be expanded in neonate surgery. We hope that more neonatal surgeons will conduct ERAS studies for neonatal surgery in the future to form a standardized approach for the application of ERAS in this field.

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