DOI: 10.4274/terh.galenos.2022.68335
J Tepecik Educ Res Hosp 2022;32(2):273-8

CLINICAL RESEARCH / KLİNİK ARAŞTIRMA

Evaluation of Risk Factors Affecting Metabolic Alkalosis in Infantile Hypertrophic Pyloric Stenosis

İnfantil Hipertrofik Pilor Stenozunda Metabolik Alkalozu Etkileyen Risk Faktörlerinin Değerlendirilmesi

Oktay Ulusoy[1], Efil Aydın[1], Ayşe Güneş Karakurt[2]

[1]Dokuz Eylül University Faculty of Medicine, Department of Pediatric Surgery, İzmir, Turkey
[2]Afyonkarahisar Government Hospital, Clinic of Pediatric Surgery, Afyonkarahisar, Turkey

Cite as: Ulusoy O, Aydın E, Güneş Karakurt A. Evaluation of Risk Factors Affecting Metabolic Alkalosis in Infantile Hypertrophic Pyloric Stenosis. J Tepecik Educ Res Hosp 2022;32(2):273-8

Abstract

Objective: The cardinal sign of infantile hypertrophic pyloric stenosis (IHPS) is projectile non-bilious vomiting, which may lead to severe dehydration, electrolyte imbalance, acid-base balance disorder as metabolic alkalosis, malnutrition, growth delay and retardation. We investigated the risk factors for developing metabolic alkalosis and the effectiveness of the operative procedures, i.e., open vs. laparoscopic pyloromyotomy.

Methods: The data of 30 infants with IHPS who were treated with Ramstedt's and laparoscopic pyloromyotomy between January 2014 and March 2022 were reviewed retrospectively. Demographic characteristics, blood chemistry, pyloric muscle thickness and length measurements by ultrasonography were recorded.

Results: Metabolic alkalosis was present in the first blood gas analysis in 20 (66.7%) of the cases. When the patients were evaluated in terms of metabolic alkalosis, no statistical difference was found regarding prenatal age, body weight, and length of stay. In patients with metabolic alkalosis, duration of symptoms was significantly long ($p<0.001$), serum lactate level ($p=0.016$) and chlorine level ($p=0.006$) were significantly high. Pyloric muscle thickness ($p=0.019$) and pyloric muscle length ($p=0.004$) measured using ultrasonography were significantly increased in the metabolic alkalosis group.

Conclusion: Metabolic alkalosis is an important parameter in determining the severity of the disease in IHPS. In the present study, it has been shown that length of symptom duration, increase in pyloric muscle thickness and muscle length, increase in serum lactate levels and low serum chloride levels are risk factors for developing metabolic alkalosis.

Keywords: Metabolic alkalosis, infantile hypertrophic pyloric stenosis, pyloromyotomy

Address for Correspondence/Yazışma Adresi: Oktay Ulusoy MD, Dokuz Eylül University Faculty of Medicine, Department of Pediatric Surgery, İzmir, Turkey
Phone: +90 232 412 30 01 **E-mail:** oktay.ulusoy@deu.edu.tr
ORCID ID: orcid.org/0000-0002-0992-8724

Received/Geliş tarihi: 28.04.2022
Accepted/Kabul tarihi: 03.05.2022

Öz

Amaç: İnfantil hipertrofik pilor stenozunun (İHPS) temel belirtisi, şiddetli dehidratasyon, elektrolit dengesizliği, metabolik alkaloz gibi asit-baz dengesi bozuklukları, malnütrisyon, büyüme gecikmesi ve retardasyona neden olabilen fışkırır şekilde safrasız kusmadır. Bu çalışmada metabolik alkaloz gelişimi için risk faktörleri ile açık ve laparoskopik piloromyotomi prosedürlerinin etkinliğini araştırmayı amaçladık.

Yöntem: Ocak 2014-Mart 2022 tarihleri arasında İHPS nedeniyle Ramstedt's piloromiyotomi veya laparoskopik piloromyotomi uygulanan 30 hastanın verileri geriye dönük olarak incelendi. Hastaların demografik özellikleri, laboratuvar analizleri, ultrasonografi ile ölçülen pilor kas kalınlığı ve uzunluk ölçümleri kaydedildi.

Bulgular: Olguların 20'sinde (%66,7) ilk kan gazı analizinde metabolik alkaloz mevcuttu. Hastalar metabolik alkaloz açısından değerlendirildiğinde doğum öncesi yaş, vücut ağırlığı ve yatış süresi açısından istatistiksel olarak fark saptanmadı. Metabolik alkalozlu hastalarda semptom süresi anlamlı olarak uzundu (p<0,001), serum laktat düzeyi (p=0,016) ve klor düzeyi (p=0,006) anlamlı olarak yüksekti. Ultrasonografi ile ölçülen pilor kası kalınlığı (p=0,019) ve pilor kası uzunluğu (p=0,004) metabolik alkaloz grubunda anlamlı derecede artmıştı.

Sonuç: Metabolik alkaloz, İHPS'de hastalığın şiddetini belirlemede önemli ve hayati bir parametredir. Bu çalışmada semptom süresindeki uzunluğun, pilorik kas kalınlığında ve kas uzunluğundaki artışın, serum laktat düzeylerindeki artış ve düşük serum klorür düzeylerinin metabolik alkaloz gelişimi için risk faktörleri olduğu gösterilmiştir.

Anahtar Kelimeler: Metabolik alkaloz, infantil hipertrofik pilor stenozu, piloromyotomi

Introduction

Infantile hypertrophic pyloric stenosis (IHPS) is one of the common gastrointestinal disease in infants. IHPS is encountered four-fold more in male infants, the incidence is about 2-3.5 per 1000 live births[1,2]. Clinical presentations of IHPS frequently occur between postnatal 3-10 weeks[3] and the main known risk factors are prematurity and mother's first birth[4]. The cardinal sign of IHPS is projectile non-bilious vomiting, which may lead to severe dehydration, electrolyte imbalance, acid-base balance disorder as metabolic alkalosis, malnutrition, growth delay and retardation[5]. Associated anomalies with IHPS, including renal[6], urological[6] and cardiac[7] have been reported.

Pyloromyotomy is the gold standard surgical procedure for IHPS. The first described operative procedure is Ramstedt's pyloromyotomy. Ramstedt's pyloromyotomy is performed as an open surgery through a right upper quadrant transverse incision[8]. The aim of Ramstedt's pyloromyotomy is to incise the hypertrophic pyloric muscle seromuscularly in a longitudinal fashion and to separate the pyloric muscle wide enough to create pyloric mucosal bulging[8]. The minimal invasive alternative to open pyloromyotomy is laparoscopic pyloromyotomy, described by Alain et al.[9] in 1991. Although laparoscopic pyloromyotomy provides advantages such as better cosmetic results, earlier postoperative feeding time, and shorter recovery time, it may have disadvantages such as inadequate pyloromyotomy and technical difficulties[10,11]. Ramstedt's pyloromyotomy is preferred by 60% of the pediatric surgeons, while laparoscopic pyloromyotomy is preferred by 26%[12].

We investigated the risk factors for developing metabolic alkalosis and the effectiveness of the operative procedures, i.e., open vs. laparoscopic pyloromyotomy.

Materials and Methods

The data of 30 infants with IHPS who were treated with Ramstedt's and laparoscopic pyloromyotomy between January 2014 and March 2022 were retrospectively reviewed. Demographic characteristics, blood chemistry, pyloric muscle thickness and length measurements by ultrasonography were recorded. Operative, postoperative feeding and hospitalization times were reviewed. Patients with clinical signs suggesting IHPS but incompatible with diagnostic criteria were excluded from the study. The threshold pH limit for metabolic alkalosis has been determined as 7.45[13]. The ultrasonographic diagnostic criteria for IHPS have been determined as pyloric muscle length more than 16 mm, and unilateral pyloric muscle thickness >4 mm[14]. All patients underwent pyloromyotomy after adequate fluid resuscitation plus correction of electrolyte imbalance and blood gas parameters.

Open Ramstedt's pyloromyotomy was performed through a 3 to 4 cm longitudinal right upper transverse incision. Laparoscopic pyloromyotomy was conducted through a 5 mm umbilical camera port, another 3 mm right upper quadrant grasped port (Figure 1). Laparoscopic Benson's clamp was inserted through the left upper quadrant stab incision.

Pneumoperitoneum pressure was held within 6-8 mm High (carbon dioxide insufflation 1-2 L/min). Hypertrophic pyloric muscle was incised starting from the duodenal side of the pylorus, ending within the gastric muscles. The non-vascular area on the anterior wall of the pyloric tube was incised seromusculary in a longitudinal fashion using monopolar L-cautery. Then, the pyloric muscle was separated with laparoscopic Benson's clamp, and pyloric muscular separation was continued until the pyloric mucosal bulging was observed. Air (approximately 60 mL) was slowly injected from the nasogastric tube to create an artificial mucosal bulging and mucosa was checked for possible air leaks. After confirming that there was no bleeding or mucosal leak, port sites were sutured. Laparoscopic tools were removed, pneumoperitoneum was evacuated and skin incisions were closed layer-by-layer.

Oral intake was started within 4-8 hours after the operation, depending on the patient's ability to tolerate the feeding. In cases who could not tolerate feeding, feeding was interrupted for a while and then feeding was resumed with the same protocol. The first feeding was started with 5 mL of 5% dextrose solution, and the feeding volume was increased to 15 mL after 3 h, then it was increased to 15 mL every 3 h by switching to breast milk, and when feeding with 75 mL breast milk was reached, normal feeding was resumed.

Approval for the study was obtained from the decision of the Ethics Committee of Dokuz Eylül University Faculty of Medicine, dated March 23, 2022, and numbered 2022/11-02. Written informed consent was obtained from all patients included in the study.

Statistical Analysis

Statically Package for Social Sciences 22.0 (Chicago, Illinois) was used for static analysis. The data were expressed as mean±1 standard deviation. Chi-square test was used for qualitative variables; one-way ANOVA and paired t-tests were used to compare quantitative variables. P value of less than 0.05 was considered significant.

Results

Thirty patients were operated with a diagnosis of IHPS. Twenty-three (76.7%) of the patients were male and 7 patients (23.3%) were female. The mean age at surgery was 38.33±15.55 months, while the mean duration of symptoms was 9.03±4.42 days. There was a history of premature birth in 20% of the patients. An additional anomaly was present in 8 (26.6%) patients. All additional anomalies were of cardiac origin. The most common symptom was vomiting (100% of patients).

While metabolic alkalosis was present in the first blood gas analysis in 20 (66.7%) of the cases, the blood gas values of the other patients were within normal limits. In metabolic alkalosis was corrected with fluid and electrolyte replacement before the operation in all cases. The mean pH value was 7.47±0.06. When the patients were evaluated in terms of metabolic alkalosis, no statistical difference was found regarding prenatal age, body weight, and length of stay. In patients with metabolic alkalosis, duration of symptoms was significantly long (p<0.001), serum lactate level (p=0.016) and chlorine level (p=0.006) were significantly high (Table 1). Pyloric muscle thickness (p=0.019) and pyloric muscle length (p=0.004) measured using ultrasonography were significantly increased in the metabolic alkalosis group (Table 2).

While Ramstedt's pyloromyotomy was performed in 16 (53.3%) patients, laparoscopic pyloromyotomy was performed in 14 (46.7%) patients. The mean body weight, operation time, the time to start postoperative feeding and the time to discharge from the hospital are summarized in Table 3. The body weight of the patients who underwent

Table 1. Risk factors for the development of metabolic alkalosis in IHPS

	Patients without metabolic alkalosis (n=10)	Patients with metabolic alkalosis (n=20)	p value
Prenatal age	37.20±2.34	38.20±1.93	*0.211*
Body weight (g)	3805.00±815.96	3825.00±810.67	*0.280*
Length of stay (days)	6.00±1.82	5.40±1.04	*0.405*
Duration of symptoms (day)	5.30±2.05	10.90±4.10*	*<0.001*
Serum lactate level (mmol/L)	2.03±0.66	2.72±0.94*	*0.016*
Serum chlorine level (mmol/L)	103.10±4.35	96.75±5.06*	*0.006*

*Indicates statistical significance at the p<0.05 level.
IHPS: Infantile hypertrophic pyloric stenosis

Table 2. Evaluation of ultrasonographic pyloric muscle measurements in terms of metabolic alkalosis			
	Patients without metabolic alkalosis (n=10)	**Patients with metabolic alkalosis (n=20)**	**p value**
Pyloric muscle thickness (mm)	4.73±5.18	5.41±0.83*	*0.019*
Pyloric muscle length (mm)	17.80±3.17	22.25±3.33*	*0.004*
*Indicates statistical significance at the p<0.05 level.			

Table 3. Comparison of the pyloromyotomy procedures performed in IHPS			
	Ramstedt's pyloromyotomy (n=16)	**Laparoscopic pyloromyotomy (n=14)**	**p value**
Body weight (g)	3450.00±535.07	4162.00±881.20*	0.023
Operation times (minutes)	44.00±23.76	49.01±18.04	0.182
Postoperative feeding times (hour)	30.13±29.97	13.37±13.07*	0.033
Discharge (days)	3.13±2.16	2.40±0.91	0.546
*Indicates statistical significance at the p<0.05 level. IHPS: Infantile hypertrophic pyloric stenosis			

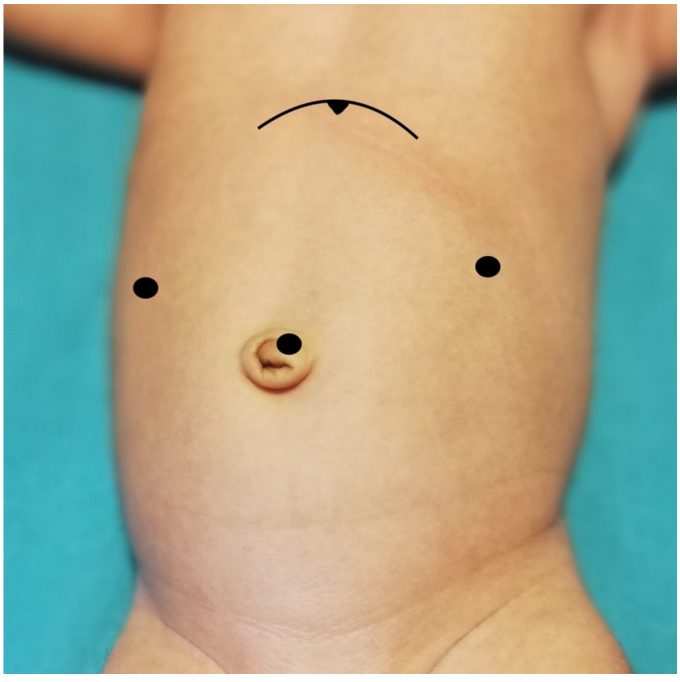

Figure 1. Port entry sites in laparoscopic pyloromyotomy

laparoscopic pyloromyotomy was significantly high (p=0.023). In laparoscopic pyloromyotomy, the time to start postoperative feeding was significantly short (p=0.033). The discharge time was shorter in laparoscopic pyloromyotomy, but no statistically significant difference was found. Eight patients with additional cardiac anomalies were treated with Ramstedt's pyloromyotomy. There were no per-operative and/or postoperative complications associated with cardiac anomaly in these patients.

In two patients who underwent Ramstedt's pyloromyotomy, perforation developed by opening the duodenal mucosa per-operatively. In these patients, perforation repair and pyloromyotomy from a different point were performed. No perioperative complications were observed in patients who underwent laparoscopic pyloromyotomy. The follow-up period was uneventful in all patients, no recurrent vomiting was observed. The growth and development (height and weight) of the two pyloromyotomy groups were normal.

Discussion

IHPS is basically characterized by mechanical gastric outlet obstruction and associated recurrent projectile non-bilious vomiting. Projectile vomiting causes loss of stomach contents such as hydrochloric acid, water and electrolytes, resulting in the development of severe dehydration and metabolic disorders. The progressive loss of gastric contents predisposes to the development of hypochloremic metabolic alkalosis. Metabolic alkalosis may cause respiratory distress before surgery[15], delay awakening from anesthesia after surgery and may trigger apnea during the postoperative follow-up[16]. Metabolic alkalosis has also been shown to reduce regional cerebral oxygenation in patients with IHPS[17]. Fluid replacement before surgery and correcting electrolyte imbalances are important to avoid aforementioned complications[18,19]. In the present study, projectile non-bilious vomiting was the main symptom in all patients. Metabolic alkalosis was present in 66.7% of the patients. In patients with metabolic alkalosis, while serum lactate and chlorine levels were significantly high, the duration of symptoms was significantly long. In studies evaluating

metabolic alkalosis and pyloric muscle characteristics, increased muscle thickness has been shown to be related to the development of metabolic alkalosis[5,20]. In the current study, both pyloric muscle thickness and pyloric muscle length were significantly increased. The data of the present study indicate that the prolongation of symptom duration, increased serum lactate level, low chlorine level, increase in pyloric muscle thickness and muscle length, as measured using ultrasonography, were risk factors for developing metabolic alkalosis. We consider that it is possible to avoid perioperative and postoperative complications with early and aggressive fluid and electrolyte replacement before surgery by determining the risk factors.

Pyloromyotomy is the gold standard treatment in the surgical treatment of IHPS. The most commonly used pyloromyotomy operations today are Ramstedt's and laparoscopic pyloromyotomy. Ramstedt's pyloromyotomy is an effective traditional method, but the skin incision is long, postoperative recovery is slow, the skin scar after healing is relatively large, and the cosmetic results may not be satisfactory[21,22]. Currently, laparoscopic pyloromyotomy has become increasingly popular and used all over the world[9-11,23,24], following the first description of the method[9]. However, open performed Ramstedt's pyloromyotomy is still the preferred operative method[12]. The main advantages of laparoscopy for treating IHPS are; providing magnification and clarity of the operation field, convenience in finding the anatomical localization of the pyloric muscle, enabling the performance of the operation solely in the abdominal cavity, the operation time is relatively short, and the skin incisions used are small[25]. The disadvantages of laparoscopy, especially in infants, are that the intra-abdominal working space is small, the carbon dioxide insufflation pressure cannot be increased much, the surgical instruments are smaller, and the laparoscopy has a certain learning curve for infants[26]. In the present study, when the two pyloromyotomy methods were compared, no statistically significant difference was found in terms of age, gender, hospital admission and operation times. Patients who underwent laparoscopic pyloromyotomy were fed significantly early after surgery. The postoperative hospital stay was shorter in the laparoscopic pyloromyotomy group, although it was not statistically significant. In the literature, there are similar rates for open and laparoscopic pyloromyotomy in terms of inadequate pyloromyotomy and mucosal perforation[27]. In the present series, perforation due to pyloric mucosal opening was observed in 2 cases who underwent Ramstedt's pyloromyotomy, while no complication was found in any case who underwent laparoscopic pyloromyotomy. Our study showed that laparoscopic pyloromyotomy has similar efficacy and safety compared with the traditional open operative method. The main advantages of laparoscopy are shorter postoperative feeding times, shorter hospital stay and small incisions. We believe that laparoscopic pyloromyotomy can be used effectively and safely for treating IHPS. The main reasons why we prefer Ramstedt's pyloromyotomy in patients with low body weight and cardiac anomalies are; the concern of reducing the morbidity caused by low birth weight and to promoting cardiac worsening induced by metabolic alkalosis. Prospective studies are needed to further evaluate the hemodynamic and metabolic effects of pneumoperitoneum in infants with low body weight and cardiac anomaly and to definitely clarify the indications and contraindications for laparoscopic surgery in this distinct group of patients.

Study Limitations

There were some limitations to our study. Firstly, the sample size is small, and secondly, it is retrospective and single-center study.

Conclusion

Metabolic alkalosis is an important parameter in determining the severity of the disease in IHPS. In the present study, it has been shown that length of symptom duration, increase in pyloric muscle thickness and muscle length, increase in serum lactate levels and low serum chloride levels are risk factors for developing metabolic alkalosis. It is important to provide effective fluid replacement and correct electrolyte imbalances before surgery to avoid morbidity that may be promoted by metabolic alkalosis.

Ramstedt's pyloromyotomy, which is the traditional operative method for treating IHPS, continues to be a preferred method in the presence of additional anomalies and in patients with low body weight. Laparoscopic pyloromyotomy has similar operative times, similar efficacy and safety to open surgery. Additionally, performing pyloromyotomy in the abdomen with smaller incisions, rapid postoperative feeding and lower complication rates are advantages of laparoscopic pyloromyotomy, which is an effective operative treatment method in the treating of IHPS.

Ethics

Ethics Committee Approval: The study was approved by the Medical Ethics Committee of Dokuz Eylül University Faculty of Medicine (protocol no: 2022/11-02, date: 23.03.2022).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: O.U., E.A., Concept: O.U., E.A., Design: O.U., E.A., A.G.K., Data Collection or Processing: E.A., A.G.K., Analysis or Interpretation: O.U., E.A., A.G.K., Literature Search: O.U., E.A., A.G.K., Writing: O.U., E.A., A.G.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Krogh C, Fischer TK, Skotte L, et al. Familial aggregation and heritability of pyloric stenosis. JAMA 2010;303:2393-9.
2. Galea R, Said E. Infantile hypertrophic pyloric stenosis: an epidemiological review. Neonatal Netw 2018;37:197-204.
3. Aboagye J, Goldstein SD, Salazar JH, et al. Age at presentation of common pediatric surgical conditions: Reexamining dogma. J Pediatr Surg 2014;49:995-9.
4. Krogh C, Gørtz S, Wohlfahrt J, Biggar RJ, Melbye M, Fischer TK. Pre- and perinatal risk factors for pyloric stenosis and their influence on the male predominance. Am J Epidemiol 2012;176:24-31.
5. AlMaramhy HH. Is there a relation between pyloric muscle thickness and clinical and laboratory data in infants with hypertrophic pyloric stenosis? Indian J Surg 2015;77:827-30.
6. Atwell JD, Levick P. Congenital hypertrophic pyloric stenosis and associated anomalies in the genitourinary tract. J Pediatr 1981;16:1029-35.
7. Mehta AV, Ambalavanan SK. Infantile hypertrophic pyloric stenosis and congenital heart disease: an under-recognized association. Tenn Med 1997;90:496-7.
8. Ramstedt C. For the operation of congenital pyloric stenosis. Med Klinik 1912;8:1702-5.
9. Alain JL, Grousseau D, Terrier G. Extramucosal pyloromyotomy by laparoscopy. Surg Endosc 1991;5:174-5.
10. Siddiqui S, Heidel RE, Angel CA, Kennedy AP Jr. Pyloromyotomy: randomized control trial of laparoscopic vs open technique. J Pediatr Surg 2012;47:93-8.
11. Carrington EV, Hall NJ, Pacilli M, et al. Cost-effectiveness of laparoscopic versus open pyloromyotomy. J Surg Res 2012;178:315-20.
12. Cosper GH, Menon R, Hamann MS, Nakayama DK. Residency training in pyloromyotomy: a survey of 331 pediatric surgeons. J Pediatr Surg 2008;43:102-8.
13. Emmett M. Metabolic Alkalosis: A Brief Pathophysiologic Review. Clin J Am Soc Nephrol 2020;15:1848-56.
14. Ramji J, Joshi RS. Laparoscopic pyloromyotomy for congenital hypertrophic pyloric stenosis: Our experience with twenty cases. Afr J Paediatr Surg 2021;18:14-7.
15. van den Bunder FAIM, van Woensel JBM, Stevens MF, van de Brug T, van Heurn LWE, Derikx JPM. Respiratory problems owing to severe metabolic alkalosis in infants presenting with hypertrophic pyloric stenosis. J Pediatr Surg 2020;55:2772-6.
16. Bissonnette B, Sullivan PJ. Pyloric stenosis. Can J Anaesth 1991;38:668-76.
17. Nissen M, Cernaianu G, Thränhardt R, Vahdad MR, Barenberg K, Tröbs RB. Does metabolic alkalosis influence cerebral oxygenation in infantile hypertrophic pyloric stenosis? J Surg Res 2017;212:229-37.
18. Glatstein M, Carbell G, Boddu SK, Bernardini A, Scolnik D. The changing clinical presentation of hypertrophic pyloric stenosis: the experience of a large, tertiary care pediatric hospital. Clin Pediatr (Phila) 2011;50:192-5.
19. Graham DA, Mogridge N, Abbott GD, Kennedy JC, Kempthore PM, Davidson JR. Pyloric stenosis: the Christchurch experience. N Z Med J 1993;106:57-9.
20. Said M, Shaul DB, Fujimoto M, Radner G, Sydorak RM, Applebaum H. Ultrasound measurements in hypertrophic pyloric stenosis: don't let the numbers fool you. Perm J 2012;16:25-7.
21. Peters B, Oomen MW, Bakx R, Benninga MA. Advances in infantile hypertrophic pyloric stenosis. Expert Rev Gastroenterol Hepatol 2014;8:533-41.
22. Cai BL, Zhang YX. Progress in the study of surgical methods for congenital hypertrophic pylorus stenosis. Int J Pediatr 2016;43:201-3.
23. Zhang YX, Nie YQ, Xiao X, Yu NF, Li QN, Deng L. Treatment of congenital hypertrophic pyloric stenosis with endoscopic pyloromyotomy. Zhonghua Er Ke Za Zhi 2008;46:247-51.
24. Bataineh ZA, Novotny NM. A novel nonelectrosurgical technique for incising the pylorus in laparoscopic pyloromyotomy. J Laparoendosc Adv Surg Tech A 2018;28:235-6.
25. Huang WH, Zhang QL, Chen L, Cui X, Wang YJ, Zhou CM. The Safety and Effectiveness of Laparoscopic versus Open Surgery for Congenital Hypertrophic Pyloric Stenosis in Infants. Med Sci Monit 2020;26:e921555.
26. Huang ZQ, Tang HJ. Clinical effect of laparoscopic surgery in the treatment of congenital hypertrophic pylorus stenosis. Chinese and Foreign Medical Research 2014;21:149-50.
27. Hall NJ, Eaton S, Seims A, et al. Risk of incomplete pyloromyotomy and mucosal perforation in open and laparoscopic pyloromyotomy. J Pediatr Surg 2014;49:1083-6.