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Observational Study

Tracheobronchial intubation using flexible bronchoscopy in children with Pierre Robin sequence: Nursing considerations for complications

Ying-Long Ye, Cai-Feng Zhang, Li-Zhen Xu, Hui-Feng Fan, Jun-Zheng Peng, Gen Lu, Xiao-Yin Hu

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Abstract

BACKGROUND

It has been shown that children with Pierre Robin sequence (PRS) have a higher risk of difficult intubation before surgery. When mask ventilation or tracheobronchial intubation is expected to be challenging, flexible bronchoscopy (FB) is advantageous in airway safety when it is used to guide tracheobronchial intubation (TI).

AIM

To evaluate the complications of TI using FB in children with PRS and explore the effect of nursing services on postoperative complications.

METHODS

One hundred and five children with PRS underwent TI using FB before early mandibular distraction osteogenesis. One hundred and eight children with common pneumonia who did not have a difficult airway were set as the control group. Demographic data, success rates of TI, time required for TI, number of TI attempts, and the incidence of postoperative complications were assessed. Besides, the strategies used to attenuate complications were investigated.

RESULTS

The success rate of TI was 100% in children with PRS, while the success rate at the first attempt in the PRS group was significantly lower than that in the control group (88.6% vs 98.2%, $P = 0.005$). The time required for TI in the PRS group was markedly longer than that in the control group ($P < 0.001$). Children in the PRS group required repetitive operations to enter the glottis successfully ($P = 0.017$). The incidence of complications was noticeably higher in the PRS group (50/105, 47.6%) than in the control group (36/108, 33.3%) ($P = 0.034$). Seven of 105 PRS

children experienced laryngeal edema (LE) (6.7%), compared with one (0.9%) in the control group ($P = 0.034$). Out of the seven patients who had LE, all were reintubated and managed with steroids: six recovered with inhaled steroids alone before extubated, and one was given systemic corticosteroids before recovery.

CONCLUSION

FB contributes to a high success rate of TI in children with PRS. To prevent LE, operators should pay more attention to catheter material, catheter lubrication and intubation time.

Key Words: Clinical nursing; Pediatrics; Surgical nursing; Patient safety; Operating room

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Core Tip: Flexible bronchoscopy contributes to a high success rate of tracheobronchial intubation in children with Pierre Robin sequence (PRS). Laryngeal edema (LE) is the main focus of perioperative nursing in patients with PRS. To prevent LE, surgeons should operate gently, choose the right material for the catheter, lubricate the catheter thoroughly, shorten the time required for incubation, and avoid repeated intubation.

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INTRODUCTION

Flexible bronchoscopy (FB) has become a progressively popular diagnostic method for airway evaluation in children[1,2]. Also, when mask ventilation or tracheobronchial intubation (TI) is expected to be challenging, FB is advantageous in airway safety when it is used to guide TI[3,4].

Pierre Robin sequence (PRS) is a congenital disability in humans, which is characterized by facial abnormalities[5]. It is featured by micrognathia (abnormally small mandible), glossoptosis (downwardly displaced or retracted tongue), and obstruction of the upper airway[6]. At present, mandibular distraction osteogenesis is a new treatment option for children with PRS, which can relieve upper airway obstruction by gradually lengthening the mandible[7,8]. However, Yin *et al*[3] reported difficult intubation in 71% of children with PRS before surgery. Therefore, the stomatologists strongly recommended that TI using FB was performed for PRS children preoperatively, which had the following advantages: indication of the location of airway obstruction in children, elimination of airway obstruction below the tongue level, and reduction of the difficulty of endotracheal intubation[4,9]. The previous study indicated that endotracheal intubation using FB is safe and effective even in neonates with PRS[10,11].

However, it is a new challenge to perform TI using FB for nurses who lack experience. Some research investigated the incidence and severity of complications of TI using FB in adults[12], but children were not investigated. In this study, we analyzed the demographic characteristics, success rates of intubation, the time required for intubation, number of intubation attempts, and postoperative complications of children with PRS and those with common pneumonia who did not have a difficult airway.

MATERIALS AND METHODS

Ethical consideration

The protocol was approved by the Medical Ethics Committee of Guangzhou Women and Children's Medical Centre (approval No. [2020] 24901), and the study was conducted following the Declaration of Helsinki.

Study design

An observational controlled study was performed. Children with PRS who underwent TI using FB before mandibular distraction osteogenesis were enrolled, and children with common pneumonia and no difficult airway that required bronchoscopy were set as the control group.

Setting and samples

The participants were 105 children with PRS from the Department of Stomatology, and 108 children with common pneumonia from the Department of Respiratory Medicine, at Children's Hospital in Guangzhou, China, from January 2016 to January 2019. The procedures were performed in the bronchoscopy room of the respiratory department. Inclusion criteria of the PRS group were: Children with PRS who underwent mandibular distraction osteogenesis; aged < 12 mo; and informed consent was obtained from the children's parents or guardians. Exclusion criteria were: combined with other severe diseases, *e.g.*, pulmonary arterial hypertension, cancer, pulmonary dysplasia, severe congenital heart disease; critical disorder; or the patient's guardian disagreed with the study. Inclusion criteria of the control group were: Children with pneumonia and no difficult airway; aged < 12 mo. The bronchoscopy operators were all qualified and specialized in bronchoscopy. The nurses had an equivalent level and experience in both groups.

Measurement and data collection

The data were collected from the perioperative records and other electronic medical records according to the survey items. The demographic data, success rates of intubation, the time required for intubation, number of intubation attempts, and the incidence of perioperative complications in the two groups were assessed. The time required for intubation referred to the interval between entrance of a bronchoscope into the nasal cavity and passing through the glottis. The attempts at intubation were also recorded. The possible complications included laryngeal edema (LE), epistaxis, bradycardia, bronchospasm, adverse drug reactions, transitory pyrexia, pneumothorax, hypoxemia, and respiratory depression.

Data analysis

The data were analyzed by SPSS for Windows version 25.0 (IBM, Armonk, NY, United States). The measurement data obeying a normal distribution were described by mean \pm SD, and an independent-sample *t* test was performed; otherwise, the distance between median and quartile was *M* (Q_1 - Q_3), and a Mann-Whitney *U* test was performed. Frequencies and ratios were used to describe the numerical data, and Fisher's exact test was performed. *P* < 0.05 was considered statistically significant.

Preparation and monitoring of patients

Preparation of patients: Medical history of children included in this study was evaluated. Specialists in FB encouraged parents to provide accurate medical information about their children, and the specialists actively answered questions raised by parents and provided the necessary data. All parents included in the study signed the written informed consent forms.

Preoperative preparation: It was ensured that the children were fasted for 6 h and refrained from drinking fluids for 2 h to avoid reflux of gastric contents and aspiration during the perioperative period. The infants with low glycogen reserves were intravenously injected with glucose solution in the ward after fasting for 2 h to prevent hypoglycemia and dehydration. Besides, first-aid medicines and first-aid kits were provided. A nurse evaluated the children's tolerance to the surgical procedure. Lidocaine (2%) was inhaled to reduce cough response. The nurse placed the children in the supine position and simultaneously monitored and supplied oxygen. Additionally, airway secretions were reduced by intravenous injection of atropine. In the control group, intravenous injection of midazolam was carried out by an anesthetist, as the first choice for moderate sedation. In the PRS group, TI using FB was performed on conscious patients to avoid airway relaxation, which increases the difficulty of TI.

Surgical nursing procedures: Principles of aseptic technology were followed throughout the procedures of TI using FB. For the PRS children, the first step was to remove nasal secretions. In the second step, the nurse attempted to insert the endotracheal tube into one side of the nasal cavity to explore whether it was smooth, and the malformed stenosis of the nasal meatus was excluded accordingly. In the third step, the surgeon stood behind the child's head, the nurse and anesthetist stood on the right side of the child's head, and the assistant helped hold up the child's lower jaw to separate the epiglottis from the pharyngeal wall. In the fourth step, the nurse lubricated the outer wall of the FB by silicone oil, while they kept the surface of the endotracheal tube from the oil. In the fifth step, the nurse separated the endotracheal tube connector, inserted the endotracheal tube over the FB, and then pulled the endotracheal tube to the top of the FB. In the sixth step, the surgeon inserted the FB through the nose to observe the epiglottis, oropharynx, larynx and trachea, ascertaining contraindications for intubation. If there were no contraindications, the surgeon continued to place the FB in the central airway. In the seventh step, the nurse gently inserted the endotracheal tube into the airway, and the surgeon confirmed the location of the catheter by auscultation.

Postoperative care: In the control group, postoperative resuscitation was carried out in the post-anesthesia care unit, which was equipped with emergency intervention equipment. During resuscitation, nurses closely monitored the child's electrocardiography and percutaneous oxygen saturation. All the children were fasted and restrained drinking fluids for approximately 2 h to avoid reflux and aspiration. In the PRS group, the children were sent directly to the operating room for

operation after catheterization.

RESULTS

There was no significant difference in age and gender between the two groups; however, the weight difference between the two groups was significant (Table 1). There were no deaths during the perioperative period. The success rate of the intubation was 100% for the children in the two groups, while the success rate at the first attempt of children in the PRS group was significantly lower than that in the control group (88.6% vs 98.2%, $P = 0.005$). The time required for intubation in the PRS group was significantly longer than that in the control group ($P < 0.001$), and children in the PRS group needed more attempts of intubation than those in the control group to enter the glottis successfully ($P = 0.017$). Meanwhile, the incidence of complications was markedly higher in the PRS group (50/105, 47.6%) than that in the control group (36/108, 33.3%) ($P = 0.034$) (Table 1), such as LE, epistaxis, bronchospasm and hypoxemia. Seven of 105 PRS children experienced LE (6.7%), compared with one (0.9%) in the control group. The rate of LE differed markedly between the groups ($P = 0.034$). Out of the seven patients who had LE, the mean age was 1.19 ± 0.82 mo, the mean weight was 3.33 ± 0.75 kg, the time required for intubation was 65 (58–68) s, and there were two or three reintubation attempts for the bronchoscope and endotracheal tube. All seven patients were managed with steroids: six recovered with inhaled steroids alone before extubation, and one was given systemic corticosteroids before recovery. There was no significant difference ($P > 0.05$) in other complications, such as epistaxis, bradycardia, tracheospasm, adverse drug reactions, transitory pyrexia, pneumothorax and hypoxemia, between the PRS and control groups.

DISCUSSION

Since most children with PRS had difficult feeding, their body weight was lower compared to the control group. In the present study, the success rate of endotracheal intubation using FB in children with PRS was 100%, which was noticeably higher compared with other intubation-based methods. Previous research indicated that endotracheal intubation was achieved in only 13 of 35 (37%) children with PRS under direct laryngoscopy, and intubation using FB was applied to the remaining 22 of 35 (63%) who failed[11]. Sanfilippo *et al*[13] reported that the success rates of video-laryngoscopy and direct laryngoscopy in difficult tracheal intubation were 83% and 55%, respectively, while the rate was equal to 100% in the current research. However, in terms of complications, direct laryngoscopy is prone to endanger children's lives due to a high failure rate of intubation[13]. Although video-laryngoscopy also has high success rates in difficult tracheal intubation[9], the reported failure rates and severe complications must be taken into account[14]. To date, there have been fewer hemodynamic responses and adverse events during endotracheal intubation using FB[15,16]. Therefore, FB may be a promising alternative for the management of difficult tracheal intubation.

In the present study, we also analyzed complications, the time required for intubation, and number of attempts of intubation in the two groups. TI is often complicated by subglottic edema in children[17], which may be characterized by hoarseness or dyspnea after extubation, or both[18]. In the current research, LE was the most prominent complication in children with PRS (6.7%), the incidence of which was higher compared to the control group (0.9%). The incidence of LE in our study was consistent with that reported in some previous studies (6.7%)[19]. Previous research indicated that difficult intubation is a significant risk factor for LE[20]. It was also found that the success rate at the first attempt in the PRS group was significantly lower than that in the control group (88.6% vs 98.2%, $P = 0.005$). The present study also indicated that the time required for intubation was 31.0 (25–37) s, and the number of attempts at intubation was one in the PRS group. Among the seven patients who had LE, the time required for intubation was 65 (58–68) s, and there were two or three attempts at bronchoscopy and endotracheal intubation. Therefore, we should further concentrate on the number of attempts required for intubation and avoid multiple intubations. In addition, among the seven patients who had LE, the mean age was 1.19 ± 0.82 mo and the mean weight was 3.33 ± 0.75 kg, which were lower than 2.25 ± 0.36 mo and 3.84 ± 0.82 kg in the PRS group. It is suggested that we should pay attention to low weight and young age of children with PRS who undergo TI using FB in the future, since they may be more likely to develop LE.

In the current research, we might primarily focus on the possible risk factors at endotracheal intubation to prevent the occurrence of LE. A recently published guideline recommended the selection of an appropriate-size endotracheal catheter, which was made of soft-materials[21]. A previous study pointed out that a surgeon should select an appropriate catheter according to children's age and weight, which may reduce the risk of obstruction of the catheter to the glottis[22]. The recent studies have reported that an ultrasmooth endotracheal catheter can be selected, due to its ultraslippery, nonirritating, and anti-inflammatory hyaluronic-acid-based coating to mitigate intubation injury, and the friction coefficient was reduced by 77% compared to the normal endotracheal catheter in a Crab-

Table 1 Demographic characteristics and postoperative complications of patients

Variable	PRS group (n = 105)	Control group (n = 108)	P value
Demographic characteristics			
Age, mo (mean ± SD)	2.25 ± 0.36	2.91 ± 0.24	0.120
Male, n (%)	67 (63.8)	82 (75.9)	0.053
Weight, kg (mean ± SD)	3.85 ± 1.68	5.59 ± 1.76	< 0.001 ^a
Success rate at first attempt (%)	93 (88.6)	106 (98.2)	0.005 ^a
Total success rate (%)	105 (100)	108 (100)	< 0.999
Time-consuming of intubation (s) [M(Q1-Q3)]	31.0 (25-37)	21.0 (20-23)	< 0.001 ^a
Number of intubation attempts [M(Q1-Q3)]	1 (1-1)	1 (1-1)	0.017 ^a
Operative complications, n (%)	50 (47.6)	36 (33.3)	0.034 ^a
Laryngeal edema, n (%)	7 (6.7)	1 (0.9)	0.034 ^a
Epistaxis, n (%)	12 (11.4)	10 (9.3)	0.603
Bradycardia, n (%)	1 (1.0)	3 (2.8)	0.622
Bronchospasm, n (%)	13 (12.4)	6 (5.6)	0.095
Adverse drug reactions, n (%)	0 (0)	0 (0)	< 0.999
Transitory pyrexia, n (%) ¹	3 (2.9)	6 (5.6)	0.499
Pneumothorax, n (%)	0 (0)	0 (0)	< 0.999
Hypoxaemia, n (%)	14 (13.3)	10 (9.3)	0.391

¹axillary temperature > 37.5°C;^aP < 0.05. PRS: Pierre Robin sequence.

eating monkey experiment[23,24]. Moreover, aseptic medical-oil-based lubricants should be used to lubricate the front end of the tracheal tube before intubation to lower the friction and lessen the risk of mucosal injury. One study reported that failure of intubation was found in 10% of children due to failure to lubricate the front end of the catheter[25]. Meanwhile, the duration of intubation should be shortened, and number of attempts at intubation should be reduced as much as possible, as these are both significant risk factors for LE[18]. In future research, we need to pay attention to some key points, such as proper position and orientation of the catheter and bronchoscope lens, and catheter materials, *etc.*

In this study, the complications of TI using FB in children with PRS were summarized, and we will explore further effective care measures in the future. We found that LE is a critical complication in PRS children after TI using FB, and the prevention of LE remains to be improved in the future.

CONCLUSION

The success rate of intubation using FB is high for children with PRS and is a promising alternative for the management of difficult tracheal intubation. The incidence of postoperative complications of TI using FB, especially LE, is higher in children with PRS compared to children with pneumonia.

ARTICLE HIGHLIGHTS

Research background

Flexible bronchoscopy (FB) has become a progressively popular diagnostic method for airway evaluation in children, which is advantageous in airway safety when it is used to guide tracheo-bronchial intubation (TI). Pierre Robin sequence (PRS) is a congenital disability in humans, and difficult intubation has been reported in 71% of children with PRS before surgery. Previous studies have indicated that endotracheal intubation using FB is safe and effective even in neonates with PRS. However, it is a new challenge to perform TI using FB for nurses who lack experience. Some research investigated the incidence and severity of complications of TI using FB in adults, but children have not

been investigated.

Research motivation

The incidence and severity of complications of TI using FB in children remain to be investigated.

Research objectives

This study aimed to analyze demographic characteristics, success rates of intubation, the time required for intubation, number of intubation attempts, and postoperative complications of children with PRS and those with common pneumonia who did not have a difficult airway.

Research methods

105 children with PRS from the Department of Stomatology, and 108 children with common pneumonia from the Department of Respiratory Medicine, at Children's Hospital in Guangzhou, China, from January 2016 to January 2019 were recruited. The procedures were performed in the bronchoscopy room of the respiratory department. The data were collected from the perioperative records and other electronic medical records according to the survey items. The demographic data, success rates of intubation, the time required for intubation, number of intubation attempts, and the incidence of perioperative complications in the two groups were assessed. Furthermore, the attempts of intubation were also recorded. The possible complications were observed.

Research results

There was no significant difference in age and gender between the two groups; however, the weight difference between the two groups was significant. There were no deaths during the perioperative period. The success rate of intubation was 100% for the children in the two groups, while the success rate at the first attempt of children in the PRS group was significantly lower than that in the control group (88.6% *vs* 98.2%, $P = 0.005$). The time required for intubation in the PRS group was significantly longer than that in the control group ($P < 0.001$), and children in the PRS group needed more attempts of intubation than those in the control group to enter the glottis successfully ($P = 0.017$). The incidence of complications was markedly higher in the PRS group (50/105, 47.6%) than in the control group (36/108, 33.3%) ($P = 0.034$). Seven of 105 PRS children experienced LE (6.7%), compared with one (0.9%) in the control group. The rate of LE differed markedly between the groups ($P = 0.034$). Out of the seven patients who had LE, the mean age was 1.19 ± 0.82 months, the mean weight was 3.33 ± 0.75 kg, the time required for intubation was 65–68 s, and there were two or three reintubation attempts for bronchoscopy and endotracheal intubation. All seven patients were managed with steroids: six recovered with inhaled steroids alone before extubation, and one was given systemic corticosteroids before recovery. There was no significant difference ($P > 0.05$) in other complications between the PRS group and control group.

Research conclusions

Given the high success rate of intubation using FB for children with PRS, it is a promising alternative for the management of difficult tracheal intubation. The incidence of postoperative complications of TI using FB, especially LE, is higher in children with PRS compared to children with pneumonia.

Research perspectives

Effective care measures for the complications of TI using FB in children with PRS will be further explored, and the prevention of LE remains to be improved in the future.

FOOTNOTES

Author contributions: Zhang CF, Hu XY and Fan HF studied conception and design; Ye YL, Xu LZ and Peng JZ contributed to data collection; Zhang CF and Lu G contributed to data analysis and interpretation; Ye YL, Zhang CF, and Fan HF contributed to drafting of the article; Hu XY and Fan HF contributed to critical revision of the article; Ye YL and Zhang CF contributed equally to the manuscript.

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