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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

**Abstract****BACKGROUND**

It has been shown that children with Pierre Robin Sequence (PRS) had 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 the tracheobronchial intubation (TI).

**AIM**

This study aimed 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 control group. Demographic data, success rates of TI, the time required for TI, times of TI, 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 remarkably longer than that in the control group ( $P<0.001$ ). Furthermore, 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%) ( $P=0.034$ ). 7 of 105 PRS children experienced laryngeal edema (6.7%), compared with one child (0.9%) in the control group ( $P=0.034$ ). Out of the seven patients who had LE, all were re-intubated and managed with steroids. 6/7 recovered with inhaled steroids alone before extubated, and 1/7 was given systemic corticosteroids before recovery.

## CONCLUSION

The FB diagnostic technique contributes to a high success rate of tracheobronchial intubation in children with PRS. Laryngeal edema is the main focus of perioperative nursing in patients with PRS. To prevent laryngeal edema, 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.

## INTRODUCTION

Flexible bronchoscopy (FB) has become a progressively popular diagnostic method for airway evaluation in children (Bhat *et al*, 2020; Ok *et al*, 2019) (1). Also, when mask ventilation or tracheobronchial intubation is expected to be challenging, FB is advantageous in airway safety when it is used to guide the tracheobronchial intubation (TI) (Yin *et al*, 2017; Zhang *et al*, 2021).

Pierre Robin Sequence (PRS) is a congenital disability in human, which is characterized by facial abnormalities (Breugem & Courtemanche, 2010). It is featured by micrognathia (abnormally small mandible), glossoptosis (downwardly displaced or retracted tongue),

and obstruction of the upper airway (Hsieh & Woo, 2019). At present, <sup>5</sup>mandibular distraction osteogenesis is a relatively new treatment option for children with PRS, which can relieve upper airway obstruction by gradually lengthening the mandible (Pfaff *et al*, 2020; Taylor & Shakir, 2020). However, Yin *et al* reported difficult intubation in 71% of children with PRS before surgery (Yin *et al*, 2017). 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 (Peterson *et al*, 2021, Zhang *et al*, 2021). The previous study indicated that endotracheal intubation using FB is safe and effective even in neonates with PRS (Koukouvitaki *et al*, 2019; Marston *et al*, 2012).

However, it is a new challenge to perform TI using FB for the nurses who lack experience. Some research investigated the incidence and severity of complications of TI using FB in adults (Cabrini *et al*, 2019), but children was not investigated. In this study, we analyzed the demographic characteristics, success rates of intubation, the time required for intubation, times of intubation, and postoperative complications of the 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.<sup>[2020]</sup> 24901), and the study was conducted following the Declaration of Helsinki.

### **Study Design**

An observational controlled study was performed. The children with PRS who underwent TI using FB before mandibular distraction osteogenesis were enrolled, and the children with common pneumonia and no difficult airway which 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, 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: children with PRS who underwent mandibular distraction osteogenesis; aged less than 12 mo; informed consent was obtained from the children's parents or guardians. Exclusion criteria: combined with other severe diseases, *e.g.*, pulmonary arterial hypertension, cancer, pulmonary dysplasia, severe congenital heart disease; critical disorder; the patient's guardian disagrees with the study. Inclusion criteria of the control group: children with pneumonia and no difficult airway; aged less than 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, times of intubation, 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. Furthermore, the attempts of intubation were also recorded. The possible complications included laryngeal edema (LE), epistaxis, bradycardia, bronchospasm, adverse drug reactions, transitory pyrexia, pneumothorax, hypoxaemia, and respiratory depression.

## Data analysis

The data were analyzed by SPSS version 25.0, Windows software (IBM, Armonk, NY, USA). The measurement data obeying normal distribution were described by mean  $\pm$  standard deviation, and an independent-sample t-test was performed; otherwise, the distance between median and quartile was M (Q<sub>1</sub>~Q<sub>3</sub>), and Mann-Whitney U test was performed. Frequencies and ratios were used to describe the counting data, and Fisher's exact test was performed.  $P < 0.05$  was considered statistically significant.

## Preparation and monitoring of the patients

### Preparation of the patients

Medical history of children included in this study was evaluated. Specialists in FB encouraged parents to provide accurate medical information of the 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 six hours and refrained from drinking fluids for two hours to avoid reflux of gastric contents and aspiration during perioperative period. The infants with low glycogen reserves would be 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. 2% lidocaine was inhaled to reduce cough response. The nurse placed the children in a 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 anaesthetist, as the first choice for moderate sedation. In the PRS group, TI using FB was performed on the conscious patients to avoid airway relaxation which increases the difficulty of tracheal intubation.

### **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 children's head, the nurse and anaesthetist stood on the right side of the children'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 he/she kept 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 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, the postoperative resuscitation was carried out in the post-anaesthesia care unit (PACU), which was equipped with emergency intervention equipment. During resuscitation, nurses must closely monitor the children's electrocardiography (ECG) and percutaneous oxygen saturation (SpO<sub>2</sub>). All the children were fasted and restrained drinking fluids for about two hours to avoid reflux and aspiration. In the PRS group, the children were sent directly to the operating room for operation after catheterization.

## **RESULTS**



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There was no statistically significant difference in age and gender between the two groups, however, the weight difference between the two groups was statistically significant (**Table 1**). There was no death in all children 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 laryngeal edema, epistaxis, bronchospasm and hypoxemia. 7 out of 105 PRS children experienced LE (6.7%), compared with one child (0.9%) in the control group. The rate of LE remarkably differed between the groups ( $P=0.034$ ). Out of the seven patients who had LE, the mean age was ( $1.19\pm0.82$ ) months, the mean weight was ( $3.33\pm0.75$ ) kg, the time required for intubation was 65 (58~68) s, and the reintubation attempts of the bronchoscope and endotracheal tube were 2(2~3), 2(2~3), respectively, all of which were managed with steroids. 6/7 recovered with inhaled steroids alone before extubated, and 1/7 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 group and the control group.

## DISCUSSION

Since most children with PRS had difficult feeding, their body weight was lower compared to the control. 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 (Marston *et al*, 2012). Besides, a study reported that the success rates of video-laryngoscopy and direct laryngoscopy in difficult tracheal intubation were 83% and 55%, respectively (Sanfilippo *et al*, 2019), while the rate was equal to 100% in the current research. However, in terms of complications, direct laryngoscopy is prone to bring danger to children's life due to a high failure rate of intubation (Sanfilippo *et al*, 2019). Although video-laryngoscopy also has relatively high success rates in difficult tracheal intubation (Peterson *et al*, 2021), the reported failure rates and severe complications must be taken into account (Nestler *et al*, 2013). To date, there were fewer hemodynamic responses and adverse events in the endotracheal intubation using FB (Ozkan & Akbas, 2018; Simma *et al*, 2017). 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 attempts of intubation in the two groups. Tracheobronchial intubation is often complicated by subglottic edema in children (Khemani *et al*, 2016), which may be characterized by hoarseness or dyspnea after extubation, or both (Pluijms *et al*, 2015). 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%) (Gros *et al*, 2012). Previous research indicated that difficult intubation is a significant risk factor for LE (Kuriyama *et al*, 2017). 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 attempt of intubation was 1(1~1) in the PRS group. Especially out of the seven patients who had LE, the time required for intubation was 65 (58~68) s, and the attempts of intubation of the bronchoscope and endotracheal tube were 2(2~3) and 2(2~3), respectively. Therefore, we should further concentrate on the attempts required for intubation and avoid multiple intubations. In

addition, out of the 7 patients who had LE, the mean age was ( $1.19 \pm 0.82$ ) months and the mean weight was ( $3.33 \pm 0.75$ ) kg, which were lower than ( $2.25 \pm 0.36$  m) and ( $3.84 \pm 0.82$  kg) in the PRS group, respectively. It is suggested that we should pay attention to low weight and young age of children with PRS who underwent 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 (Commission EGOP *et al*, 2018). 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 (Xue *et al*, 2008). On the other hand, the recent studies presented that the ultra-smooth endotracheal catheter can be selected, due to <sup>4</sup> ultra-slippery, nonirritating, and anti-inflammatory hyaluronic acid-based coating to mitigate intubation injury, and the friction coefficient is reduced by 77% compared to the normal endotracheal catheter in Crab-eating monkey experiment (Baisong *et al*, 2021; Li *et al*, 2020). 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. A study reported that failure of intubation was found in 10% of children due to failure to lubricate the front end of the catheter (He-Ping *et al*, 2008). Meanwhile, the duration of intubation should be shortened, and attempts of intubation should be attenuated as much as possible, which are significant risk factors for LE (Pluijms *et al*, 2015). In the future research, we also need to pay attention to some key points, such as the proper position, orientation of the catheter and the bronchoscope lens, 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. Moreover, it was herein 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 technique 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 conclusions***

Given the high success rate of intubation using FB technique 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 laryngeal edema remains to be improved in the future.

### ***Research results***

2 There was no statistically significant difference in age and gender between the two groups, however, the weight difference between the two groups was statistically significant. There was no death in all children 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

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### ***Research methods***

105 children with PRS from the department of stomatology, and 108 children with common pneumonia from the department of respiratory, 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, times of intubation, 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 objectives***

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

### ***Research motivation***

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

### ***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 the tracheobronchial intubation (TI).

Pierre Robin Sequence (PRS) is a congenital disability in human, and difficult intubation has been reported in 71% of children with PRS before surgery. The previous study has 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 the nurses who lack experience. Some research investigated the incidence and severity of complications of TI using FB in adults, but children was not investigated.

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