Airway Complications in Neonates Who Received Mechanical Ventilation

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Abstract

Objective : To determine the incidence, type and severity of airway complications in high risk neonates who received conventional mechanical ventilation.

Method : Forty-five infants who had received conventional mechanical ventilation in the Neonatal Intensive Care Unit, Department of Pediatrics, Faculty of Medicine Siriraj Hospital for at least 4 days were enrolled. Orotracheal intubation with blue line, non-cuffed, non-shouldered polyvinylchloride tube was used exclusively. The average number of intubations was 2 (range 1-7), and the average duration for intubation was 25 days. The details of the intubation, and the presence of respiratory distress after extubation were recorded. All of the infants had endoscopic examination of the airway within 5 days of extubation.

Results : Following extubation, 14 (31.1%) infants developed signs of upper airway obstruction, of which inspiratory dyspnea was the most common manifestation. Only 4 infants developed inspiratory stridor, three of them had a birth weight greater than 2,500 g. Abnormal bronchoscopic findings were found in 42 infants, 68.8 per cent had multiple sites of injury. Supraglottic lesions were found in 55.7 per cent of cases. Laryngomalacia was an associated finding in 8 and gastro-esophageal reflux (GER) in 1 occasion.

Conclusions : From the result of this study, the authors found that airway complications related to endotracheal intubation are common among survivors from the Neonatal Intensive Care Unit. When the diagnosis of airway complications only depends on symptoms and signs of upper airway obstruction, the incidence and extent of injuries may be under-estimated. When attempted

extubation fails or when VLBW infants develop increasing respiratory distress that is not clearly explained by an apparent disorder involving the pulmonary parenchyma, flexible bronchoscopic examination should be performed at the bedside with minimal risk.

Key word : Airway Complications, Mechanical Ventilation, Endotracheal Intubation, Neonate

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During the past two decades, tremendous advances in neonatal medicine have taken place that allow for survival of very low birth weight (VLBW) infants. An important component of this technological advancement involves airway management and prolonged assisted ventilation in the Neonatal Intensive Care Unit. As neonatal mortality improves, greater likelihood exists of survival of infants with impaired respiratory function. Prolonged intubation in a VLBW infant is not without complications, it has been reported to be associated with the risk of airway damage including: laryngeal edema, formation of granulation tissue, ulceration, subglottic stenosis, tracheomalacia, necrotizing tracheobronchitis, subglottic cyst, tracheal perforation, tracheal stenosis and other less serious lesions[1-5]. Pathological changes in the larynx or trachea following prolonged intubation have been reported in 74-100 per cent of the autopsied neonates[6]. Prior to the development of the ultrathin flexible bronchoscope, the study of tracheo-bronchial injury and long-term large airway complications in VLBW infants could not be accomplished easily. Rigid brochoscopy allows excellent visualization of large airways, but is limited by the need for general anesthesia and extubation. Flexible bronchoscopy has several advantages: the ability to be performed at the bedside, the ability to pass the instrument through the existing endotracheal tube, and it does not require general anesthesia[7]. There have been an increasing number of applications of flexible bronchoscopy in pediatric patients after the first prototype of flexible bronchoscope (BF 3C4, Olympus Corp. of America, NY) became available in late 1978[7]. In recent years, ultrathin fiberoptic bronchoscopy has been demonstrated to be a reliable technique to examine the airway of the premature infant, and adverse consequences have been reported to be minimal[8-12]. The diagnosis of upper airway complications in VLBW infants requires clinical experience in neonatal medicine. To determine the incidence and extent of airway injuries related to endotracheal intubation, the authors performed an endoscopic examination in neonates who had received conventional mechanical ventilation in the Neonatal Intensive Care Unit.

PATIENTS AND METHOD

Forty-five infants who received conventional mechanical ventilation were enrolled if they had no congenital anomalies. Endotracheal intubation was performed by either neonatologists, neonatal fellows or pediatric residents with varying degrees of experience. In the unit, orotracheal intubation is exclusively used for ventilatory support. The choice of tube size was based on the infants' weight at the time of intubation. As a general guideline, a 2.5-mm tube was used for infants $\leq$1,000 g, a 3.0-mm tube for infants >1,000 g, and $\leq$2,000 g, a 3.5-mm tube for infants >2,000 g and $\leq$3,000 g, a 3.5 or 4.0-mm tube for infants >3,000 g. An infant who was intubated with an endotracheal tube of a larger internal diameter for weight than the criteria outlined above was

considered to have an inappropriately sized tube in place, and the number of days using such a tube was recorded. Blue line polyvinylchloride, non-cuffed, non-shouldered tubes (Portex, Concord/Portex, Keene, N.H., USA) were used. Clinical data, details of intubation including, size of the endotracheal tube, number of intubations, and the difficulty of each intubation were recorded to determine the events that could be associated with airway injury. Ventilatory support was provided by a continuous flow, pressure-limited, time-cycled ventilator (Bourn BP 200 or Bear Cup, Bear Coop).

After extubation, the presence of respiratory distress, dysphonia or inspiratory stridor was recorded. Stridor is defined as a harsh, high-pitched respiratory sound with or without indrawing and retraction. Within 5 days of extubation, flexible bronchoscopy was performed at the bedside by the neonatologist after obtaining informed consent. Either an ultrathin fiberoptic endoscope with an outer diameter of 2.2 mm (BF N20, Olympus America, Inc.) or an endoscope with an outer diameter of 3.5 mm (BF 3C30, Olympus America, Inc.) was used. Prior to examination, the infant was kept Nothing Per Oral (NPO) for 4 hours and pre-oxygenated with an oxygen facemask to keep the transcutaneous oxygen saturation (SpO_2) greater than 95 per cent. Sedation was not required. Respiratory rate, heart rate, blood pressure and SpO_2 were monitored during the procedure and 12 hours later. Complications were defined as bradycardia (heart rate <100 bpm), tachycardia (heart rate >180 bpm), hypoxemia (SpO_2 <85%), change in baseline systolic blood pressure (increase or decrease in baseline SBP greater than 10%), increase in oxygen requirement, tracheal bleeding and the need for re-intubation. The examination was recorded by a video tape recording system and was subsequently reviewed by both of the neonatologist and pediatric otolaryngologist. None of the infants required re-intubation except one who developed septic shock 6 days after the examination.

Table 1. Number of intubations.

Number	Cases
1	24
2	7
3	8
4	4
7	2

RESULTS

Forty-five infants were enrolled in the study. Almost half (44.4%) were VLBW infants less than 1,500 g. The infants had a mean birth weight of 1,919 ± 875 g (range 760-3,670) and a mean gestational age of 33.0 ± 4.9 (mean ± SD) weeks. Thirty-four infants had an appropriately sized tube, while eleven infants had a small tube size for weight. The infants had been mechanically ventilated for a mean duration of 25 days (range 4-90). Approximately half (21/24) were intubated at least twice or more (Table 1). Following extubation, thirty-one infants were apparently well with no signs of upper airway obstruction. Fourteen infants developed signs of upper airway obstruction, of which inspiratory dyspnea was the most common sign (Table 2-3). There was only 4 infants who had inspiratory stridor, and three of them had a birth weight >2,500 g. Abnormal bronchoscopy was found in 42 infants. Approximately two-thirds had multiple sites of injury, and half of these injuries (55.7%) were confined to the supra-

Table 2. Signs and symptoms in 14 symptomatic infants.

Signs and symptoms	Cases/Total	Per cent
Inspiratory dyspnea	8/14	57.2
Inspiratory dyspnea	6	
Inspiratory dyspnea with dysphonia	2	
Inspiratory stridor	4/14	28.6
Stridor with dyspnea	2	
Stridor with dysphonia	2	
Dysphonia	1/14	7.1
Arching of neck	1/14	7.1

Table 3. Signs and symptoms of upper airway obstruction classified by birth weight.

BW (g)	Total (case)	Asymptomatic (case)	Dyspnea* (case)	Stridor* (case)	Dysphonia (case)	Arching of neck (case)
<1,000	8	6			2	
1,000-1,499	12	8	3	1		
1,500-1,999	4	4	1			
2,000-2,499	7	5				1
>2,500	14	8	3	3		
Total	45	31	7	4	2	1

* with dysphonia

Table 4. Distribution of lesions.

Site of involvement	Number
Supraglottis	39
Vocal cords	8
Subglottis	6
Trachea	17

Table 5. Number of lesions.

Number	Cases	Per cent
0	3	6.7
1	14	31.1
2	15	33.3
3	6	13.3
4	6	13.3
8	1	2.2

glottis (Table 4-5). Laryngomalacia and GER were associated with airway injuries in 8 and 1 occasion respectively. The extent and type of airway complications are shown in Table 6.

DISCUSSION

The incidence and extent of airway injury related to endotracheal intubation has never been established in our Neonatal Intensive Care Unit. The injuries are usually located in the area of vocal cords, trachea, supraglottis and subglottis[13]. Lesions which are consistently found include nonspecific changes, edema, granulation tissue, ulceration and other miscellaneous injuries. Three possible sites of major damage have been described: first, the medial surface of the arytenoid cartilage, cricoarytenoid joints, and vocal processes, second in the posterior glottis and interarytenoid region, and third in the inner surface of the cricoid cartilage, usually the posterior lamina[2]. In one autopsy report, mild lesions (mucosal or submucosal necrosis) were seen in 63.3 per cent and severe lesions showing inflammatory changes in 15.8 per cent of cases. Vocal cords with or without the subglottic region of the larynx and trachea were the commonest lesion sites [12]. The two most important factors contributing to severity of airway injury are the duration of intubation and the physical characteristics of the endotracheal tube, other factors include the number of intubations, pre-existing abnormalities of the larynx, unskilled intubation, stasis of secretions, increased patient activity, bacterial infection, GER, and acute or chronic disease states[2,12,14]. The results of the present study revealed that most of the VLBW infants who were subsequently found to have airway injuries were apparently well after extubation. There were only 14 infants who developed one or more signs of upper airway obstruction. Interestingly, laryngomalacia was found as an etiology associated with airway injuries on 8 cases. Gould and Young [12] demonstrated that acute laryngeal injury in surviving newborn infants was almost universal. In their previous publications, they reported severe airway injuries relating to intubation including ulceration and granuloma which occurred in 44 per cent to 47 per cent, and subglottic stenosis in 0.7-9 per cent[6,15-17]. Because orotracheal intubation was used exclusively and heavy sedation was rarely prescribed in our unit, the incidence of supraglottic lesions including edema and inflammation in the present study was rather high (59.8%). This confirms the study of Albert et al[18] that active neonates or

Table 6. Bronchoscopic findings.

Finding	Number of occasions
Supraglottis	
Edema	24
Erythema	24
Ulceration	12
Infection (supraglottitis)	1
Vocal cords	
Edema	2
Ulceration and adhesion	3
Loss of movement: bilateral	1
Erythema	1
Granulation	1
Subglottis	
Edema	3
Narrowing	3
Trachea	
Tracheomalacia	7
Erythema	2
Granulation: suspected candidiasis	4
Bacterial tracheitis	1
Bronchus	
Bronchomalacia	6
Granulation : suspected candidiasis	4

neonates with orotracheal intubation will have more abnormalities in the supraglottis than those who are quiescent. Despite finding endoscopic evidence of GER in only 1 infant and supraglottic edema with inflammation in 2 infants, further investigation should be done to establish the role of GER in supraglottic injury of the VLBW infants who had prolonged intubation.

Acquired lesions of the trachea and bronchi, such as subglottic stenosis, tracheomegaly, necrotizing tracheobronchitis, and vocal cord injuries, have been noted in infants who have received prolonged intubation and mechanical ventilation. In the neonate, acquired subglottic stenosis is one of the most serious long-term complications of intubation, but that progression of the injury is mostly short-lived. Ulcer healing starts after a few days, rapidly progresses from day 10, and in the majority of cases is complete after 30 days. Long standing acute injury in the subglottis is an exception, even when the endotracheal tube remains in place[14]. The etiology of subglottic stenosis is multifactorial, and risk factors in the newborn are not well known. Low birth weight, low gestational age, and tube size may be responsible for this type of injury[15-21]. The authors found an incidence of subglottic stenosis of 6.9 per cent which is close to the study reported by Contencin et al[22]. All the cases of subglottic stenosis that the authors found were acquired except for one infant who had a history of difficult intubation with an appropriately sized endotracheal tube since birth. Recently, Contencin et al[22] found that the incidence of subglottic stenosis was lower than in previous reports because of the difference in birth weight, duration of intubation, and size of the endotracheal tube. Although their study had many unknown variables, they concluded that the size of the endotracheal tube appears to be a major risk factor for acquired laryngotracheal stenosis in the neonates[22].

Despite technical advances and dramatic improvement in survival, mechanical ventilators still have tremendous effects on airway and pulmonary parenchyma of newborn infants. Pulmonary air leaks and chronic lung disease continue to occur. Factors that may be associated with tracheal damage appeared to be the duration of intubation and method of ventilation[2]. In recent years, high frequency ventilation has been proposed as an alternative to reduce the incidence of ventilator-induced airway injuries. In 1983, Mammel[2] reported clinical tracheal obstructions in three neonates treated with high frequency-jet ventilation. The airway lesions were unusual, consisting of mucosal necrosis, inflammatory cell infiltration, and luminal obstruction with necrotic debris and mucus[2,23]. Similar lesions have been reported in infants who received conventional mechanical ventilation[24]. Fox et al[25] reported impacted tracheal secretions in five infants treated with rapid-rate conventional ventilation and they described the clinical features suggestive of necrotizing tracheobronchitis (NTB). A clinicopathological review performed by Mammel et al, [2] concluded that NTB can occur following all forms of mechanical ventilation, both conventional and unconventional. Airway damage appears to be magnified by prolonged mechanical ventilation, decreased humidity, and an increased ventilator rate. None of the infants in the present study had clinical features or lesions suggestive of NTB, except two infants who showed erythema of the tracheal mucosa which may have been sub-clinical NTB. Other lesions that the authors found included 7 cases of tracheomalacia, 6 of bronchomalacia, 5 cases of suspected bacterial or fungal infection of the trachea, and 4 cases of suspected fungal infection in a secondary bronchus.

SUMMARY

From the results of the present study, the authors found that airway complications related to endotracheal intubation are very common among surviving neonates in our Neonatal Intensive Care Unit. When the diagnosis of airway complications only depends on signs and symptoms of upper airway obstruction, the etiology, incidence and extent of injuries may be under-estimated. If a high-risk neonate fails attempted extubation or when a VLBW infant develops increasing respiratory distress that is not clearly explained by an apparent disorder involving pulmonary parenchyma, an endo- scopic examination is indicated. The present results strongly recommend that flexible bronchoscopy is essential for complete evaluation of the airway in very low birth weight infants who have had prolonged intubation.

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ความผิดปกติในทางเดินหายใจของทารกแรกเกิดที่ได้รับการรักษาด้วยเครื่องช่วยหายใจ

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วัตถุประสงค์ : เพื่อศึกษาอุบัติการณ์ อาการและอาการแสดงของภาวะแทรกซ้อนในทางเดินหายใจ ซึ่งเกิดจากการรักษาด้วยเครื่องช่วยหายใจ

ผู้ป่วยและวิธีการศึกษา : ผู้วิจัยได้ตรวจหาความผิดปกติในทางเดินหายใจของทารก 45 รายซึ่งได้รับการดูแลรักษาในหออภิบาลทารกแรกเกิด (neonatal intensive care unit) ของภาควิชากุมารเวชศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล ด้วยกล้องส่องตรวจทางเดินหายใจ (flexible bronchoscope, BF N20 หรือ BF 3C30, Olympus America, Inc) ภายใน 5 วันหลังจากที่เอาเครื่องช่วยหายใจออก ทารกทุกรายได้รับการช่วยเหลือหายใจด้วยวิธี conventional mechanical ventilation ผ่าน blue line polyvinylchloride, non-cuffed, non-shouldered tubes เป็นเวลาไม่น้อยกว่า 4 วัน (เฉลี่ย 25 วัน) การเลือกใช้ขนาดท่อช่วยหายใจขึ้นอยู่กับน้ำหนักแรกเกิดดังนี้ : ขนาด 2.5, 3, 3.5 หรือ 4.0 มม ทารก≤1,000, 1,000-2,000 และ 3,000 กรัม ตามลำดับ ข้อมูลที่เกี่ยวกับการใส่ท่อช่วยหายใจ (เส้นผ่าศูนย์กลาง จำนวนครั้ง และความยากของการใส่ท่อช่วยหายใจ) และความผิดปกติภายหลังจากการเอาท่อช่วยหายใจออกจะถูกบันทึกลงในแบบฟอร์ม ผลการตรวจจะถูกบันทึกในม้วนเทปวีดีโอเพื่อนำมาศึกษาเพิ่มเติมและหาข้อสรุประหว่างแพทย์เฉพาะทางสาขาทารกแรกเกิดและแพทย์สาขาโสต ศอ นาสิก และลาริงซ์วิทยา

ผลการศึกษา : ทารก 14 ราย (31.1%) มีอาการและอาการแสดงของทางเดินหายใจส่วนบนอุดตันภายหลังถอดท่อช่วยหายใจ อาการที่พบบ่อยคือหายใจเข้าลำบาก (inspriratory dyspnea) มีเพียง 4 รายเท่านั้นที่มีอาการ inspiratory stridor ทั้ง 4 รายมีน้ำหนักแรกเกิดมากกว่า 2,500 กรัม ตรวจพบความผิดปกติจากการทำ flexible bronchoscopy ในทารก 42 ราย ร้อยละ 68.8 มีพยาธิสภาพเกิดขึ้นที่หลายตำแหน่ง พยาธิสภาพบริเวณ supraglottic พบได้ร้อยละ 55.7 และมีทารก 9 ราย ที่มีพยาธิสภาพอื่นร่วมด้วย (laryngomalacia 8 ราย, gastroesophageal reflux 1 ราย)

สรุป : จากการศึกษาพบว่าภาวะแทรกซ้อนในทางเดินหายใจซึ่งเกิดจากการใส่ท่อช่วยหายใจ พบในทารกแรกเกิดเกือบทุกราย มักพบพยาธิสภาพหลายตำแหน่ง ทารกส่วนใหญ่ไม่แสดงอาการภายหลังถอดท่อช่วยหายใจออก ทารกที่แสดงอาการมักมีน้ำหนักมากกว่า 2,500 กรัม อาการที่สำคัญคือ อาการหายใจลำบาก ดังนั้นถ้าตรวจพบทารกมีอาการหายใจลำบากซึ่งไม่มีความสัมพันธ์กับพยาธิสภาพในปอดหรือไม่สามารถถอดท่อช่วยหายใจได้ ควรตรวจวิเคราะห์หาสาเหตุโดยการทำ flexible bronchoscopy เพราะสามารถทำได้ที่ข้างเตียง และไม่พบภาวะแทรกซ้อนที่รุนแรง

คำสำคัญ : ท่อช่วยหายใจ, การช่วยหายใจ, การส่องกล้องตรวจทางเดินหายใจ, ภาวะแทรกซ้อนในทางเดินหายใจ, bronchoscopy, newborn infant, ทารกแรกเกิด

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