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Incidence and Predictors of Postextubation Laryngeal Edema in Pediatric Patients with Congenital Heart Disease

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Laryngeal edema developed in 10.1% of studied patients with congenital heart disease after cardiac surgery. The 181 patients were divided into two groups; those with laryngeal edema (group 1) and those without laryngeal edema (group 2). The mean ages in group 1 and 2 were 10 and 22.9 months. Group 1 patients were younger on average than those of group 2 ($p<0.05$). The differences in the cardiopulmonary bypass time and anesthesia time between the two groups were not statistically significant. The duration of intubations and ventilatory support before and after the onset of laryngeal edema and the period of the ICU stay were longer in group 1 than in group 2 ($P<0.05$). A predictor of postextubation laryngeal edema was not found in our patients from above mentioned parameters. We conclude that the higher incidence of laryngeal edema may be due to young age (most were under 1 year of age), and duration of intubation and ventilatory support.

Key Words: Postextubation laryngeal edema, child, congenital heart disease, cardiac surgery

The rapid development of upper airway obstruction or croup as evidenced by hoarseness, stridor and critical airway obstruction is a potential threat to child who have had endotracheal intubation. Laryngeal edema is one of the most severe complications of tracheal intubation because it causes significant morbidity and can lead to death (Colice *et al.* 1989; Becher and Marin-Padilla. 1992; Supance *et al.* 1982; Johi *et al.* 1972; Stein *et al.* 1960). There are many risk factors associated with the incidence of postextubation laryngeal edema (Kemper *et al.* 1991). However, it is not easy to find specific predictors of laryngeal edema.

In this study, we evaluated the incidence of and looked for the predictors of laryngeal edema in pediatric patients with congenital heart disease after cardiac surgery.

PATIENTS AND METHODS

All pediatric patients under 15 years of age with congenital heart disease were included. Patients were admitted to the Intensive Care Unit, Cardiovascular Center, Yonsei Medical College from January to June, 1993, then intubated by the oral route for hemodynamic and respiratory management including ventilator support after cardiac surgery for congenital heart disease.

Endotracheal tubes were extubated after cardiovascular and respiratory stability was a-

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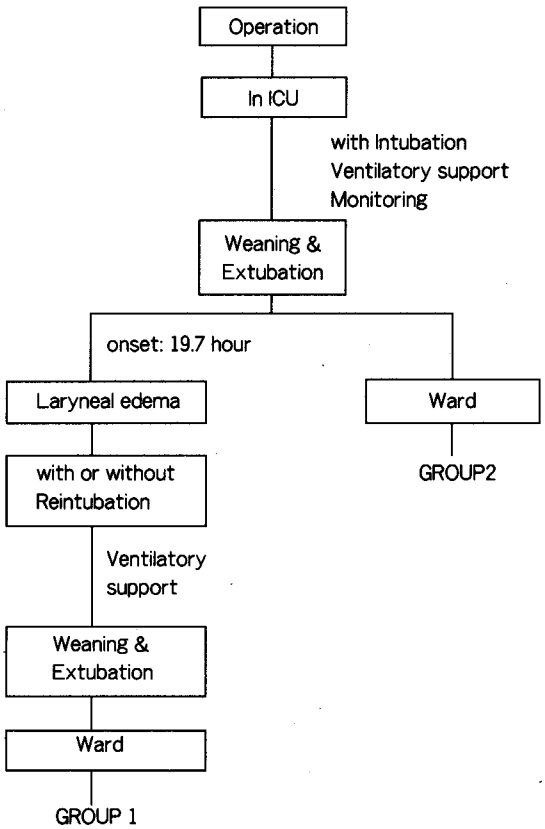

Fig. 1. *Patient interhospital movement diagram.*

chieved. In 20 patients, laryngeal edema developed and reintubation by the oral route was performed. We classified these patients into group 1, the other patients in whom laryngeal edema did not developed during their stay in the Intensive Care Unit were classified as group 2. A smaller endotracheal tube was used for reintubation because the laryngeal edema was generally too severe to allow insertion of the same size endotracheal tube. During recovery, the patient received cardiovascular and respiratory management. After recovery re-extubation was performed. All patients were then transferred to the general ward (Fig. 1).

Data was collected from a special protocol form completed for each child, and the following characteristics were recorded: age, gender, diagnosis with operation name, admission time, hemodynamic data and arterial gas analysis at admission and at weaning, extubation time, and discharge time.

Student's t-test or the Chi-square test were used to compare the variables for the patients in group 1 and group 2. Stepwise logistic regression was used to arrange the variables in the order of the strongest to the weakest factor.

Table 1. Vital sings and blood gas data at onset of laryngeal edema in group 1 Mean±SD

Onset(hours)	19.69±7.80
MAP	68.31±1.64
Pulse rate	153.00±6.45
RR	52.40±4.43
BT	37.35±0.23
PaO_2	84.12±9,56
pH	7.42±0.00
$PaCO_2$	38.56±6.56

MAP: Mean arterial pressure, mmHg, Pulse rate: frequency/min, RR: Respiratory rate, frequency/min, BT : body temperature, ℃, PaO_2−mmHg; $PaCO_2$−mmHg

RESULTS

Laryngeal edema developed on average of 19.7 hours after extubation. In group 1, the diagnosis of laryngeal edema was based on clinical symptoms and signs, such as inspiratory stridor, tachypnea (52.40±4.43 times/minutes) and tachycardia (153.00±6.45 frequencies/minutes) (Table 1).

The number of patients in group 1 was 20 and in group 2 was 161. The incidence of laryngeal edema was 10.1% in our patients. All patients in group 1 were under 3 years of age. More than fifty percent of patients were under 12 months old (110 out of 181 patients). There was no death in group 1 while 10 patients died in group 2 (Table 2).

The mean age in group 1 was 10 months old; group 1 was significantly younger than

Table 2. Age distribution

Age(Year)	Group 1	Group 2	Total
< 1month	3	8	11
1 to 6 months	8	55	63
7~12 months	3	33	36
1~3 Yrs.	6	38	44
4~15 Yrs.	0	27	27
Expired patients	0	10	

Group 1: patients in whom larygeal edema developed and reintubation was done.
Group 2: patients in whom laryngeal edema did not develop.

Table 3. Patient characteristics **Mean±SD**

	Group 1	Group 2
Age(month)	10.0±4.56[a]	22.85±4.65
Bwt(Kg)	6.99±1.70[b]	9.65±1.38
Ht(cm)	69.76±3.65[c]	79.52±3.44
BSA(L/m^2)	0.36±0.07[d]	0.55±0.23

[a,b,c,d] $P<0.05$ between Group 1 and Group 2
Bwt: body weight, Ht: height, BSA: body surface area

Table 4. Cardiopulmonary bypass time and anesthesia time **Mean±SD**

	Group 1	Group 2
Bypass time(min)	87.00±10.20	84.99±12.34
Anesthesia time(min)	263±15.34	261.59±14.22

min: minutes

group 2 ($P<0.05$). The mean body weight and height were also significantly less (Table 3).

Table 4 shows the bypass time and anesthesia time. Although both times were greater for group 1, the difference was not statistically significant.

The period of intubation and ventilatory support before the onset of laryngeal edema and reintubation in group 1 were 68.31±0.98 hours and 59.13±2.32 hours respectively. These were longer than those of group 2 ($p<0.05$) (Table 5).

Table 5. Duration of intubation and ventilatory support before the onset of laryngeal edema **Mean±SD**

Duration	Group 1	Gruop 2
Ventilatory support (hours)	59.13±2.32[a]	35.31±12.33
Intubation(hours)	68.31±0.98[b]	37.73± 8.44

[a,b] $P<0.05$ between Group 1 and Group 2

Table 6. Duration of intubation, ventilatory support and ICU stay **Mean±SD**

Duration	Group 1	Group 2
Ventilatory support (hours)	114.72±16.22[a]	35.31±12.33
Intubation(hours)	126.18±12.44[b]	37.73±8.44
ICU stay(days)	13.30± 2.22[c]	5.84±1.29

[a,b,c] $P<0.05$, between Group 1 and Group 2.

Table 7. Predictors of postextubation laryngeal edema

	Estimate	Chi-Square*
Age(months)	−0.003	0.10
Body weight(kg)	0.012	0.05
Endotracheal tube size	0.017	0.00
pH at admission	−0.976	0.26
$PaCO_2$ at admission	−0.005	0.05
Duration of ventilatory support	0.000	1.39
Duration of intubation	0.000	1.55
Duration of ICU stay	0.005	0.02

*: all values of Chi-square were not statistically significant.

Duration of intubation, ventilatory support and the ICU stay were 126.18 ± 12.44, 114.72 ± 16.22 hours and 13.30 ± 2.22 days respectively

and these were longer than those of group 2 ($P<0.05$) (Table 6).

Predictors of postextubation laryngeal edema were not found among the factors of age, body weight, endotracheal tube size, pH or $PaCO_2$ at admission to the intensive care unit or to the duration of ventilatory support, intubation, or ICU stay ($p>0.05$) (Table 7).

DISCUSSION

The incidence of laryngeal edema is variable. The incidence varies from 1% to 13.7% in children under 15 years of age and from 2% to 15.4% in adults (Darmon *et al.* 1992). In our study the incidence was 10.1% among 181 patients under 3 year of age. The high incidence of laryngeal edema in our patient may be due to the young age of our patients, mean age 10 months old, as compared with other studies. An increased risk of tracheolaryngeal injury after tracheal intubations in humans (Darmon *et al.* 1992) has been associated with trauma during tracheal intubation (Koka *et al.* 1977), i. e., the number of times intubation tried, duration of intubation (Donnelly, 1969), use of large tubes (Deming and Oech. 1961), overinflated cuffs (Bernhard *et al.* 1985), intubation by the oral route (Dubick and Wright, 1978) and alteration of tracheal tube position (Conrardy *et al.* 1976). Especially in infants, the number of times intubation tried and a duration of intubation of more than 7 days is significantly associated with laryngeal injury (Fan *et al.* 1983; Sherman *et al.* 1986). In our patients, orotracheal intubation was done by a skilled anesthesiologist at the operation room with the use of sedatives and neuromuscular blockades. All the intubations were performed successfully during the first trial and the duration of intubation before the onset of laryngeal edema and reintubation was about 68 hours. We could not find any statistically significant predictors of postextubation laryngeal edema among the factors of age, body weight, endotracheal tube size, duration of ventilatory support, intubation, or ICU stay (Table 7). In group 1, no patients expired because reintubation was performed before the patients' conditions became worse. An absence of an airleak at a pressure of 25 cmH_2O~30 cmH_2O during suctioning before extubation is a predictor of laryngeal edema requiring treatment in pediatric postoperative and trauma patients (Koka *et al.* 1977: Kemper *et al.* 1991). However an airleak at an inflation pressure of 25 cmH_2O in neonate has not been described as a significant risk factor (Fan *et al.* 1983).

In our patients, we did not permit an airleak around the tube because the duration of surgery was more than 4 hours and all the patients required ventilator support. During ventilatory support, a leak around the endotracheal tube would cause a loss of tidal volume and result in hypoventilation. In addition, we had to determine that the patients were not in a state of heart failure, because reintubated cardiac patients have greater tidal volume values and lower respiratory rates than those with successful extubation (Hilberman *et al.* 1976; Michel *et al.* 1979; Tahvainen *et al.* 1983; Locicero *et al.* 1992).

Patients undergoing a cardiopulmonary bypass of more than 30 minutes have a three times greater chance of requiring postoperative mechanical ventilatory support. Longer intubation increases the opportunities for equipment malfunction, iatrogenic injury or self extubation. In patients requiring anesthesia for longer than 6 hours, the need for mechanical ventilation is twice as great when compared with those with a duration of less than 6 hours (Barash *et al.* 1990; Heard *et al.* 1985; Schuller *et al.* 1984). In our patients, the cardiopulmonary bypass time averaged 87 minutes and the anesthesia time averaged 260 minutes, although the difference was not significant between the two groups.

The patients of group 1 required longer periods of intubation and ventilatory support. Laryngeal edema prolongs the duration of respiratory failure and the need for continued intubation (Rashkin and Davis, 1986).

In our patients the incidence of laryngeal edema was higher than in other groups. This may be due to the fact that most of patients were under 1 year of age and in a high risk category. Also the cardiopulmonary bypass

time was over 30 minutes and the anesthesia time was more than 4 hours. The incidence of laryngeal edema might be lower if we inserted a smaller tube which permitted an airleak. However, because an airleak during ventilatory support could cause hypoventilation which would make patients more unstable immediately after surgery and during their ICU stay, we did not.

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