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Clinical report

Simple deep hypothermia for repair of congenital tracheal stenosis: a case report

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Introduction

Congenital tracheal stenosis (CTS) is a rare disease that is frequently accompanied by cardiovascular malformations such as pulmonary artery sling (PA sling). It is difficult to make the diagnosis soon after birth, and death may occur before surgery. Anesthetic management for surgical repair is technically difficult, and the prognosis is particularly poor when the stenotic lesion is extensive or close to the tracheal carina [1–4]. The present report describes tracheal repair of CTS using a costal cartilage graft under simple deep hypothermia.

Case report

A 6-month-old boy, 58 cm in height and 4.1 kg in weight, was admitted to our hospital because of stridor and dyspnea. He was born in the 37th gestational week with a birth weight of 2088 g, and was diagnosed postnatally as having anorectal stenosis, idiopathic intestinal perforation, and trisomy 13. Partial intestinal resection and proctostomy were performed immediately after birth. He suffered from tachypnea, stridor, and tracheal tug after the surgery. At 5 months of age, these tracheal symptoms deteriorated, and emergency cardioangiography confirmed the diagnosis of PA sling, for which left pulmonary artery grafting was performed. Artificial ventilation was continued for one month after the surgery, with no symptomatic improvement. At 6 months of age, CTS was diagnosed, based on computed tomography, bronchoscopy and esophagography (Fig. 1). Surgery for tracheal repair under simple deep hypothermia was scheduled.

The patient was premedicated with 0.05 mg of atropine sulfate, 2.5 mg of hydroxyzine hydrochloride, and 5 mg of pethidine intramuscularly 30 min before the induction of anesthesia.

Two hundred micrograms of fentanyl were administered i.v. at the beginning of the surgery, and then a piece of costal cartilage was extracted for tracheal repair. After a further 300 μg of fentanyl (for a total of 700 μg) and 150 mg of methyl prednisolone had been administered i.v., the patient was covered with a vinyl sheet and immersed in iced water for surface cooling. During the cooling period, 55 ml of 10% low-molecular-weight-dextran in lactated Ringer's solution (LMWD-L), 55 ml of 5% dextrose, and lidocaine at the high dose of 40 $mg \cdot h^{-1}$ (10 $mg \cdot kg^{-1} \cdot h^{-1}$) were infused continuously. Dobutamine hydrochloride (DOB) at 5 to 15 $\mu g \cdot kg^{-1} \cdot min^{-1}$ was also given continuously to maintain an optimal arterial blood pressure during anesthesia. When the esophageal temperature had fallen to 30°C, 500 units of heparin were administered i.v. When severe hypotension was observed, 1 ml of cardiotonic cocktail (10 ml of 20% dextrose, 10 ml of 2% $CaCl_2$, and 1 ml of 0.1% norepinephrine in 21 ml solution) was administered i.v. When the target esophageal temperature of 20°C had been achieved, iced water was removed and surgery was started. The esophageal temperature fell naturally to 19.6°C.

After median sternotomy, the venae cavae, the pulmonary artery, and the aorta were clamped. Ten milliliters of Young's solution (5 g of potassium citrate, 12.3 g of magnesium sulfate, and 5 mg of neostigmine bromide in 500 ml solution) was injected into the coronary artery through the aorta to induce cardiac standstill. Tracheal

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repair was then completed using the costal cartilage as a graft.

After the tracheal repair, the patient underwent intubation with a specially designed long nasotracheal tube (26 cm length, 4 mm ID; Portex, Kent, England) just above the carina (13 cm from the nares), beyond the stenotic region. To confirm the position of the endotracheal tube in postoperative management, a titanium marker was attached to the distal end of the costal cartilage patch. Cardiac resuscitation was then performed at 19.9°C esophageal temperature, as follows. Artificial ventilation was started and the clamps were removed from all large vessels, except the aorta. Ten milliliters of the cardiotonic cocktail and autologous blood were pumped with a syringe several times into the coronary artery through the aorta. Because of bradycardia and hypotension, cardiac massage was then performed for about 10 min. When the heart started to beat, the aortic clamp was removed. The duration of aortic clamping was 73 min. The patient was surface-warmed to 36°C esophageal temperature with warm water at 42°C.

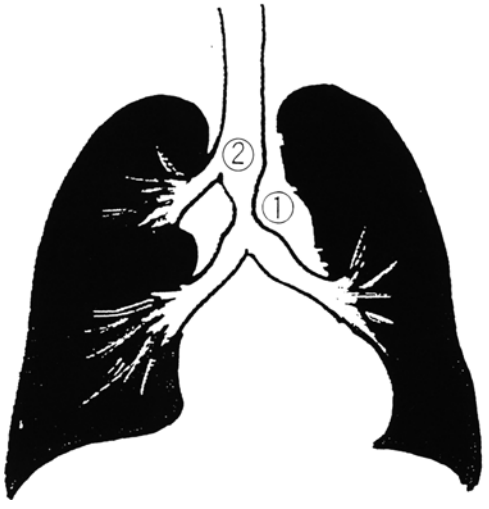

Fig. 1. Congenital tracheal stenosis. ① Stenotic lesion; ② tracheal bronchus to right upper lobe

The acid-base balance was corrected with 20 ml of 7% sodium bicarbonate solution after cardiac resuscitation. During rewarming, lactated Ringer's solution at 20 $ml \cdot h^{-1}$ and stored whole blood were infused to maintain the level of CVP at 10 mm Hg. DOB was administered at 5 to 15 $\mu g \cdot kg^{-1} \cdot min^{-1}$ to maintain an optimal arterial blood pressure for the body temperature. At an esophageal temperature of 30°C, 5 mg of protamine sulfate was administered to reverse the effect of heparin, and 15 mg of furosemide was administered to induce urination at the end of rewarming. After reaching an esophageal temperature of 36°C, the patient was transferred to the intensive care unit, where mechanical ventilation was performed. Although an artificial heart-lung machine had been on stand-by in case of urgent events such as difficulty in cardiac resuscitation or circulatory arrest for over 75 min, it was not necessary to use it.

The anesthesia record and laboratory data during surgery are shown in Fig. 2 and Table 1. Fentanyl decreased heart rate but slightly increased arterial blood pressure at induction of anesthesia. Both arterial blood pressure and heart rate decreased gradually with decreased body temperature and recovered to baseline levels after rewarming to 36°C(Table 1). ECG revealed no risky changes such as ventricular arrhythmia or abnormal ST segment during the entire course of anesthesia.

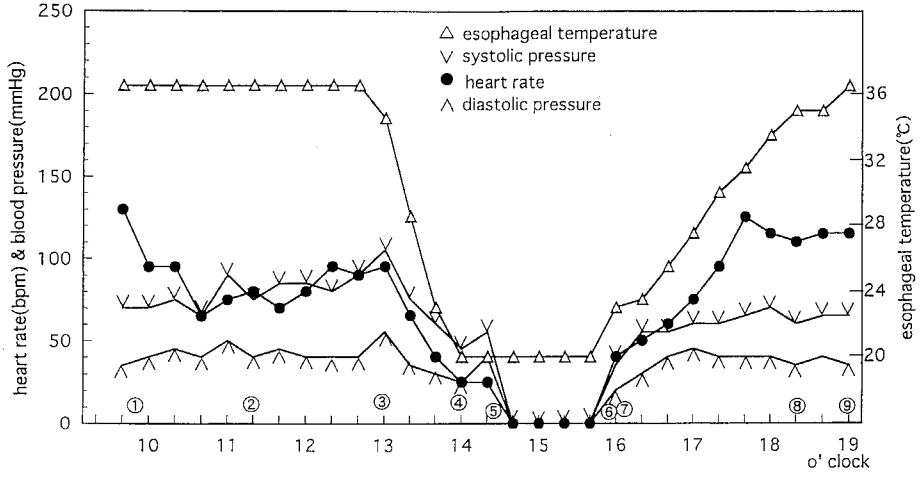

Fig. 2. Anesthesia record. ① Induction of anesthesia; ② beginning of surgery; ③ beginning of cooling; ④ end of cooling; ⑤ induced cardiac arrest; ⑥ release of aortic clamp; ⑦ beginning of rewarming; ⑧ end of rewarming; ⑨ end of surgery

Table 1. Laboratory data during anesthesia

Time	BT (°C)	Ph	$PaCO_2$ (mmHg)	PaO_2	BE ($mEq \cdot l^{-1}$)	Na^+	K^+	Ca^{++} ($mmol \cdot l^{-1}$)	BS ($mg \cdot dl^{-1}$)
9:35	36.5								
10:20	36.5	7.22	61	215	−3.1	129	4.8	1.00	80
12:30	37.0	7.37	39	353	−1.9	127	4.9	0.84	
13:15	29.0	7.47	30	544	−0.8	128	3.5	0.88	89
14:05	19.6	7.59	20	690	−0.4	125	3.5	0.78	93
16:12	24.4	7.15	30	455	−17.2	119	6.1	2.49	530
17:25	30.0	7.38	29	406	−6.8	130	3.7	1.26	253
19:00	36.0	7.44	36	458	1.4	132	4.8	1.01	113

BE, Base excess; BT, esophageal temperature; BS, blood sugar.
Blood gas was analyzed at 37°C (alpha-stat).
The heart was arrested for 73 min (14:35 to 15:48).

The fluid balance during the 10 h of anesthesia was as follows. The measured blood loss and urine volume were 31 g and 120 ml ($2.9 ml \cdot kg^{-1} \cdot h^{-1}$), respectively. Fifty-five milliliters of LMWD-L, 10 ml of lactated Ringer's solution, 55 ml of 5% dextrose, and 130 ml of stored whole blood were infused. The platelet count was $290 \times 10^3 \mu l^{-1}$ before surgery and $250 \times 10^3 \mu l^{-1}$ after surgery. The patient was conscious on the following morning and reacted well to sound and light. No neurological abnormalities, such as convulsions, were observed.

The postoperative management plan was to maintain mechanical ventilation until the cartilage graft was assimilated in the trachea and smooth respiration had become possible. Although there was no ventilation problem during the early postoperative period, the tip of the endotracheal tube drifted easily with body movement, and it was difficult to stabilize at the marked position. Obstruction of the airway due to proliferation of granulation tissue in the trachea was noticed several days after surgery. Tracheal dilatation was performed with a balloon on the 24th postoperative day, without any satisfactory result. Artificial ventilation remained difficult afterwards and multiple organ failure supervened. The patient died of hemorrhage from the granulation tissue in the trachea on the 61st postoperative day.

Discussion

CTS is a life-threatening disease, particularly if it involves a long segment of the trachea. If the lesion involves or is close to the carina, as in this case, perioperative management is technically more difficult. Although many institutions use extracorporeal support, such as cardio-pulmonary bypass (CPB) [5,6], or extracorporeal membrane oxygenation (ECMO) [7] for tracheal repair, these procedures give rise to many problems. CPB canuulae may crowd the operative field in such a small child as our patient. V-A ECMO can easily be accomplished through a cervical incision, and this approach for intraoperative support is attractive. Another benefit of ECMO is the option to provide postoperative extracorporeal support, which will spare the repaired portion from the stress of mechanical ventilation and suction during the early postoperative period. Although ECMO requires less heparin than CPB, the risk of bleeding is present in both types of extracorporeal support. Normal or high-freqency jet ventilation is one method of respiratory management during the surgery. However, this application is unusual, because it is lacking in reliability in ventilatory function, and blood is dispersed in different directions by the jet stream. The operating field can be narrowed by the endotracheal tube, and there is a risk of barotrauma to the lung.

We used simple deep hypothermia to reduce these difficulties, as described above. The platelet count was almost unchanged during the surgery, and platelet transfusion was unnecessary. Although cardiac massage was necessary, cardiac resuscitation was easily accomplished. The period of cardiac arrest slightly exceeded the time limit (60 min at 20°C [8]), but emergence from the anesthesia was smooth and no signs of cerebral damage were observed. Respiratory and hemodynamic functions were stable during the surgery. These findings suggest that simple deep hypothermia similar to CPB or ECMO can be recommended as management for repair of CTS.

A large dose of lidocaine ($10 mg \cdot kg^{-1} \cdot h^{-1}$) was infused continuously during the cooling phase to prevent serious ventricular arrhythmia due to hypothermia. Although we have infused a similar large dose of lidocaine during the cooling phase in all cases of simple deep

hypothermia under a large dose of fentanyl anesthesia, we have never experienced any problems due to lidocaine intoxication such as convulsions, circulatory dysfunction, or delayed awakening [9]. The total dose of lidocaine administered reached 15 mg·kg^{-1} for 90 min. We were not concerned about lidocaine intoxication, because a large dose of lidocaine (approximately 5–10 mg·kg^{-1} or more i.v. by rapid infusion) is recommended for ventricular fibrillation in the pediatric patient [10]. Lidocaine was also expected to have a protective effect for the ischemic brain during circulatory arrest [11].

Postoperative respiratory management required special attention for this case. The right upper lobe was not ventilated during the perioperative period, because the trachea was intubated over the tracheal bronchus. Although ventilation of the lobe might be possible by using a special endotracheal tube sideholed for the abnormal bronchus, it was not carried out in the operating room. The main reason was the difficulty of adjusting the sidehole of the tube to the position of the tracheal bronchus, as well as of placing the tip of the tube just above the carina. Moreover, even if such a sideholed tube could be obtained, it might be very difficult to put it in the proper position. We decided not to ventilate the lobe, expecting that it would recover even after prolonged atelectasis [12,13].

In this case, stabilization of the endotracheal tube at a suitable position and maintenance of complete rest were very difficult because of tracheal narrowing by granulation formation and bleeding after the operation. Though there is a report in which the operation was performed without oxygenation support such as ECMO, and respiration could be managed by an endotracheal tube alone [14], ECMO may be indicated when the endotracheal tube cannot provide a proper airway because of a long stenotic lesion close to the carina, as in this case. In such a situation, simple deep hypothermia may facilitate intraoperative management by preventing hemorrhage due to thrombocytopenia, and ECMO may be useful for postoperative respiratory management.

In conclusion, simple deep hypothermia can be used for the surgical repair of CTS in babies with difficulties in anesthesia.

References

1. Kondo K, Nagaya M, Tsuda M, Iio K, Harada T (1989) A case of congenital diaphragmatic hernia with congenital tracheal stenosis (in Japanese). Shouni Geka (Jpn J Pediatr Surg) 21:461–466
2. Cantrell JR, Guild HG (1964) Congenital stenosis of the trachea. Am J Surg 108:297–305
3. Idriss FS, DeLeon SY, Ilbawi MN, Gerson CR, Tucker GF, Holinger L (1984) Tracheoplasty with pericardial patch for extensive tracheal stenosis in infants and children. J Thorac Cardivasc Surg 88:527–536
4. Kimura K, Mukaihara N, Tsugawa T, Matsumoto Y, Murata H (1982) A new technique for repair of congenital tracheal stenosis involving the entire trachea (in Japanese). Shouni Geka (Jpn J Pediatr Surg) 14:1267–1272
5. Walker LK, Wetzel RC, Haller JA (1992) Extracorporeal membrane oxygenation for perioperative support during congenital tracheal stenosis repair. Anesth Analg 75:825–829
6. Michawl ED, Lauren DH, Carl LB, Constantine M (1994) Management of severe congenital tracheal stenosis. Ann Otol Rhinol Laryngol 103:351–356
7. Nagata T, Taenaka N, Imanaka H, Yagi M, Sasaki S, Kamata S, Yoshiya I (1992) Perioperative management with extracorporeal membrane oxygenation of congenital tracheal stenosis—a report of two cases (in Japanese with English abstract). ICU To CCU (J Intensive Care Med) 16:983–987
8. Wakusawa R, Okada K (1989) Simple deep hypothermia (in Japanese). In: Kimoto S, Wada T (eds) New encyclopedia of surgical science 3. Nakayama Shoten, Tokyo, pp 149–166
9. Okada K, Kawamura T, Okada H, Nakayama H, Wakusawa R (1997) Simple deep hypothermia with a large amount of fentanyl anesthesia in neonates undergoing correction for total anomalous pulmonary venous return. J Anesth 153–158
10. Montgomery WH (1986) Standard and guidlines for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). JAMA 255:2905–2992
11. Fujitani T, Adachi N, Miyazaki H, Liu K, Nakamura Y, Kataoka K, Arai T (1994) Lidocaine protects hippocampal neurons against ischemic damage by preventing increase of extracellular excitory amino acid: a microdialysis study in Mongolian gerbils. Neurosci Lett 179:91–94
12. Logeais Y, Florent GD, Danrigal A, Barre E, Maurel A, Vanetti A, Renault P, Galey JJ, Mathey J (1970) Traumatic rupture of the right main bronchus in an eight-year-old child successfully repaired eight years after injury. Ann Surg 172:1039–1047
13. Suito T, Ishihara T, Yamazaki S, Kobayashi K, Kaseda S, Suzuki S, Nishimura Y, Sakai S, Kato R, Yamasawa F, Kawasiro T, Okada Y (1985) Preservation of respiratory function by right upper sleeve lobectomy with creation of new carina for complete atelectasis of the right lung (in Japanese with English abstract). Kyoubu Geka (Jpn J Thoracic Surg) 38:700–705
14. Sugimoto M, Fujino Y, Nishimura S, Hagihira S, Ikeda M, Kawase T, Taenaka N, Yoshiya I (1996) Postoperative management of congenital tracheal stenosis—method of sedation (in Japanese with English abstract). Nippon Shuuchu Chiryou Igakkai Zasshi (J Jpn Soc Intensive Care Med) 4:263–268