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Experiences of Tracheal Procedure Assisted by Extracorporeal Membrane Oxygenator

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We report on the application of a venovenous type extracorporeal membrane oxygenator (ECMO) in high-risk tracheal procedures in six cases consisting of five patients with tracheal stenosis. An ECMO should be helpful for preventing respiratory emergency during a tracheal procedure.

Key words: 1. Tracheal stenosis
2. Extracorporeal circulation

CASE REPORT

A 43-year-old woman was transferred from another hospital complaining of aggravated dyspnea on exertion. She was diagnosed with squamous cell carcinoma of the trachea with liver and bone metastasis (clinical stage IV, T4N3M1b) one month prior. The trachea mass was located 3 cm below the vocal cord and was worsening the dyspnea (Fig. 1A, B). For symptom relief, mass excision using rigid bronchoscopic cryotherapy was planned. During the procedure, extracorporeal lung assist was also planned to prevent complications such as respiratory arrest due to airway obstruction and a prolonged procedure.

The extracorporeal membrane oxygenator (ECMO) insertion and cryotherapy were performed at the intensive care unit (ICU) without intubation. The patient was 159 cm in height and weighed 64.5 kg (body surface area 1.69 m^2). Midazolam (2 mg) and ketamine (100 mg) were used for sedation induction, and remifentanil (0.1 μg/kg/min) was continuously infused for sedation during the procedure. Before ECMO cannula insertion, heparin 4,000 IU was administered for anticoagulation. An inflow cannula (18 Fr) was inserted into the right femoral vein, and an outflow cannula (22 Fr) into the left femoral vein according to Seldinger's technique. The peak flow of the ECMO perfusion was 4.0 L/min, and nafamostat mesilate (7.5 mg/hr) was continuously administered via the outflow cannula for anticoagulation. Rigid bronchoscopic cryotherapy was performed for 20 minutes without any complications (Fig. 1C). After the procedure, the patient was stabilized without bleeding and cautiously weaned off the ECMO. The total ECMO time was 478 minutes. No problems occurred during or after ECMO perfusion. The patient was transferred to the general ward on same day of the operation and was discharged from the hospital on postoperative day 3. The follow-up bronchoscopy on postoperative day 13, revealed an intact airway with a regressed tumor size (Fig. 1D).

The representative case was introduced above. A total of planned extracorporeal lung assist in five patients were performed from December 2009 to March 2011 (Table 1). The

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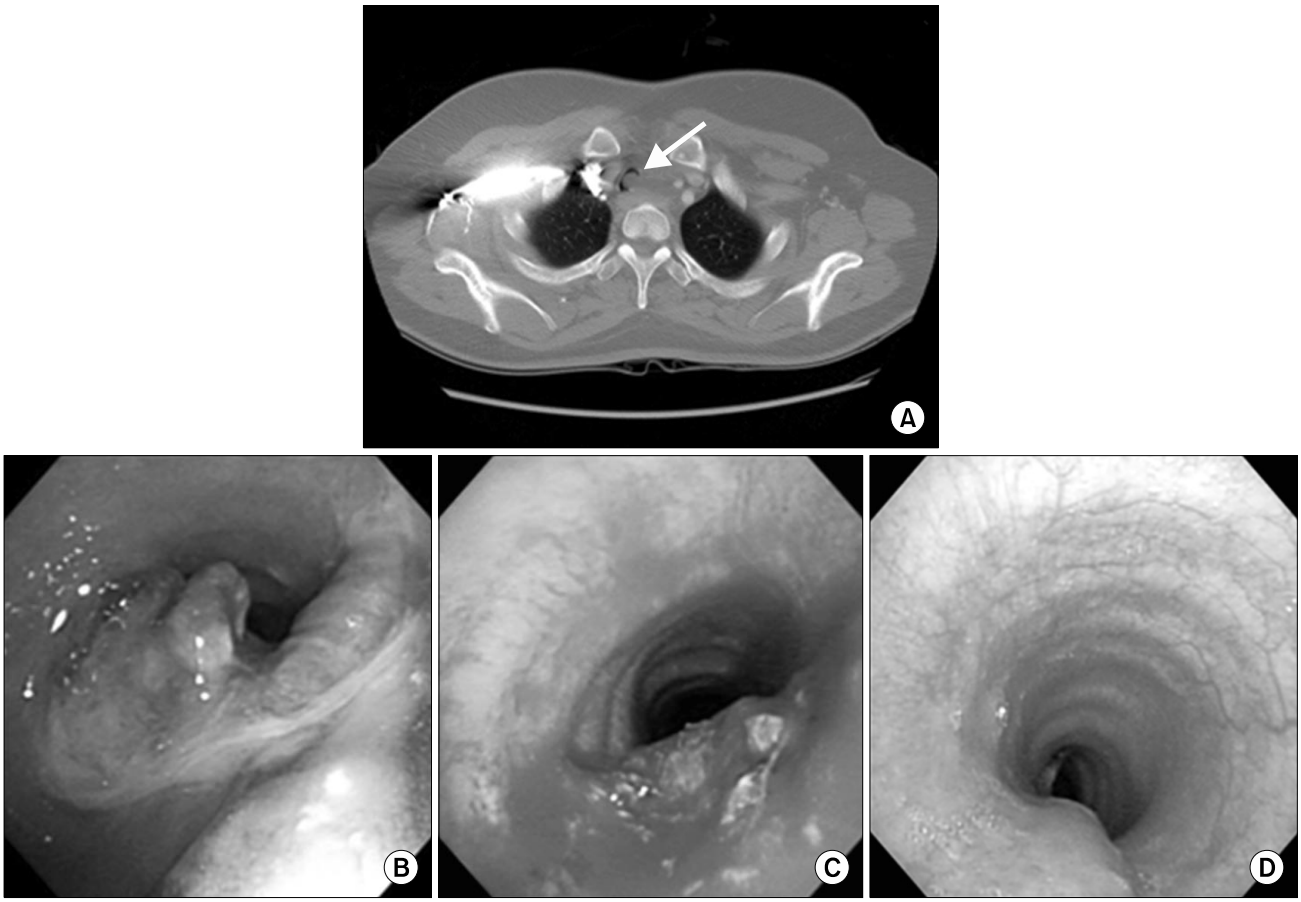

Fig. 1. (A) Chest computed tomography and (B) bronchoscopy showing the tracheal mass and narrow airway. (C) Bronchoscopy immediately after cryotherapy shows the tumor excision site with mild bleeding. (D) Follow-up bronchoscopy on 13 days after cryotherapy shows an intact airway with a regressed tumor size.

patients' mean age was 64.4 years. The underlying diseases that lead to tracheal stenosis were malignancies in four cases and tracheal stent malfunctions in two cases. A venovenous type ECMO (Capiox Emergency Bypass System; Terumo Inc., Tokyo, Japan) was applied at the ICU in all the cases. Among the six tracheal procedures, three tracheal stent insertions were performed in the fluoroscopy room, and the other procedures at the ICU. The mean ECMO duration was 775.2 minutes. Nafamostat mesilate or heparin was used for anticoagulation. In the stent removal and cryotherapy cases, nafamostat mesilate (mean dosage 0.13 mg/kg/hr) was infused via the outflow cannula to reduce bleeding complications. In the cases using heparin, the activated clotting time was maintained at 160 to 180 seconds.

Except in one case, there was no emergency situation or complications during ECMO perfusion. One early death caused by bleeding occurred. A 74-year-old man who had undergone tracheal stent insertion 2 months previously, underwent tracheal stent removal due to a tracheal stent fracture. ECMO insertion and tracheal stent removal were performed without any problems. However, five hours after the procedure, bleeding of an unknown origin occurred despite the use of a low dose of nafamostat mesilate.

DISCUSSION

The first case of non-cardiac surgical application of extracorporeal circulation was reported by Woods et al. [1] in 1961. They used extracorporeal circulation for resection of the carina and both main stem bronchi for bronchial

Table 1. Characteristics of the five patients (six cases) who underwent planned extracorporeal lung assist in a tracheal procedure

No.	Sex/age	Underlying disease	Tracheal procedure (place)	Intubation	ICU stay (hr)
1	F/67	Recurred thyroid cancer	Tracheal stent insertion (fluoroscopy room)	Post procedure	50
2-1	M/74	Small cell lung cancer	Tracheal stent insertion (fluoroscopy room)	Post procedure	23
2-2		Tracheal stent insertion 2 mo ago, tracheal stent fracture	Tracheal stent removal (ICU)	Post procedure	-
3	M/82	Esophageal cancer	Tracheal stent insertion (fluoroscopy room)	No	72
4	M/57	Postintubation tracheal stenosis, (tracheal stent insertion 5 mo ago), tracheal stent downward migration	Tracheal stent removal (ICU)	No	28
5	F/42	Tracheal cancer	Cryotherapy (ICU)	No	9

No.	ECMO							
	ECMO type	ECMO duration (min)				Cannulae (inflow [Fr]/outflow [Fr])	Anticoagulation	Complications
		Pre	Procedure	Post	Total			
1	V-V	187	95	1,360	1,642	RFV (18)/LFV (20)	Heparin	None
2-1	V-V	180	45	347	572	RFV (18)/LFV (22)	Heparin	None
2-2	V-V	115	75	852	1,042	RFV (18)/LFV (22)	Futhan	Bleeding→expired
3	V-V	180	55	215	450	RFV (18)/LFV (20)	Heparin	None
4	V-V	12	60	395	467	RFV (18)/LFV (20)	Futhan	None
5	V-V	13	20	445	478	RFV (18)/LFV (20)	Futhan	None

ICU, intensive care unit; ECMO, extracorporeal membrane oxygenator; V-V, venovenous; RFV/LFV, right/left femoral vein.

adenoma. Phillips et al. [2] described the percutaneous use of extracorporeal circulation in 1983. In 1996, Horita et al. [3] reported that a venovenous bypass with an oxygenator via a percutaneous femoral venous approach was used to perform carinal reconstruction. Choi and Kim [4] reported that tracheostomy was used to assist with an emergency bypass system in a case of severe tracheal stenosis in 2007.

The causes of tracheal stenosis are numerous. The most common cause is post-intubation and tracheostomy. In addition, inflammatory diseases, tumor, and trauma can all be factors. In general, surgical treatment has had good results [5,6]. However, in our cases, the length of the stenosis was long or the lesion was below the vocal cords, and the causes of the tracheal stenosis were unresectable tumors; thus, palliative methods were chosen.

An ECMO has usually been applied in rescue situations. However, in our cases, because airway obstruction was predicted during the procedure, we decided to make preparations using venovenous ECMO. During ECMO perfusion, the surgeons could concentrate on the procedure without worrying about the patients' oxygenation. Alexander has also reported a case of ECMO preparation during rigid bronchoscopic tracheal stent removal. After the first attempted stent removal in the operation room had failed because of an airway obstruction, venoarterial ECMO assist was performed, and the stent was removed successfully [7].

Currently our institutional indication for extracorporeal lung assist in a tracheal procedure is that airway obstruction is expected during the procedure due to severe tracheal stenosis, and the tracheal procedure is difficult and time-consuming, due to issues such as ruptured tracheal stent removal. However, the ECMO also has its own risks, such as thromboembolism and bleeding due to anticoagulation. To reduce the complications, we chose the venovenous type ECMO and nafamostat mesilate as an anticoagulant for some cases. However, the duration of ECMO was quite long because we tended to wean the patients from the ECMO slowly. One death from bleeding occurred. By applying an ECMO only when necessary and according to the indications and reducing the ECMO duration, the procedure can be performed more

safely.

In our cases, for anticoagulation during ECMO perfusion, initial heparin bolus was infused, followed by continuous infusion of heparin or nafamostat mesilate for maintenance. Nafamostat mesilate, a synthetic protease inhibitor with a short half-life, has been widely used as an anticoagulant to reduce bleeding in hemodialysis patients. It has been reported that nafamostat mesilate also produces good results when it is applied for anticoagulation in cardiac surgery with an ECMO. However, various dosages were used in each study [8]. To avoid bleeding complications in our stent removal and cryotherapy cases, nafamostat mesilate was used. There was no thromboembolism or oxygenator malfunction during ECMO perfusion, but one bleeding complication had occurred. More studies are needed for determining the appropriate nafamostat mesilate dosage in ECMO perfusion.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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