Case Report

The use of veno-venous extracorporeal membrane oxygenation for massive hemoptysis following a traumatic lung injury: a case report

Takuya Sugiyama, Tokiya Ishida, Hideyuki Yokoyama, Yoshibumi Kumada, and Kazuaki Shinohara

Department of Emergency and Critical Care Medicine, Ohta Nishinouchi Hospital, Koriyama, Japan

Background: Published reports regarding the use of veno-venous extracorporeal membrane oxygenation (V-V ECMO) for massive hemoptysis following a thoracic injury are still scarce.

Case Presentation: A 34-year-old man developed massive hemoptysis from the right lung after a 2 m fall and being compressed with an iron pipe weighing 500 kg. He was immediately intubated using a double-lumen tube, and one-lung ventilation was started. Endotracheal hemorrhage was controlled by sealing the right lumen. V-V ECMO was initiated to endure the lethal hypoxemia while waiting for the right lung to heal. He came off of V-V ECMO after 17 days and was discharged on foot on day 46.

Conclusion: The strategy of using V-V ECMO in combination with one-lung ventilation is useful and should be strongly considered to save lethal massive hemoptysis cases following traumatic lung injury.

Key words: Anticoagulation, hemoptysis, one-lung ventilation, traumatic lung injury, V-V ECMO

INTRODUCTION

MANY REPORTS HAVE been published recently regarding the use of veno-venous extracorporeal membrane oxygenation (V-V ECMO) for trauma-related acute respiratory distress syndrome.[1] However, publication regarding the use of V-V ECMO for massive hemoptysis following a traumatic lung injury is still scarce.

We report a case of massive hemoptysis following a thoracic injury, who was successfully treated applying V-V ECMO in combination with one-lung ventilation using a double-lumen tube (DLT).

CASE REPORT

A 34 -year-old man with a history of hypertension and hyperuricemia was admitted to our hospital after accidently falling on to a concrete floor from a height of 2 m and then being compressed between the floor and an iron pipe weighing 500 kg that fell from the overhead scaffold. Primary survey findings were as follows: airway intact, tachypneic with a respiratory rate of 35 breaths/min, SpO_2 of 93% (O_2 10 L/min with reservoir mask), decreased breath sounds on the right, chest wall tender to palpation on both sides, heart rate of 115 b.p.m., blood pressure of 172/95 mmHg, no active bleeding on the body surface, Glasgow Coma Scale score 15 (E4V5M6), pupils equal and reactive at 4 mm, and no hemiplegia. Focused Assessment with Sonography for Trauma was negative, chest X-ray showed diffuse contusion on the right lung, and pelvic X-ray showed no pelvic fracture. Contrast-enhanced computed tomography scan (CE-CT) showed bilateral pulmonary contusions and hematomas with multiple traumatic pneumatoceles on the right lung (Fig. 1A), right hemopneumothorax, bilateral multiple rib fractures, right scapula fracture, a sternal fracture, and a minor liver injury.

He showed no signs of hemoptysis on admission, so after a right chest tube insertion, he was admitted to the intensive care unit (ICU). However, on day 2, he suddenly developed massive hemoptysis with his PaO_2/FiO_2 ratio (P/F ratio) falling to 41.1 (Fig. 2). He was immediately intubated using a left DLT for one-lung ventilation to prevent the blood from

Corresponding: Takuya Sugiyama, MD, Department of Emergency and Critical Care Medicine, Ohta Nishinouchi Hospital, 2-5-20 Nishinouchi, Koriyama, Fukushima 963-8558, Japan. E-mail: pioneer1248st@gmail.com.
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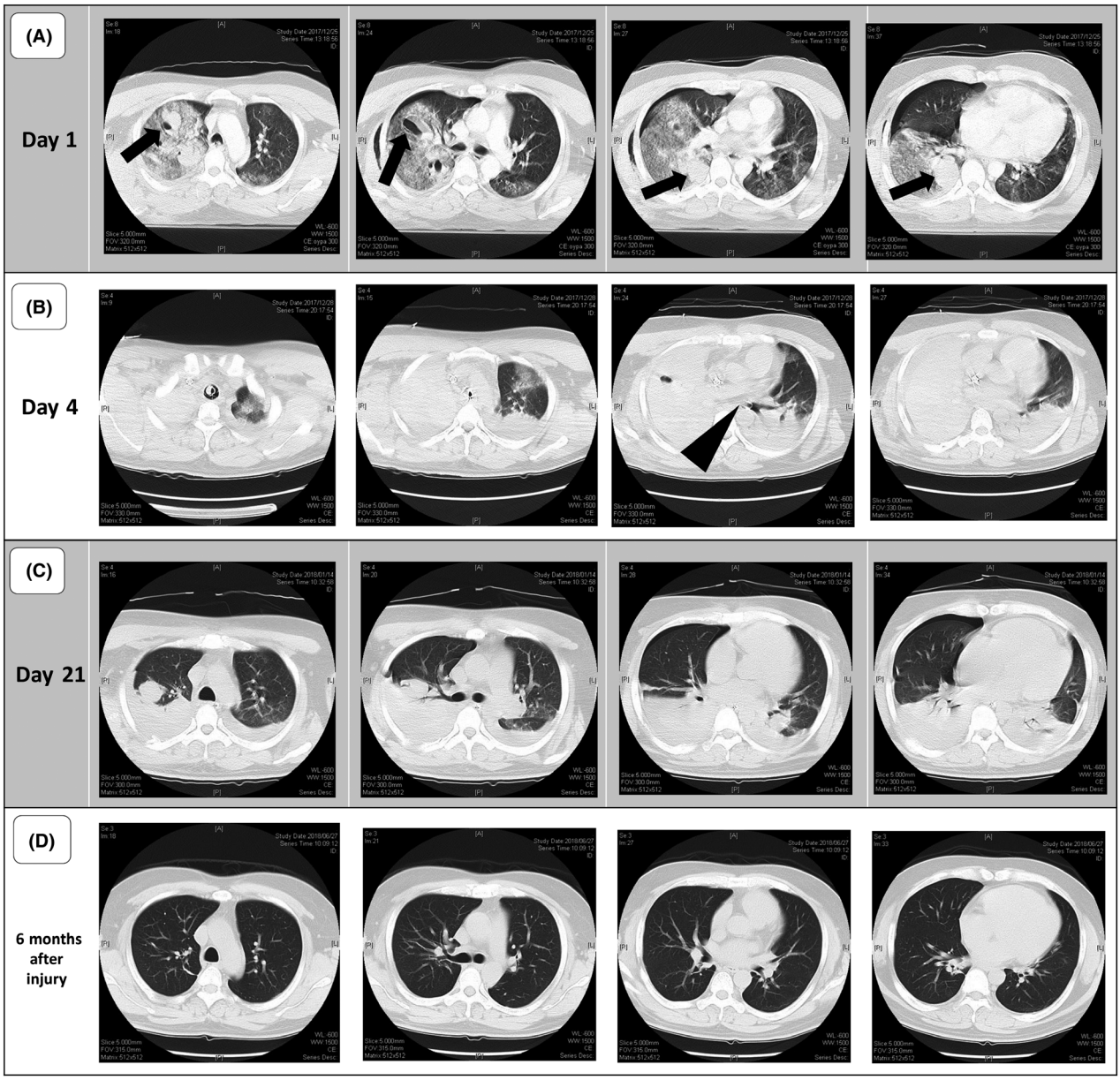
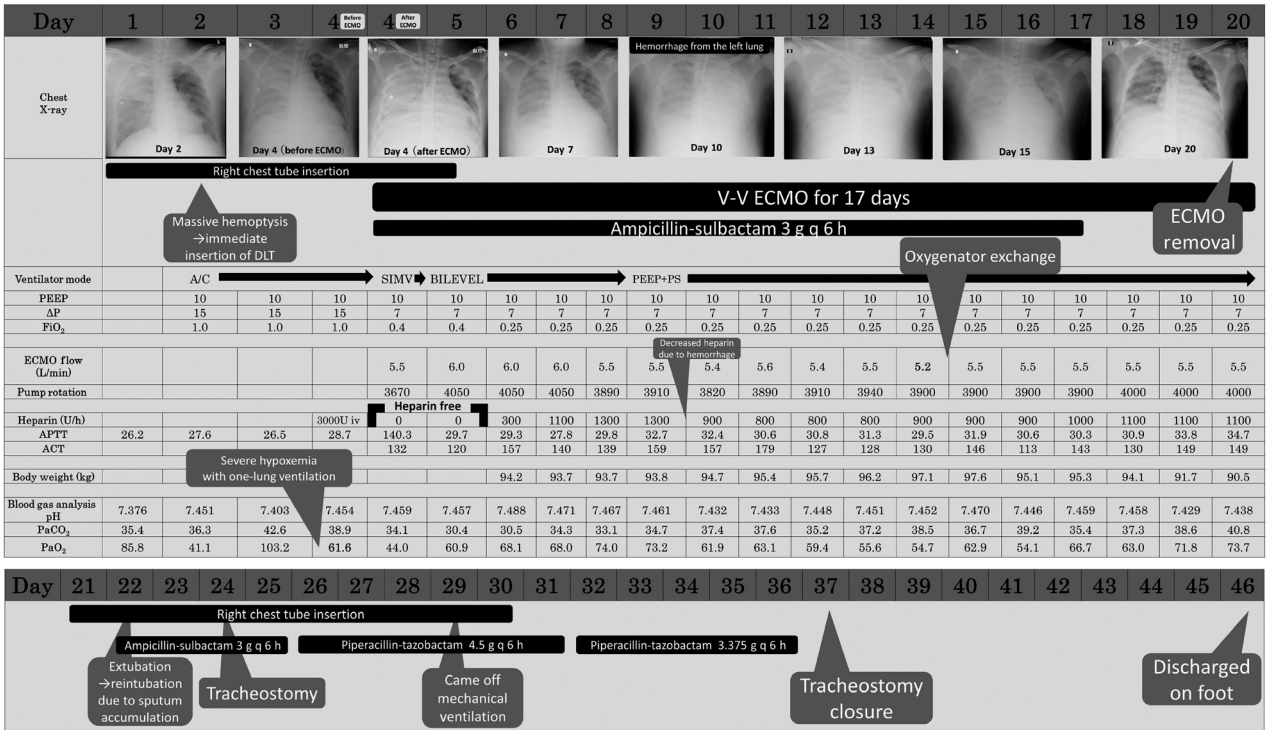


Fig. 1. Contrast-enhanced computed tomography scan (CE-CT) of a 34-year-old man on day 1 (A), day 4 (B), day 21 (C), and 6 months (D) after a traumatic lung injury. A, Multiple large pneumatoceles (arrows) and hemopneumothorax on the right. B, CE-CT several hours after the initiation of veno-venous extracorporeal membrane oxygenation (V-V ECMO). Entire right lung and right lumen of the double-lumen tube (DLT) is filled with blood due to hemoptysis. Tip of the left DLT is in an appropriate position (arrowhead). C, CE-CT after removal of V-V ECMO. Pneumatoceles remain but pulmonary contusion has healed. D, Confirmed complete resolution of the pneumatoceles at outpatient follow-up 6 months after the injury.

the right lung to flow into the left bronchus. The right lumen of DLT was filled with blood immediately after intubation. We decided to control the bleeding by sealing the right lumen for tamponade effect. The bleeding eventually subsided just from the tamponade effect without further treatment, and the P/F ratio improved temporarily up to 103.2 by suctioning the left bronchus.

Subsequently, however, the oxygenation level worsened hourly. We confirmed with bronchoscopy that the placement of DLT was appropriate, and the cuff avoided any blood



Day	1	2	3	4 Before ECMO	4 After ECMO	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ventilator mode		A/C			SIMV	BILEVEL				PEEP+PS											
PEEP		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
ΔP		15	15	15	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
FiO_2		1.0	1.0	1.0	0.4	0.4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
ECMO flow (L/min)					5.5	6.0	6.0	6.0	5.5	5.5	5.4	5.6	5.4	5.5	5.2	5.5	5.5	5.5	5.5	5.5	5.5
Pump rotation					3670	4050	4050	4050	3890	3910	3820	3890	3910	3940	3900	3900	3900	3900	4000	4000	4000
Heparin (U/h)				3000U iv	0	0	300	1100	1300	1300	900	800	800	800	900	900	900	1000	1100	1100	1100
APTT	26.2	27.6	26.5	28.7	140.3	29.7	29.3	27.8	29.8	32.7	32.4	30.6	30.8	31.3	29.5	31.9	30.6	30.3	30.9	33.8	34.7
ACT					132	120	157	140	139	159	157	179	127	128	130	146	113	143	130	149	149
Body weight (kg)							94.2	93.7	93.7	93.8	94.7	95.4	95.7	96.2	97.1	97.6	95.1	95.3	94.1	91.7	90.5
Blood gas analysis pH	7.376	7.451	7.403	7.454	7.459	7.457	7.488	7.471	7.467	7.461	7.432	7.433	7.448	7.451	7.452	7.470	7.446	7.459	7.458	7.429	7.438
$PaCO_2$	35.4	36.3	42.6	38.9	34.1	30.4	30.5	34.3	33.1	34.7	37.4	37.6	35.2	37.2	38.5	36.7	39.2	35.4	37.3	38.6	40.8
PaO_2	85.8	41.1	103.2	61.6	44.0	60.9	68.1	68.0	74.0	73.2	61.9	63.1	59.4	55.6	54.7	62.9	54.1	66.7	63.0	71.8	73.7

Day	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46

Fig. 2. Clinical course of a 34-year-old man with massive hemoptysis after a traumatic lung injury. ΔP, driving pressure; ACT, activated clotting time; APTT, activated partial thromboplastin time; ECMO, extracorporeal membrane oxygenation; PEEP, positive end-expiratory pressure; PS, pressure support; V-V ECMO, veno-venous ECMO. A/C, SIMV, and BILEVEL indicate ventilation modes of Puritan Bennett™ 840 Ventilator (Medtronic, Boulder, CO, USA).

from flowing into the left bronchus. Presumably from the left lung also suffering contusion and from forming atelectasis, the P/F ratio approached 60 by day 4. At that point, we decided that we could no longer wait for the recovery of the right lung to bring the oxygenation level back and initiated V-V ECMO.

The devices used for our V-V ECMO system were as follows: MERA Centrifugal blood pump HCF-MP23™, MERA NHP Exelung HPO-23WH-C™, MERA Exeline CPB Circuit HP2™ (Senko Medical Instrument, Tokyo, Japan), and HLS Cannulae™ (draining cannula, 23 Fr 38 cm; reinfusion cannula, 21 Fr 23 cm) (Maquet Cardiopulmonary, Rastatt, Germany). The draining cannula was placed in the right internal jugular vein and the reinfusion cannula was placed in the right femoral vein.

Lung protective strategy was carried out throughout the course of the case. To prevent ventilator-associated lung injury, driving pressure was always kept below 15. After confirming the recovery of the lungs, he came off of V-V ECMO on day 20, went off mechanical ventilation on day 29, and was discharged on foot on day 46. Pulmonary contusion and multiple pneumatoceles eventually resolved 6 months after the injury (Fig. 1B-D).

As a complication of V-V ECMO, he developed short-term right ventricular failure several hours after the initiation of V-V ECMO, and after the removal of the cannulae, he developed a thrombus in the right internal jugular vein. We confirmed the resolution of the right ventricular failure with echocardiogram and the regression of the thrombus with neck vein echo prior to discharge and at outpatient follow-up 6 months after the injury. We did not detect any evidence of pulmonary embolism on CE-CT throughout the course of the case.

DISCUSSION

TRADITIONALLY, THE USE of ECMO in trauma had been extremely limited from the fear of exacerbating hemorrhage by anticoagulation and from the restriction that its use was contraindicated when the patient had traumatic brain injury.[2] However, the number of reports on the use of V-V ECMO in trauma-related ARDS is increasing recently, and in a systematic review in 2016, the survival rate was reported as 50–79%.[1] Given the previous publications, we should not overestimate the risk of hemorrhagic complications and consider the use of V-V ECMO even in trauma when the benefit outweighs the risks.

Massive hemoptysis is a term used to describe a large amount of expectorated blood or rapid rate of bleeding associated with a serious risk of mortality. There is still no clear consensus on its definition; thresholds ranging from 100 mL/24 h to more than 1,000 mL/24 h have been proposed in the past.[3]

The novelty of our report is the application of V-V ECMO combined with the use of one-lung ventilation in a massive hemoptysis case. This was possible by limiting the anticoagulation and by constantly keeping the ECMO flow higher than 5 L/min to avoid clot formation. We used 3,000 units of intravenous heparin during cannulation to avoid immediate clot formation, and for the next 48 h, the patient was heparin-free due to the obvious concern that anticoagulation could worsen the bleeding from the right lung. Continuous run of V-V ECMO was possible for the entire 17 days with one oxygenator exchange on day 14.

In our case, hemostasis was achieved through the tamponade effect of sealing the right lumen alone. Whether or not this is sufficient solely depends on how vigorous the endotracheal bleeding is. If the endotracheal bleeding is unstoppable just from the tamponade effect, additional measures including emergency bronchial artery embolization or a pneumonectomy must be taken into account. However, we should keep in mind that the mortality rate of pneumonectomy in trauma has been reported as extremely high, as high as 100% in some reports.[4]

We were extremely cautious of adjusting anticoagulation using heparin. Even with low levels of activated clotting time and activated partial thromboplastin time, bleeding from the left lung and left bronchus became apparent on day 9 as we were increasing heparin. Although it has been reported that prolonged heparin-free management does not necessarily lead to lethal complications,[5] we were concerned that by limiting the anticoagulation excessively, massive thrombus formation could occur as the patient recovered from trauma-related coagulopathy. We adjusted our heparin doses based on the next six factors: (i) endotracheal hemorrhage by bronchoscopy, (ii) gross thrombus formation in the oxygenator, (iii) pressure difference between the pre-oxygenator and the post-oxygenator, (iv) oxygenation level in the post-oxygenator, (v) blood flow and pump rotation, (vi) the transition of the D-dimer, platelet count, and fibrinogen values. The quantitative values of most of these factors would differ among different ECMO circuits and among different cases of trauma, so it is difficult to generalize a detailed strategy on how to effectively adjust anticoagulation at this point. Further study regarding the optimal management of anticoagulation in V-V ECMO in trauma is still warranted.

CONCLUSION

IN LETHAL MASSIVE hemoptysis cases in trauma, the strategy of using V-V ECMO in combination with one-lung ventilation is useful, could be life-saving, and should be strongly considered.

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DISCLOSURE

Approval of the research protocol: N/A.
Informed consent: Written informed consent was obtained from the patient for the publication of this case report.
Registry and the registration no. of the study/trial: N/A.
Animal studies: N/A.
Conflict of interest: None.

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