Case report

A case report of prolonged (71 days) and continuous use of venovenous extracorporeal membrane oxygenation (VV-ECMO) without changing the line and VV-ECMO equipment in progressive respiratory failure after blunt chest injury

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The use of extracorporeal membrane oxygenation (ECMO) in a trauma setting is a treatment preserved as a rescue therapy for unsuccessful conventional treatment modalities. A 21 year-old male patient was transferred from a secondary hospital after 2 weeks of multiple trauma, due to progressive respiratory failure, with bilateral air leakage of the lung. He received cardiopulmonary resuscitation and high setting of cardiopulmonary support. The venovenous ECMO (VV-ECMO) was initiated after fully conventional therapy failed. The clinical parameters of vital signs, gas exchange, hemodynamics and consciousness were improved after VV-ECMO was initiated. However, he could not tolerate weaning on ECMO. In addition, a massively clotted hemothorax was detected in the left lung 64 days after ECMO. The patient underwent a thoracotomy three times for blood clot removal and to stop the bleeding. Unfortunately, the patient could not tolerate the last operation and he passed away. The total time of VV-ECMO was 71 days without changing the line and equipment, and complications arose. In conclusion, this is a first case in this institute of ECMO initiation in a trauma setting, with the longest duration of VV-ECMO without changing the line and equipment. However, the complications of bleeding and underlying lung pathology resulted in an adverse outcome. **Chiang Mai Medical Journal 2016;55(2):65-73.**

keywords: extracorporeal membrane oxygenation, severe chest injury, severe respiratory failure, complication

Introduction

Extracorporeal membrane oxygenation (ECMO) has been used widely in cardiac and respiratory support for selected critically ill patients[1]. However, its use in cases of acute trauma is still controversial and patients should be selected carefully[2]. Most reports on trauma used a small group of patients (case or case series) in each institute[3-6]. The results of ECMO use is interesting. According to a large series in a 10 year report (between 2002 and 2012) in the Regensburg ECMO Registry

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database, the overall survival of trauma patients was 79 percent. In addition, a comparative observation study compared between early initiation of ECMO and conventional ventilation, and demonstrated that the ECMO group had a significantly lower mortality rate than the conventional one (13.3% vs. 64%)[7]. All of the patients in these studies used ECMO for less than 3 weeks[3-7]. Furthermore, the company that manufactures ECMO equipment provides a warranty of 14 days for each set. As Thailand is a middle income developing country, ECMO in trauma patients is used as a start to treatment, mostly in cardiothoracic surgical patients, cardiac arrest, myocardial infarction, and isolated lung diseases. This report demonstrated the case of a poly trauma patient who developed respiratory failure from severe pulmonary failure, and venovenous ECMO (VV-ECMO) was used for a very long period as rescue therapy, without changing the line and equipment, and complications arose.

Presentation of the case

A 21-year-old man had a motorcycle accident and was admitted to hospital with right pulmonary contusion, grade III liver injury at the left lobe, small splenic laceration and left adrenal gland hematoma, and all of the lesions had no extravasation of contrast media. Although the abdominal injury was treated successfully, he was intubated and admitted to the surgical intensive care unit (ICU), due to progressive respiratory failure. The respiratory symptoms worsened during the two weeks of hospital admission and he needed high level respiratory support [high positive end expiratory pressure (PEEP) and high inspiratory pressure]. The ventilator induced barotrauma, and intercostal tube drainage was performed on both sides of the chest. However, continuous air leakage occurred. The patient was transferred finally to Maharaj Nakorn Chiang Mai Hospital, which is a level 1 Thai-northern region trauma center, due to his progressive respiratory failure and persistent bilateral air leakage. Computed tomography (CT) of the brain before the hospital transfer showed no intracranial hemorrhage and intact cervical-spine. The chest X-ray (CXR) is demonstrated in Figure 1.

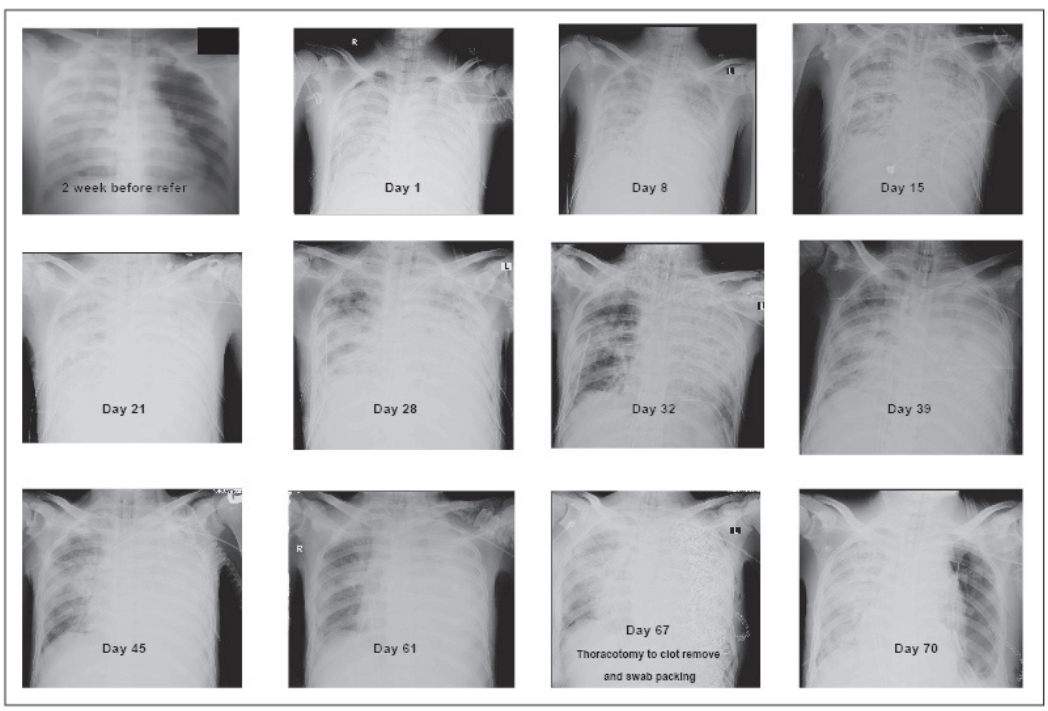

Figure 1. Chest X-ray of patient during admission

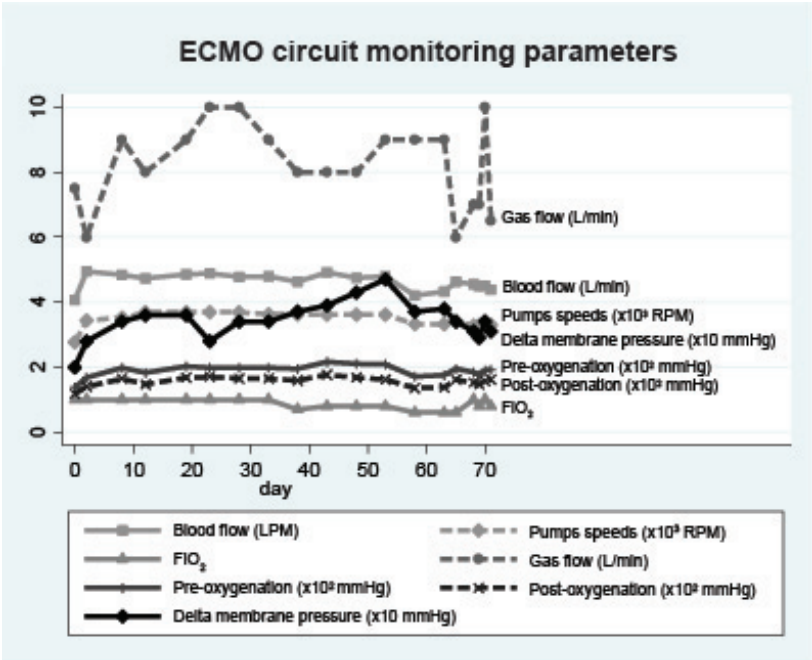

Figure 2. ECMO setting during admission

The vital signs in the emergency room were unstable, with severe hypoxemia and hypercapnia together with severe acidosis, and the CXR showed bilateral pulmonary haziness. Although he had full consciousness before the transfer, he was in a coma with a Glasgow Coma Score of E1VtM1 when reaching the emergency room. His arterial blood gas (ABG) demonstrated partial pressure of arterial oxygen pressure (PaO_2) of 50 mmHg with an inspiratory oxygen fraction (FiO_2) of 1.0, partial pressure of arterial carbon dioxide ($PaCO_2$) of 80 mmHg and pH7.12. According to the Murray lung injury score, the CXR showed 4 quadrant infiltrations (Murray lung injury score >3, Figure 1). The patient received cardiopulmonary resuscitation (CPR) and high vasopressor therapy before receiving ECMO.

ECMO support was initiated using coated adult bioline (Maquet Cardiopulmonary AG, Rastatt, Germany), a Quadrox permanent life support set (PLS), oxygenetor and Rotaflow centrifugal pump. VV ECMO used bicaval cannulation by cannulating the right femoral vein with 22 Fr for venous drainage and right internal jugular vein with 20 Fr. for blood returning inflow. The ECMO worked well with a blood flow of 4-5 Liters per minute, gas flow of 4-10 Liters/minute, FiO_2 between 0.6 and 1.0 and heparin dose of 1,000–2,500 unit/hour for maintaining ACT at 160-220 sec (Figure 2 and 3). The VV-ECMO and line insertion caring element during ECMO support are demonstrated on Table 1 and 2.

ABG improved rapidly on the first day of ECMO support (Figure 4) and the mechanical ventilator (MV) setting was stepped down to lung protective strategy (tidal volume ≤6 mL/kg, plateau pressure ≤35 cmH_2O). Further improvement in ABG was evidenced in the first week of ECMO support (Figure 4), but while the CXR showed right lung improvement, the left lung remained hazy (Figure 1). The ECMO circuit continued to work well with the ACT and heparin infusion maintained (Figure 2 and 3), but there was no improvement in chest findings. The patient returned to full consciousness (E4VtM6).

A bronchoscopy was performed on the 12th day of ECMO support, due to continued haziness of the left chest (Figure 1), but there was no significant finding. The right chest drainage tube was removed on the 42nd day of ECMO support. On the 54th day of ECMO support, bronchoscopy was repeated. However, the lung had still not expanded. Therefore, the left chest drainage tube was removed due to there being no drainage content. The vital signs of the patient were stable with improvement in ABG (Figure 4). He was awake with good consciousness, but the endotracheal tube and ventilator remained in place as a lung protective strategy. On the 64th day of ECMO support, the left lung remained white and a CT scan showed a left clotted hemothorax. Trouble from the ECMO line and equipment was unremarkable.

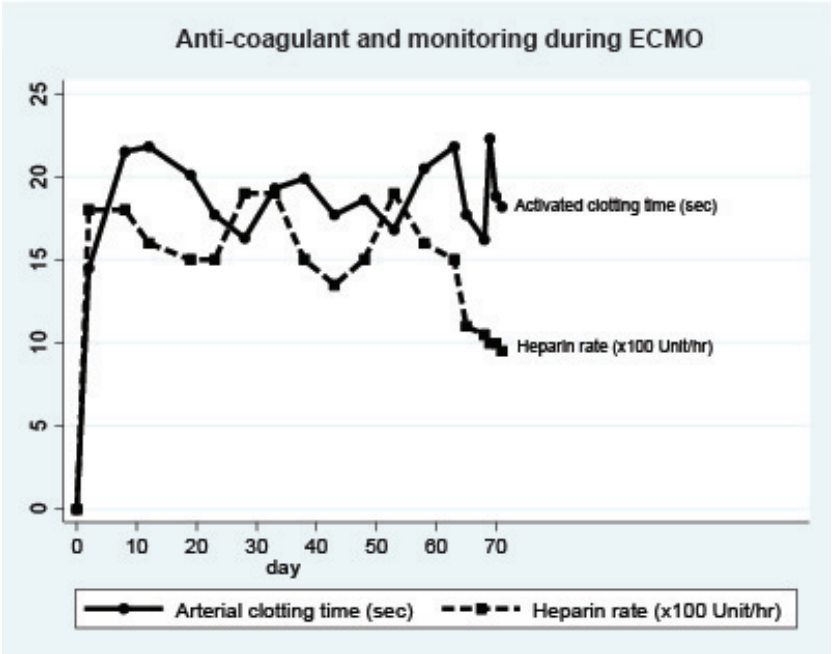

Figure 3. The arterial clotting time and heparin infusion rate

Table 1. VV-ECMO caring element.

Elements	Details
ECMO mode	VV-ECMO, Drain line: right femoral vein; Return line: right internal jugular vein
ECMO equipment	Machine: coated Bioline (Maquet Cardiopulmonary AG, Rastatt Germany) Membrane oxygenator: Quadrox permanent life support set (PLS) Pump: Rotaflow centrifugal pump Line: Bicaval cannulation, 22 Fr. for venous drainage and 20 Fr. for blood returning inflow
ECMO checklist (at least every 8 hours)	Power and battery system: -Ensure connection to AC power, Ensure AC LED light ON, Battery charge voltage Console settings: Pump speed (RPM), Blood flow (LPM), Alarm settings Blender settings: FiO_2 to oxygenator, Gas flow Oxygenator assessment: Oxygenation function; Sweep gas; Clot in oxygenator; Pre-oxygenator Pressure; Post-oxygenator Pressure; Oxygenator pressure difference (ΔP) Circuit assessment: Negative pressure circuit; All cannula's secure; Check clot in ECMO tube; Gas line connection to oxygenator; Heparin infusion connection and pressure in pressure bag ≥300 mmHg; Ensure water heater-cooler level, Tubing clamp reservation check
ECMO monitoring	ACT 180-220 sec.; aPTT 55-75 sec.; platelet count > 80,000 Oxygenator pressure difference ≤60 mmHg

ACT, activated clotting time

Table 2. Line insertion and caring element

Element	Details
General	Strict hand hygiene; insertion of another central line for hemodynamic monitoring, fluid, nutrition and drug administration
At insertion	Full barrier precautions, cleansing by chlorhexidine in alcohol
Dressing	Change transparent semi-permeable dressing every 48-72 hours or dressing when wet
Monitoring	Daily checking for insertion site infection, drawing blood for microscopic examination and culture if infection is suspected
	ECMO line was not allowed for drug administration

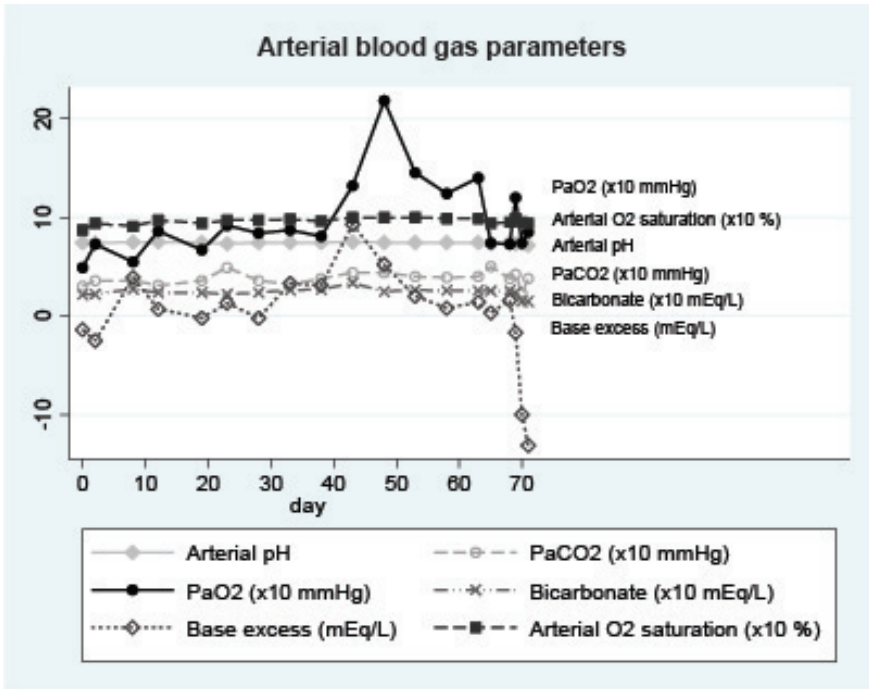

Figure 4. Arterial blood gas during ECMO support

On the 65th day of ECMO support, the patient underwent clot removal and decortication via a left thoracotomy, but there was diffuse bleeding from a raw surface at the right thoracic cavity after decortication. This might have occurred from using heparin infusion on the ECMO circuit. Therefore, the left chest was packed with swabs and the patient returned to ICU. On the 68th day of ECMO support, a second attempt to remove the swab from the left chest failed due to diffuse bleeding. The cause of bleeding was suspected to be because of lung parenchymal laceration, decortication and anticoagulation therapy required during ECMO support. The platelet count was normal before and after surgery.

On the 70th day of ECMO support, the swab packing was removed successfully. Intra-operative finding demonstrated lung damage with the lung not expanded fully (Figure 1). However, acidosis occurred with rapidly decreasing base excess. Unfortunately, the patient deteriorated. The ECMO circuit was still working well, but relatives were informed of the patient's status, and the final decision was not to resuscitate (DNR) if the patient got worse, and he passed away on the 71st day of ECMO support.

Discussion

This study reported the first case of a trauma patient using VV-ECMO in this institute. In addition, the patient used the VV-ECMO for a prolonged period (71 days) without changing the instruments, which included an insertion line, a pump and a membrane oxygenator.

Table 3. Indication and contra-indication of ECMO in respiratory failure

Indication	Contra-indication
o Acute respiratory distress syndrome - severe bacterial or viral pneumonia - aspiration syndromes - alveolar proteinosis o Extracorporeal assistance to provide lung rest - airway obstruction - pulmonary contusion - smoke inhalation o Lung transplantation - primary graft failure after lung transplantation - bridge to lung transplant - intraoperative ECMO o Lung hyperinflation - status asthmaticus o Pulmonary hemorrhage or massive hemolysis o Congenital diaphragmatic hernia, meconium aspiration	o Unrecoverable heart and not a candidate for transplant or destination therapy of VAD support o Disseminated malignancy o Known severe brain injury o Unwitnessed cardiac arrest o Prolonged CPR without adequate tissue perfusion o Unrepaired aortic dissection o Severe aortic regurgitation o Severe chronic organ dysfunction (emphysema, cirrhosis, renal failure) o Compliance (financial, cognitive, psychiatric or social limitations in patients without social support) o Peripheral vascular disease is contraindicated in peripheral VA ECMO o VV ECMO is contraindicated in cardiogenic failure and severe chronic pulmonary hypertension (mean pulmonary artery pressure >50 mmHg)

The ECMO is a rescue and cardio-pulmonary support machine and its current indications have been extended (Table 3)[8]. In the case of acute severe traumatic lung injury, a center in Taiwan has proposed indications as (1) severe hypoxemia (PaO2 to FiO_2 ratio (P/F ratio) < 60, on the setting of FiO_2 1.0 and PEEP >10 cm-$H2_O$); (2) irreversible carbon dioxide retention with unstable hemodynamics; and (3) initial P/F ratio<60, where the condition of pulmonary and hemodynamics promptly decline, despite full mechanical support[3]. That study enrolled a total of 19 patients in a 60-month study period and found 68.4% of them survived. The median period of ECMO ranged from 6 to 7 days, with an interquartile range of between 4 and 12 days[3]. Although the large ECMO registry database covered 10 years, the longest duration was only 38 days[6]. Despite prolonged periods of ECMO use being reported previously (48 and 104 days in reports from Ko WJ et al and Moon SM et al, respectively)[9,10] the oxygenator or line insertion was changed during these timeframes. Moon SM et al reported 3 changes of the ECMO circuit within the 104 days. In Thailand, the price of ECMO equipment is around 100,000 Baht (around 2,800 USD). In an economic study in a CESAR trial, the mean cost of the base case was around 3 million baht (around 90,000 USD)[11]. The company warranty was only for 14 days in the running of ECMO, with the therapeutic method not included in the re-imbursement of costs. Therefore, patients would need to pay in full or in part for the treatment. In consequence, changing the ECMO set might prove impossible for most of the patients in this institute. In this study, the ECMO could be used on the patient for 71 days before he got worse, although the ECMO was still working. This was the longest period used in this institute. Furthermore, this also was the longest use of the ECMO set after insertion and during running of the machine, without the complication of changing the line and equipment.

Although the patient recovered after improving oxygenation and running ECMO, a massive clotted hemothorax occurred at the left chest. The exact time of this complication was not identified, but it occurred around 30 days after ECMO. This condition is potentially life threatening and a medically difficult issue during the running of ECMO. Joshi et al reported 16 years of experience in a large series of adult patients needing thoracic surgery after receiving ECMO[12]. They reported that 3.2%

of the patients needed a thoracotomy and 63% required evacuation of the hemothorax, which was the most common primary operation. The median time (interquartile range, IQR) of an initial thoracotomy was 10 (1-183) days. Unfortunately, the mortality rate in the hospital was around 40% after a thoracotomy[12]. Suggested ECMO treatment for the hemothorax is initial medical therapy that stops heparin infusion, fluid restoration, temperature correction, tranexamic acid injection, decompression of the chest cavity with tube thoracotomy, and pleural epinephrine irrigation[13]. Open thoracotomy was indicated only in patients with massive and continuous bleeding and tamponade with cardiopulmonary compromise, as well as failed video-assisted thoracotomy surgery (VATS). Otherwise, full attempts at aggressive conventional treatment and thoracotomy should be delayed until ECMO has been weaned[13]. The indications of the patient in this study were respiratory compromise and tamponade effect to the left lung, which impeded lung expansion. Although the clot could be removed finally, the patient could not tolerate the damaged lung that remained.

Papadopoulos N *et al* reported the risk factors associated with adverse outcome following ECMO. They found that prior CPR, high serum lactate, high norepinephrine dosage and age >75 years were independent risk factors for adverse events[14]. In addition, the mortality rate increased to around 57-68% in patients receiving ECMO for more than 3 weeks, when compared 48% of patients receiving ECMO for 2-3 weeks[15]. Many survival prediction scores use current pre-ECMO parameters to estimate the risk of death and decision for initiating ECMO such as the ECMOnet score, PRESERVE score, RESPscore, etc[16]. Although the patient in this study had a high risk of death, as in previously mentioned variables, his consciousness returned a few days after receiving ECMO. However, due to his underlying lung damage and unavailable lung transplantation in this institute, as well as the economic burden placed on the patient's family, he passed away after removal of the clotted hemothorax.

Line caring and ECMO equipment are important issues during ECMO. Central line associated blood stream infection (CABSI) is associated with greater hospital mortality[17,18], with risk factors including site and duration of catheter insertion, ward of central line initiation, and catheter types[17,18]. Line infection does not occur during ECMO, due to the strict unit guideline for catheter care.

Finally, although this case was the first experience of ECMO in a traumatic patient for the team in this study, the initial clinical result improved in this patient. Based on the team being multidisciplinary, precautious line caring, and prompt corrections of circuit problems, maintained ECMO without infective complications or having to change the equipment or line insertion. However, because of underlying pulmonary pathology and economic burden to the patient's family, the patient passed away after a thoracotomy to remove a clotted hemothorax, which was possibly a complication during ECMO.

Conclusion

This was the first case in this institute of ECMO in a trauma patient setting as well as the longest insertion without changing the line and equipment. Although ECMO is a rescue therapy that initially improves the clinical condition, bleeding tendency and underlying lung pathology result in adverse outcomes. In addition, ECMO is very expensive and requires a multidisciplinary team, and its initiation should be selected cautiously.

Conflicts of interest

None

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รายงานผู้ป่วยที่ต้องใช้เครื่อง VV-ECMO อย่างต่อเนื่องระยะเวลานาน (71 วัน) โดยไม่มีการเปลี่ยนสายและเครื่อง VV-ECMO ในผู้ป่วยที่มีการหายใจล้มเหลวหลังจากอุบัติเหตุช่องทรวงอก

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การใช้เครื่อง ECMO ในผู้ป่วยอุบัติเหตุยังอยู่ในระยะเริ่มต้น การรักษาดังกล่าวมีวัตถุประสงค์เพื่อช่วยฟื้นชีพในกรณีที่การรักษาแบบปกติทำไม่สำเร็จ ผู้ป่วยชายอายุ 21 ปี ได้รับการส่งต่อจากโรงพยาบาลทุติยภูมิ เนื่องจากมีภาวะหายใจล้มเหลวอย่างรวดเร็วและมีลมรั่วในเยื่อหุ้มปอดทั้งสองข้างหลังจากได้รับอุบัติเหตุ 2 สัปดาห์หลังจากได้รับอุบัติเหตุ ผู้ป่วยได้รับการช่วยฟื้นชีพและต้องได้รับยาและเครื่องช่วยหายใจในระดับที่สูง ผู้ป่วยได้รับการใส่ VV-ECMO หลังจากการรักษาวิธีมาตรฐานไม่สำเร็จ ภายหลังใส่พบว่าสัญญาณชีพ การแลกเปลี่ยนก๊าซ ระบบการไหลเวียนและความรู้สึกตัวดีขึ้นมาก อย่างไรก็ตาม ผู้ป่วยไม่สามารถหย่าจากเครื่องได้ นอกจากนี้ในวันที่ 64 ของการใช้เครื่องพบว่ามีก้อนเลือดขนาดใหญ่ในปอดข้างซ้าย ผู้ป่วยได้ทำการผ่าตัดเพื่อนำก้อนเลือดออกและหยุดเลือดจำนวน 3 ครั้ง ผู้ป่วยไม่สามารถทนต่อพิษบาดแผลหลังการผ่าตัดครั้งที่ 3 และเสียชีวิต รวมระยะเวลาทั้งหมดของการใช้เครื่อง VV-ECMO คือ 71 วันโดยไม่มีการเปลี่ยนสายและอุปกรณ์รวมถึงภาวะแทรกซ้อนของเครื่อง กล่าวโดยสรุป ผู้ป่วยรายนี้เป็นรายแรกของการใช้ ECMO ในผู้ป่วยอุบัติเหตุและมีการใช้ระยะเวลายาวนานมากที่สุดโดยไม่มีการเปลี่ยนสายและอุปกรณ์ในสถาบันนี้ อย่างไรก็ตาม ภาวะแทรกซ้อนจากความเสี่ยงของการเลือดออกและปอดที่ถูกทำลายทำให้ผลการรักษาไม่ดี **เชียงใหม่เวชสาร 2559;55(2):65-73.**

คำสำคัญ: เครื่องแลกเปลี่ยนออกซิเจนนอกร่างกาย การบาดเจ็บของปอดอย่างรุนแรง ระบบการหายใจล้มเหลวอย่างรุนแรง ภาวะแทรกซ้อน