Case Report

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Improperly placed Drainage Catheter in a Patient who developed ARDS due to H1N1 Pneumonia, and increased Intra-Abdominal Pressure Mimicking Signs of Hypovolemia

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Abstract

ECMO is a technique that involves oxygenation of blood and removal of carbon dioxide using extra-corporeal circulation through an oxygenator and a magnetic pump. In V-V ECMO, drainage catheter is placed at the junction of the inferior vena cava and the right atrium or nearby, and the catheter that allows re-circulation to the patient is placed at the junction of the superior vena cava and the right atrium or into the right atrium. Having been followed up for H1N1 and referred to our hospital, a patient developing ARDS was performed femoro-jugular V-V ECMO to rest the lungs but the drainage cannula was placed distant from the junction of the inferior vena cava and the right atrium, which resulted in abdominal compartment syndrome due to volume loading. Increased intraabdominal pressure pressed the vena cava inferior, which prevented the drainage catheter from draining the blood. ECMO failed to read the blood flow and thrill was detected in the drainage catheter. All these findings suggested hypovolemia. This case report intends to present the vicious cycle that developed as a result of the collapse of the vena cava inferior due to increased intra-abdominal pressure caused by improper placement of the drainage catheter and by volume loading, which finally renders the drainage catheter unable to drain adequate volume of blood.

Keywords: H1N1 Pneumonia; Hypovolemia; ECMO

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Introduction

ECMO (Extracorporeal membrane oxygenator) is a technique that involves oxygenation of blood and removal of carbon dioxide through an oxygenator and a magnetic pump using extracorporeal circulation [1]. Veno-venous ECMO (V-V ECMO) is used in patients with reversible and severe pulmonary dysfunction where gas exchange by mechanical ventilator is insufficient [2]. V-V ECMO does not treat the lung, it only saves the patient time by oxygenating the patient's blood and removing carbon dioxide during severe pulmonary dysfunction [3]. In addition, the V-V ECMO eliminates the risk of ventilator-associated lung damage [2,3]. Re-circulation in V-V ECMO may also be affected by catheter position [4]. The end of the V-V ECMO drainage catheter is placed at the junction of the inferior vena cava and the right atrium or nearby, the catheter end that brings the blood returning from the patient is placed at the junction of the superior vena cava and the right atrium or into the right atrium [4]. The places are usually confirmed by echocardiography (ECO) after inserting the catheters in V-V ECMO [4,5]. Baskin et al. reported that the position of ECMO catheter ends can be evaluated directly using radiography.

If the intra-abdominal pressure is above 20 mmHg, it is considered abdominal compartment syndrome [5]. This condition causes compression of the inferior vena cava [3,2]. Inferior vena cava compression prevents drainage of adequate volumes of blood if the ECMO drainage catheter is far from the right atrium [4-6]. This condition can mimic hypovolemia.

This case report intends to present the vicious cycle experienced in a patient that developed ARDS after H1N1 related pneumonia and was applied V-V ECMO where the drainage catheter end was placed distant from the right atrium, which resulted in progressively increasing intra-abdominal pressure, pressure on the vena cava inferior, decreased volume of blood drained, detection of thrill on ECMO catheters, ECMO device's failure

to read the blood flow correctly that mistakenly suggested hypovolemia in the patient, which furthermore led to more fluid loading on the patient and thus further increase in the intra-abdominal pressure and further decrease in the volume of blood drained.

Case Study

A 37-year-old male patient with no comorbidities who smokes 1 pack of cigarettes per day, is engaged in metal welding as a profession, and was hospitalized in the state hospital (ICU) for 5 days for pneumonia and spent the last two days there incubated due to hypoxia and hypercarbia. On the fifth day, he was transferred to our hospital, which is considered an advanced healthcare center. The patient, who had MRSA growth from tracheal aspirate in the ICU where he was hospitalized, was administered meropenem 3 × 1 g and tigecycline 2 × 50 mg, along with oseltamivir 75 mg 2 × 1 for suspicion of H1N1. A sample of nasal swab was sent for testing. Directly admitted to the ICU, the patient had an APTT of 41 sec, PT of 12.50 sec, INR of 1.19 sec, and PT of 88%, WBC of 19.63 10^3/UL, platelet count of 46 × 10^3 U/L, haemoglobin value of 11.3 g/dL. In the thoracic tomography taken at the previous healthcare center, the infiltration's starting at and spreading from the hila were particularly evident in the middle and lower zones and had a ground-glass appearance **(Figure 1).** In the AP chest radiography run during the patient's stay in the ICU, there was an infiltrative appearance that filled most of the lower middle and upper parts **(Figure** 2**).** In the arterial blood gas

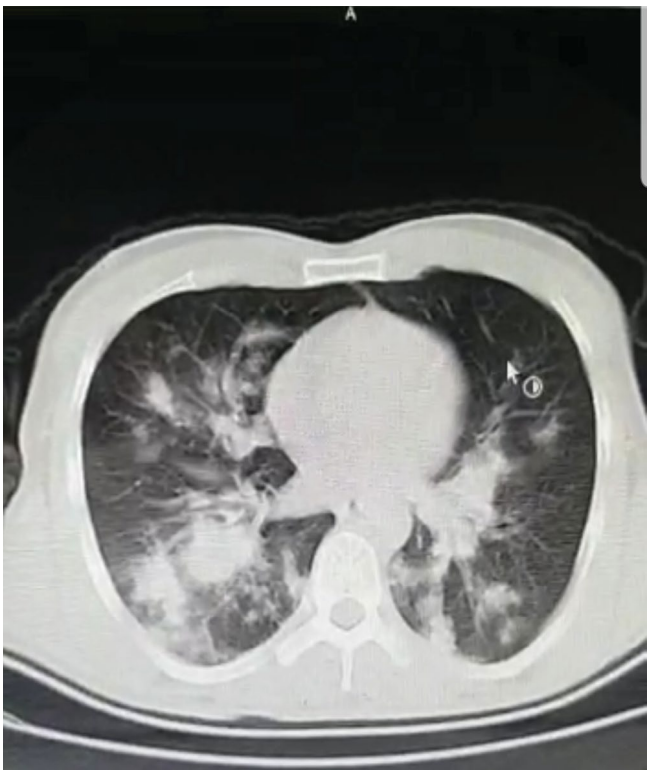

Figure 1 The infiltrations starting at and spreading from the hila were particularly evident in the middle and lozwer zones and had a ground-glass appearance.

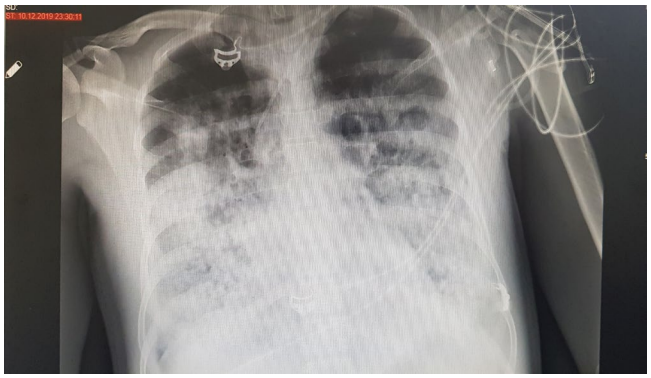

Figure 2 In the AP chest radiography run during the patient's stay in the ICU, there was an infiltrative appearance that filled most of the lower middle and upper parts.

(AKG) obtained, FiO_2 was at 100%, PO_2 was 48 mmHg, and PCO_2 was 89 mmHg while the PO_2/ FiO_2 ratio was 48. In PRCV mode, TV was 350 mL, respiratory count (RC) 22/min, PEEP was 14 cm H_2O, and super-PEEP pressure 22 cm H_2O, and pressure alarm limit 50 cm H_2O, and plateau 42 cm H_2O. Steradine was in an infusion of 0.5 mcg/kg/min. Procalcitonin was 90.20 ng/dL and CRP was 222 mg/L. The patient was administered meropenem 3 × 1 g and vancomycin 2 × 1g, which was complemented with oseltamivir 75 mg 2 × 1 for 5 days. Patient started to be sedated with IV infusion of midazolam 5 mg/kg/h and ketamine 0.5 mg/kg/h. In the patient followed up this way for 16 hours, RC was 24/min, TV 350 mL, PEEP 14 cm H_2O, super-PEEP pressure 24 cm H_2O, pressure alarm limit 55 cm H_2O, peak pressure was 50 cm H_2O in PRVC mode. While FiO_2 was at 100%, PCO_2 was 49.5 mmHg, PO_2 52.9 mmHg, and PO_2/FiO_2 ratio was 52.9 in the patient's ABG. In order to rest the lungs upon the deterioration in the patient's general condition and the disturbance of hemodynamics, veno-venous ECMO was planned for the patient (since we could not have the patient in prone position and apply APRV mode due to high PCO_2). Patient's RESP (Respiratory ECMO Survival Prediction) score was calculated to be 55-70%, and then 17 Fr arterial cannula (Maquet, Germany) was inserted through the right vena jugularis interna and 21 Fr venous cannula (Maquet, Germany) through the right femoral vein under the guidance of ultrasonography (Toshiba, TA700, Japanese). The location of the ECMO catheters was confirmed by a cardiovascular surgeon directly on the AP chest radiography. The patient's full flow was 4.10 L/min and the full flow was reached in pump rotation of 4010/minute and ECMO rotation (Maquet, Germany) was started. When placing the ECMO catheters, heparin was pushed in 5000 IU and 750 IU IV infusion was started. The heparin dose was adjusted with APTT values in the range of 60-80 sec. Antibiotics were adjusted to ECMO dose. In the ABG at the eight hour following ECMO, the airflow was 6L/min when FiO_2 was at 80% while RC was 8/min, PEEP 10 cm/H_2O, super-PEEP pressure 14 cm H_2O, Ppeak 20 cm H_2O with ventilator values showing FiO_2 at 60% in P-SIMV mode. In the ABG tested, pH was 7.535, PCO_2 was 29.8 mmHg and PO_2 was 62.8 mmHg. The patient was followed up with the antibiotic therapy started based on the culture test results, erythrocyte suspension, platelet and fresh frozen plasma replacement therapies. To

perform follow-ups on D-dimer, lipase, and amylase, the patient's biochemistry was monitored throughout the 20-day ECMO by running tests in four-hour intervals on ABG, pre-pump blood gas, PT, PTT, INR and hemogram. On the patient's 7th day in the ICU, the nasal swab test showed H1N1. The distance between the ends of the ECMO catheters was checked after ECMO installation **(Figure 3 and Figure 4).** The distance between the ends of the ECMO catheters was measured on the 3rd day after ECMO was connected **(Figure 5).** The patient developed left pneumothorax on the 5th day following his admission to the ICU and was inserted left thoracic tube **(Figure 6).** On the 6th day of his stay, the patient developed right pneumothorax and was inserted right thoracic tube **(Figure 7)**. On the 9th day of the patient's hospitalization, percutaneous tracheostomy was performed, and on the 11th day of the patient's stay, the ECMO oxygenator was replaced with the help of a manual pump upon its dysfunction **(Figure 8).** Fluid balance was facilitated intermittently through CVVHDF (Gambro, Prismaflex, Sweden) using Oxirix filter and through Coupled plasma filtration adsorption (CPFA) (Amplya, Italy) using Bellco (Bellc Via Camurana 1, Italy) set for cytokine adsorption. The vena cava inferior collapsibility index was found to be 28% in the USG performed upon the swelling observed on the 13th day of admission, and fluid loading was thought to occur in the patient.

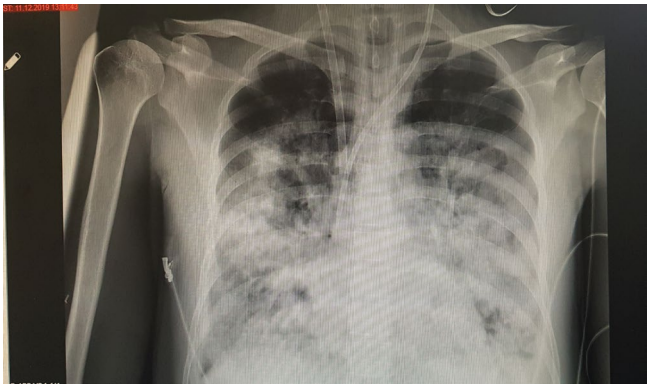

Figure 3 The right internal jugular vein ECMO catheter was checked after ECMO installation.

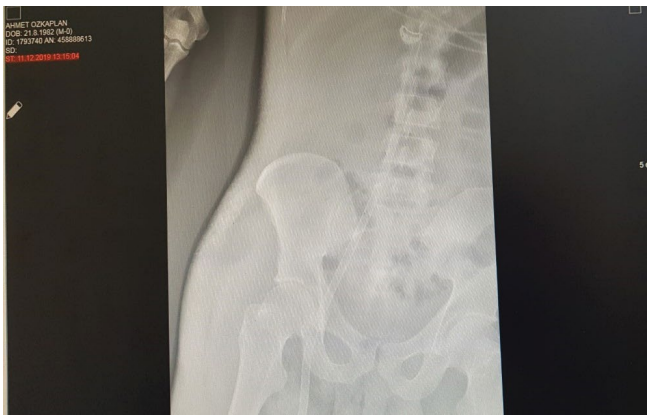

Figure 4 The right femoral vein ECMO catheters was checked after ECMO installation.

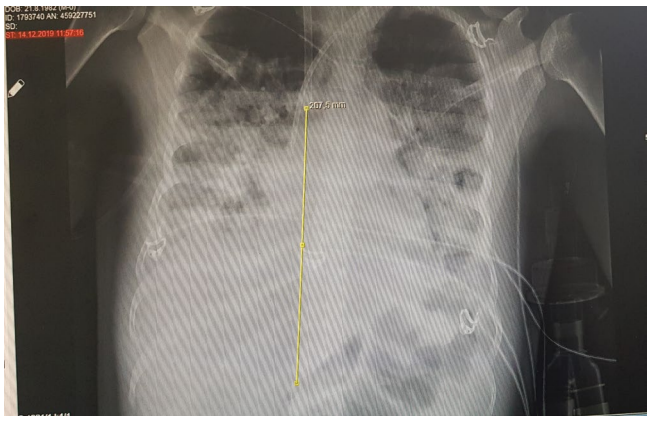

Figure 5 The distance between the ends of the ECMO catheters was measured on the 3rd day after ECMO was connected.

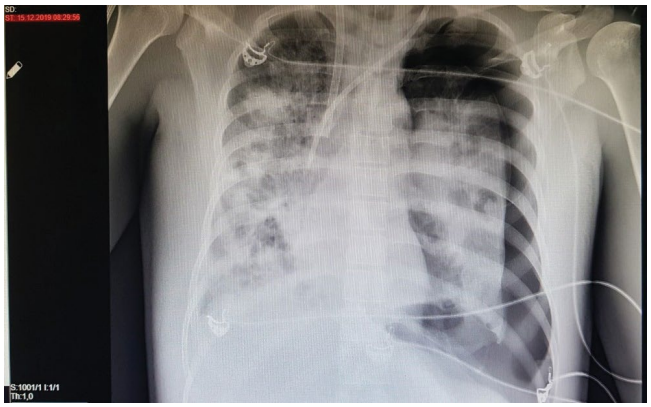

Figure 6 The patient developed left pneumothorax on the fifth day following his admission to the ICU and was inserted left thoracic tube.

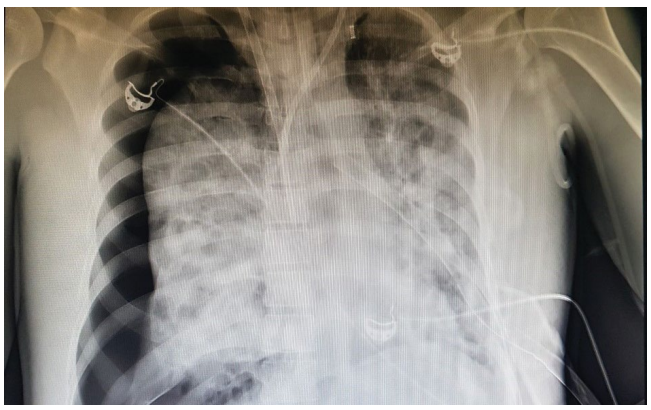

Figure 7 On the sixth of his stay, the patient developed right pneumothorax and was inserted right thoracic tube.

3000mL of fluid was withdrawn from the patient via CVVHDF. The patient was checked for vena cava inferior collapsibility index due to low arterial blood pressure on the 16th day of admission during night time, and the vena cava inferior collapsibility index was found to be 44%. The patient was administered fluid loading,

and upon detection of thrill on the drainage cannula and the pump's failure to read blood flow correctly during noon time, the patient was thought to be hypovolemic without even checking vena cava inferior collapsibility index and administered further fluid loading. However, as the fluid loading increased, the thrill on the drainage cannula increased, and the patient's arterial blood pressure and SpO_2 values began to decrease. The intra-abdominal pressure of the patient, measured through the bladder, was 24 mmHg. A surgical pathology was not considered in the patient for whom general surgical consultation was requested for the abdominal swelling, which was associated with edema. The distance between the catheter ends on the patient is on the AP chest X-Ray **(Figure 5).** Despite all the interventions, the thrill on the drainage catheter did not improve, and the blood pressure arteriole and SpO_2 continued to decrease. Then the drainage catheter was brought closer to the right atrium in a way that it did not cause re-circulation because the vena cava inferior could have been collapsed due to increased intra-abdominal pressure **(Figure 9).** With the progression of the drainage catheter, the patient's hemodynamic functions improved, and the thrill on the drainage catheter disappeared, the pump began to read the flow again. Upon detection of *A. baumanni* growth on the patient's catheter culture tests, ECMO-dose colimycin was started. On the 23rd day of admission, the patient died upon the septic shock caused by catheter-associated blood stream infection of *A. baumanni* (Procalcitonin 25.56 ng/dL, CRP 221.60 mg/L).

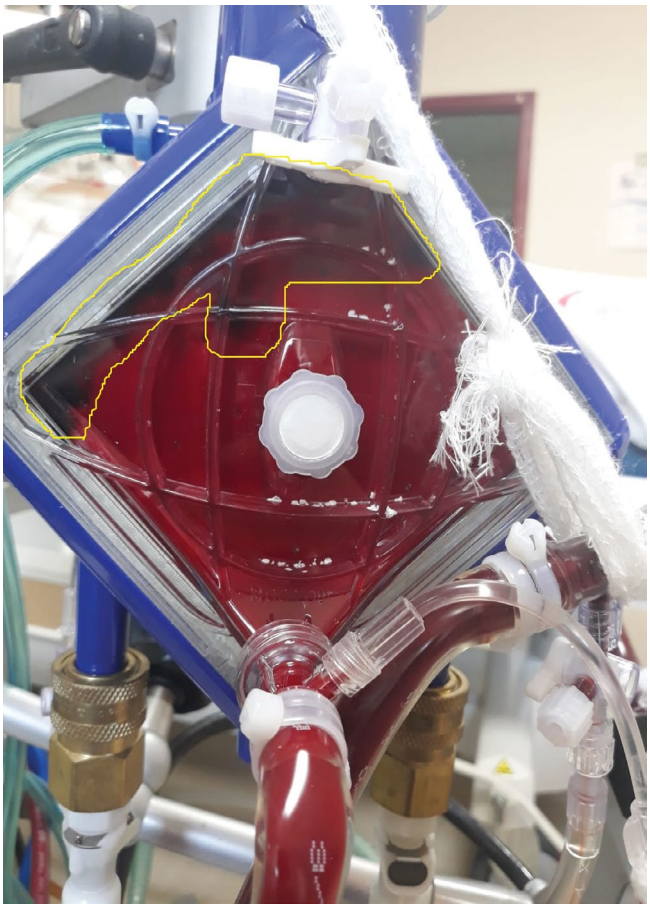

Figure 8 On the 11th day of the patient's stay, the ECMO oxygenator was replaced with the help of a manual pump upon its dysfunction.

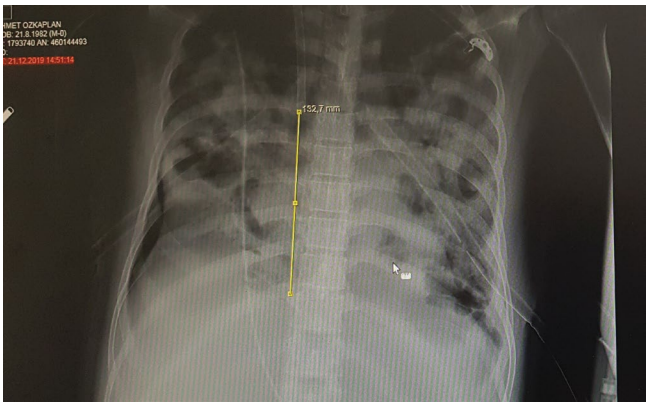

Figure 9 The drainage catheter was brought closer to the right atrium in a way that it did not cause re-circulation.

Discussion

V-V ECMO is an extra corporeal procedure that buys patients with reversible pulmonary dysfunction time for treatment by oxygenating and removing carbon dioxide from the blood [2,4,5]. Indications for V-V ECMO are clearly indicated in various publications [2,7,8]. VV-ECMO indications, firstly, include bridging in cases of prolonged mechanical ventilation in patients waiting for lung transplantation [3,8]. Other indications include: if there is hypoxic respiratory failure in any case where mortality is equal to or exceeds 50%, it can be considered and is indicated if mortality is 80% and higher; it is also indicated if there is carbon dioxide retention despite a plateau pressure above 30 cm H_2O, while severe air leakage syndromes are indicated in cases of emergency cardiac and respiratory collapses [3,8]. The cases where ECMO is applied include acute respiratory distress syndrome, airway obstruction, alveolar proteinosis, aspiration syndrome, bridging to lung transplantation, exacerbation of COPD, bacterial or viral severe pneumonia, primary organ failure after lung transplantation, pulmonary contusion, pulmonary hemorrhage and massive hemoptysis, smoke inhalation, status asthmaticus [3,8]. We believe our patient developed ARDS because of H1N1. Survival probability of our patient according to RESP score was 55-70%. Mortality was 35-40%. However, Pplateau was 40 cm H_2O, and the PO_2 value was in the range of 55-65 mmHg. The patient needed steradine and systolic arterial pressure was below 90 mmHg, although the dose of steradine was increased to 1mcg/kg/min from time to time. With these indications, V-V ECMO was administered due to H1N1-related viral infection and ARDS caused by MRSA pneumonia.

The optimal catheter end level for drainage catheter may be T10-T11 as the rotation of the hepatic vein is disrupted in cases of deeper placement [4]. During atrio-femoral ECMO, the re-circulation fraction can be significantly determined by the choice of catheter placement [5]. Adjusted cannula position may reduce re-circulation [5]. In a case report, the increase in intra-abdominal pressure in an obese patient caused collapsibility

caused by pressure in the vena cava inferior, which resulted in a dramatic reduction in flow with decreased volume of blood from the drainage catheter, thereby making an emphasis on the importance of controlling intra-abdominal pressure in ECMO patients [6]. In our case, the drainage catheter end was between the L1-T12 vertebral corpuses, the drainage catheter inserted from the right femoral vein was lower than the junction of the right atrium and the vena cava inferior.

The placement of the drainage catheter end in V-V ECMO is especially important if it has been placed into the vena cava inferior. This is even more important if the patient has increased intra-abdominal pressure. If the patient has abdominal compartment syndrome, i.e., if the intra-abdominal pressure is above 20 mmHg, vena cava inferior collapses due to the pressure against the vena cava inferior, perfusion of the abdominal organs is disturbed, thrill is detected and the pump fails to read the flow since the drainage catheter cannot drain the blood when the vena cava inferior collapses due to the increased abdominal pressure in the junction of the vena cava inferior between the catheter end in it and the right atrium. When sufficient volume of blood cannot be drained, oxygenation is disturbed, carbon dioxide retention occurs, lactic acidosis and hypotension develops. In our case, the vena cava inferior cannula was between L1-T12. The intra-abdominal pressure of our patient was 24 mmHg and thrill was detected on the drainage catheter, the pump failed to read the flow. This condition is usually associated with hypovolemia during ECMO [9]. In our patient, the junction of the vena cava inferior and the right atrium was imaged and the cannula was moved about 10 cm closer to the right atrium. All problems with ECMO were solved thanks to this manipulation. In the literature, USG is recommended to determine cannula positioning and to prevent re-circulation [5]. After this procedure, CVVHDF and CPFA were performed for removal of cytokine and fluid. In ECMO practice, catheter infection can develop at 9.9% (4.2-21.5) [8]. Our patient was followed up by making the optimum volume adjustment that ECMO could function, and the patient died on the 23rd day upon a septic shock that developed as a result of associated blood stream infection.

Conclusion

Proper catheter placement in V-V ECMO requires expertise and should definitely be checked with ECO or USG after insertion to make sure that the drainage catheter is close to the junction of the right atrium and the vena cava inferior. Because, if the catheter is left in a lower level, there may be no problems in patients with normal intra-abdominal pressure, but in patients with intra-abdominal compartment syndrome, the drainage catheter will not be able to drain blood and symptoms similar to hypovolemia will develop since the vena cava inferior will collapse in such patients. If the volume in patients is not followed up by an experienced team, this can be considered hypovolemia and cause misconceptions in volume replacement. Especially in femoro-femoral V-V ECMO, the increase in intra-abdominal pressure is more important because the drainage catheter will be affected by the collapse of the vena cava inferior if placed further away from the inferior junction of the right atrium and the vena cava inferior, thereby resulting in thrill on the catheter and the pump failing to read flow, which will be confused with hypovolemia.

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