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CASE REPORT / *OLGU SUNUMU*

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V-V ECMO Vascular Cannula Problems: 3 Case Report

V-V ECMO Vasküler Kanül Problemleri: 3 Olgu Raporu

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ABSTRACT The vascular cannulation step is of great importance for the effective and safe implementation of extracorporeal membrane oxygenation (ECMO) support. We experienced various problems associated with ECMO vascular cannulation (malposition, thrombosis, recannulation, collapse) in 3 patients who developed coronavirus disease-2019 acute respiratory distress syndrome and received veno-venous ECMO support, and here we share our experience in their management. Appropriate vascular cannula size, vascular cannula structure, selection of the vascular cannulation site, and precise vascular cannulation can make ECMO support more effective and reliable.
Keywords: ECMO, vascular, cannula, problem

ÖZ Ekstrakorporeal membran oksijenasyonu (ECMO) desteğinin etkin ve güvenli bir şekilde uygulanabilmesi için vasküler kanülasyon adımı büyük önem taşımaktadır. Çalışmamızda koronavirüs hastalığı-2019 akut solunum sıkıntısı sendromu gelişen ve V-V ECMO desteği alan 3 hastada ECMO damar kanülasyonu ile ilgili yaşadığımız çeşitli sorunlar (malpozisyon, tromboz, rekanülasyon, kollaps) ve bunların yönetimindeki deneyimlerimizi paylaşmayı amaçladık. Uygun vasküler kanül boyutu, vasküler kanül yapısı, vasküler kanülasyon bölgesinin seçimi ve hassas vasküler kanülasyon, ECMO desteğini daha etkili ve güvenilir hale getirebilir.
Anahtar Kelimeler: ECMO, vasküler, kanül, problem

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Introduction

Extracorporeal membrane oxygenation (ECMO) support which can be used as supportive therapy for reversible lung or heart failure or as bridging therapy for organ transplantation is being used as rescue therapy in the current coronavirus disease-2019 (COVID-19) pandemic, as in (H1N1) influenza pandemic (1,2).

In ECMO treatment, there is a linear relationship between ECMO blood flow and cannula diameter, so the use of large drainage cannulas is encouraged to provide full oxygen support (3). Recirculation is minimized by cannulation of the femoral vein (FV)-right internal jugular vein (IJV) and sufficient distance in between or insertion of a single double-lumen cannula through the right IJV (4). The femoral drainage cannula is advanced to remain below the diaphragm and the return cannula is at the junction of the superior vena cava/ and right atrium (5).

Vascular complications are the major cause of mortality in ECMO patients (6). Thromboembolism, bleeding, dissection, pseudoaneurysm, perforation, infection, and cannula dislocation are common complications associated with vascular cannulation (6). In COVID-19 patients, vascular thrombus may be present before vascular cannulation, mainly due to the presence of hypercoagulation, and the risk of thrombosis after cannulation is high (7).

Here, we share the problems we experienced with vascular cannulation in three patients who received veno-venous (V-V) ECMO due to COVID-19 ARDS with positive polymerase chain reaction.

Case Reports

Case 1

It was decided to start V-V ECMO support on the 24th day of intensive care unit (ICU) admission to a 37-year-old male patient with a body mass index (BMI) of 27.8 and without a known comorbid disease. It was planned to insert a 23 F drainage cannula from the right common FV and a 19 F return cannula from the right IJV under ultrasound guidance. However, despite the successful placement of the return cannula, the drainage cannula was not inserted and was instead inserted through the left common FV. The control thorax + abdominal radiograph taken to check the position of the ECMO cannulas showed that the femoral drainage cannula was in the inferior vena cava, but its tip was reversed entirely and directed caudally (Figure 1).

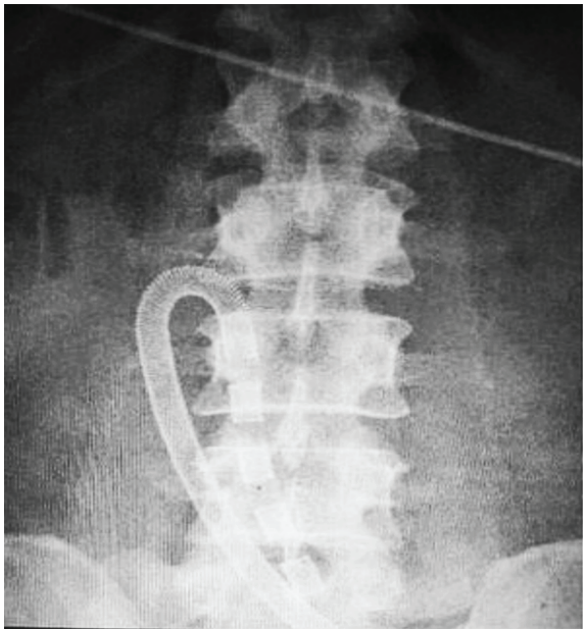

Figure 1. Left femoral vein ECMO drainage cannula dislocation
ECMO: Extracorporeal membrane oxygenation

The drainage cannula dislocation was tried to be corrected by moving the cannula back and forth, but it could not be fixed. Thereupon, the drainage cannula was tried to be withdrawn, but all the repeated attempts were unsuccessful because the cannula was compressed at the level of the left internal iliac vein (Figure 2).

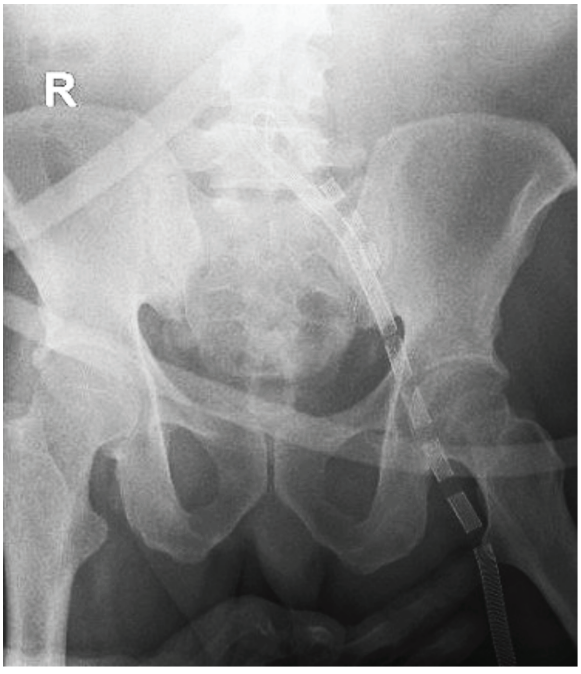

Figure 2. Drainage cannula stuck at the level of the left iliac vein

Since we failed to withdraw the drainage cannula, the cardiovascular surgery team was informed about the risk of vascular perforation, requesting support. Surgical removal was not preferred in the first place due to the critical condition of the patient and the risk of starting anticoagulation therapy for ECMO support afterward. The introducer was tried to be placed in the drainage cannula, but it could not be fully inserted. We tried to withdraw the cannula while pushing the cannula introducer piece into the cannula. Using this technique, the cannula was removed without any complications after a few minutes of effort. A new drainage cannula was then successfully placed in the right common FV.

While correcting the femoral cannula, the patient's hemodynamics did not deteriorate, but 100% O_2 support was required because oxygenation was impaired. After the left femoral cannula was withdrawn, 30-minute compression was applied to that area, and then it was closed with a primary suture. No hematoma or circulatory disorder was detected in the inguinal region, except for mild hemorrhage in which routine anticoagulation (intravenous 5000 u unfractionated heparin) was applied before cannulation (5 minutes before).

ECMO weaning was applied to this patient after a total of 57 days of V-V ECMO support. Unfortunately, he died 12 hours after weaning due to sudden cardiogenic shock.

Case 2

It was decided to start V-V ECMO support on the 5th day of ICU admission to a 36-year-old male patient with a BMI of 32.1 and without a known comorbid disease. A 23 Fr drainage cannula was inserted in the right common FV under ultrasound guidance, but due to a nearly total occlusion with thrombus into the right IJV (Figure 3) the return cannula was inserted into the left FV, and bifemoral ECMO support was started. The drainage cannula was placed at 40 cm, and the return cannula at the entrance of the right atrium with a distance of >15 cm between them.

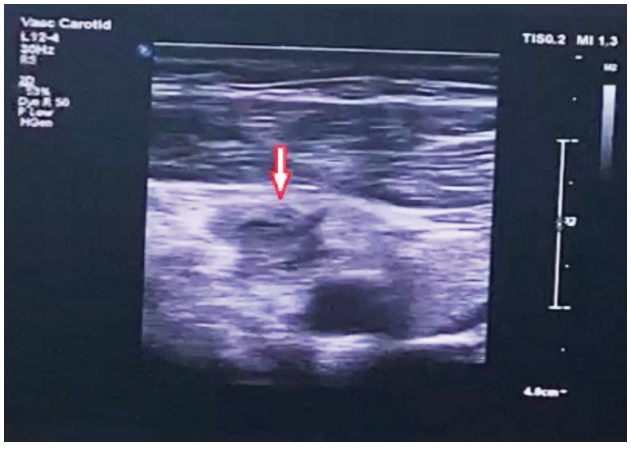

Figure 3. Nearly total thrombosis of the right internal jugular vein

Although 6,500 mL/min blood flow, 8 L/min gas flow, and FiO_2 100% were adjusted with ECMO, mechanical ventilation (MV) supports could not be reduced to lung-protective ventilation values (FiO_2 90%, PEEP 10, driving pressure 20 cm H_2O, Fr 20) and SpO_2 declined to 60%. Then, switching again to right FV-IJV ECMO support was considered since the recirculation level was lower. Return vascular cannulation with an 18 Fr cannula was applied from the most distal of the right IJV, close to the right subclavian vein junction, where thrombosis was minimal. Then, it was switched to right FV-IJV ECMO. With the same ECMO support level, SPO_2 was increased to 90%. At first, protective pulmonary MV settings could not be achieved, but MV supports were reduced in a few weeks.

The patient was weaned from V-V ECMO after 62 days of successful V-V ECMO support. Afterwards, on the 80th day of his intensive care hospitalization, he was discharged to the physical therapy center in conscious and spontaneous breathing.

Case 3

It was decided to start V-V ECMO support on the 8th day of ICU admission to a 35-year-old female patient with a BMI of 36.7 and diabetes mellitus. FV-IJV ECMO support was started by inserting a 22 Fr drainage cannula from the right common FV and a 19 Fr vascular cannula (LivaNova brand cannula) from the right IJV under ultrasound guidance. The cannulas were in the appropriate position radiographically.

When the sedation level was reduced during the patient's follow-up, a severe problem was observed in the ECMO blood draw due to both excessive inspiratory effort and abdominal obesity. There was a problem in the connector part of the ECMO drainage cannula, leading up to complete collapse during inspiration (Figure 4).

To solve this problem, the drainage cannula tip was moved back and forth to reach a more optimal level, but the problem could not be solved. During ECMO support, deep sedation or curarization had to be applied to cope with the draw problem. V-V ECMO support was applied to the patient for 20 days, but died due to septic shock on the 28th day of admission to the ICU.

Figure 4. The appearance of collapse in the connector part of the right main femoral drainage cannula

Discussion

Vascular cannulation for initiation of ECMO support is the most crucial step of effectiveness of the ECMO support. We presented the management of three patients who had problems during or after the cannulation procedure.

During the COVID-19 pandemic, we performed ultrasound guided cannulation for V-V ECMO in 44 patients under intensive care conditions. FV-IJV was applied to 43 of these cannulation procedures and only one of them was FV-FV. This FV-FV ECMO patient was then converted to FV-IJV ECMO to reduce recirculation. Since V-V ECMO cannulation is mostly a percutaneous procedure, it is a feasible procedure in the ICU. In addition, negative situations such as loss of time during the transfer of the patient to the operating room and cannula dislocation that may occur when returning to the ICU are avoided.

The decision to open ECMO for these patients was made in line with Extracorporeal Life Support Organization recommendations (8). At the beginning of V-V ECMO in all patients, ECMO gas flow was started with 2-3 L/min and blood flow was started with 2 L/min and gradually increased to allow lung protective ventilation within a protocol.

In our first case, we experienced a vascular cannula dislocation that had not been seen before in the literature (Figure 1, 2). While trying to correct this cannula dislocation, the risk of vascular perforation should be considered, and it is necessary to act in coordination with the cardiovascular surgery team in case of a possible urgent need for vascular surgery (6). If surgical intervention is performed, the use of postoperative anticoagulant therapy is also a relative contraindication for ECMO (3). We successfully managed this complication without the need for surgical intervention by the technique of pulling the cannula out while pushing the introducer back into the cannula.

In our second case, nearly-total thrombosis was detected in the right IJV by ultrasonography, this time at the pre-cannulation stage (Figure 3). In this condition, insertion of a return cannula from the right IJV is risky due to the risk of pulmonary thromboembolism. That's why we performed bi-femoral ECMO support. But, as mentioned before, it is recommended to apply femoral-internal jugular cannulation with sufficient distance in between (>15 cm) to minimize recirculation or to insert a single double-lumen cannula from the right IJV (4). Adequate oxygenation could not be achieved with bi-femoral ECMO since the patient's ARDS picture was very severe and the patient was obese. Thus, we think that femoral-internal jugular ECMO support is a much more appropriate choice than bi-femoral ECMO support, mainly in obese patients with advanced lung failure.

In our third case, we experienced a problem that severely impairs ECMO blood flow, leading to total collapse at the connector part of the ECMO drainage cannula (Figure 4). Blood suction can cause vasodilation, mostly in conditions that impair extracorporeal blood flow, such as hypovolemia, coughing, increased intra-abdominal pressure, and malposition of cannulas (9). The patient underwent adequate volume replacement under ultrasonographic guidance, and radiography affirmed that the cannulas were in the optimum position. Therefore, the patient had to be followed under curarized or deep sedation during ECMO. Apart from this, we assumed that the problem was that the connector part of the ECMO cannula type used was not sufficiently resistant to collapse. We might not encounter this problem if a more rigid connector was used as in Maquet ECMO cannulas.

Sharing experiences on the management of ECMO cannulation problems will assist clinicians in reducing ECMO-associated morbidity and mortality.

Ethics

Informed Consent: Written informed consent required for publication of the case series (clinical details and images) was obtained from the families of the patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.A., R.Y., Concept: M.A., R.Y., Z.Ç., Design: M.A., R.Y., Z.Ç., Data Collection and/or Processing: M.A., Z.Ç., Analysis and/or Interpretation:

M.A., M.S.S., Z.Ç., Literature Search: M.A., Writing: M.A., R.Y., M.S.S., Z.Ç.

Conflict of Interest: No conflict of interest was declared by the authors.

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