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Case Report

Bedside cannulation for veno-venous extracorporeal membrane oxygenation using portable X-ray system in a coronavirus disease patient

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ABSTRACT

Transportation of patients with coronavirus disease (COVID)-19 outside isolation rooms should be avoided to prevent further spread of the disease. Here, we report a safe and accurate bedside cannulation method for veno-venous extracorporeal membrane oxygenation (VV-ECMO) in a COVID-19 patient in the intensive care unit. A 71-year-old man was admitted to our hospital and diagnosed as having COVID-19 pneumonia. We decided to initiate VV-ECMO therapy because maintaining blood oxygen saturation was difficult despite the mechanical ventilation. We placed two flat-panel detectors behind the patient's chest and the right inguinal area. We repeatedly imaged and monitored insertion of wires and cannulas using a portable X-ray system. Cannulas were successfully inserted in the appropriate position, and VV-ECMO was initiated without any complications.

<**Learning objective:** Transportation of patients with coronavirus disease outside isolation rooms carries the risk of further spread of the disease. By repeatedly acquiring images using a portable X-ray system, safe and accurate cannulation for veno-venous extracorporeal membrane oxygenation cannulation can be performed at the bedside in the intensive care unit.>

Introduction

The novel coronavirus disease (COVID)-19 has rapidly spread worldwide, causing a pandemic that constitutes the largest global public health issue in recent years [1]. Approximately 12%–24% of patients hospitalized with COVID-19 develop respiratory failure requiring mechanical ventilation [2,3], and several reports have described the potential benefit of veno-venous extracorporeal membrane oxygenation (VV-ECMO) in most severe cases [4]. However, ECMO management requires substantial resources such as equipment, facilities, and a well-trained and specialized staff team. Cannulation procedure for ECMO is usually performed in the catheterization laboratory because the large-diameter cannula insertion causes serious complications if the procedure fails. However, when ECMO is required for COVID-19 patients, transportation of patients outside their isolation rooms would spread the disease. Here, we report a safe and accurate bedside cannulation method for VV-ECMO in a COVID-19 patient in the intensive care unit.

Case report

A 71-year-old man complained of cough and throat pain. He had comorbidities of chronic heart failure, past myocardial infarction, chronic atrial fibrillation, and diabetes mellites. His mother had been already diagnosed with COVID-19, and his polymerase chain reaction test result was also positive for severe acute res-

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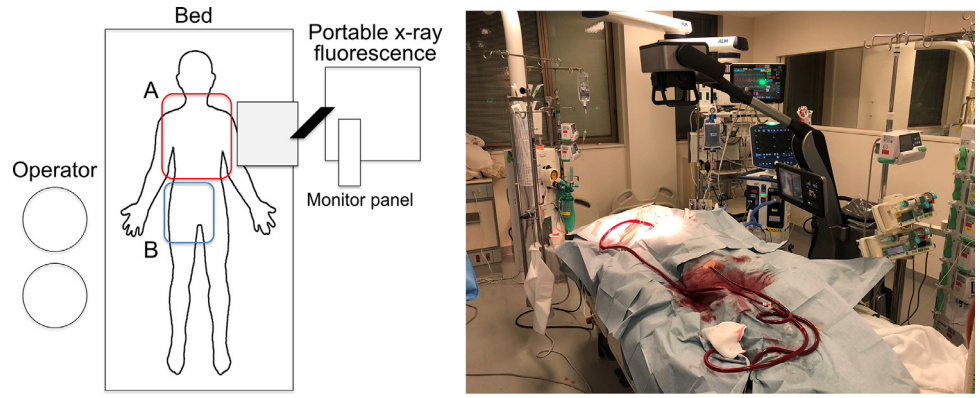

Fig. 1. Position of wireless flat-panel detectors. Portable X-ray system (FUJIFILM DR CALNEO AQRO, FUJIFILM, Tokyo, Japan) was located on the patient's left side and the operator stood on the patient's right side. (A) A 14×17-inch panel was placed behind the chest. (B) A 10×12-inch panel was placed behind the right inguinal area.

piratory syndrome coronavirus 2, which causes COVID-19. He was admitted to a hospital because of shortness of breath and fever of 38°C 5 days after symptom onset. Despite the use of dexamethasone, his respiratory condition worsened owing to COVID-19 pneumonia. Thus, emergency tracheostomy was performed to secure his airway because previous trauma precluded intubation. Mechanical ventilation was initiated 8 days after admission. However, maintaining blood oxygen saturation was difficult (ventilation setting: PEEP, 14 cm H_2O; FiO_2, 100%), and the PaO_2/FiO_2 ratio was 86. Additionally, the patient could not be moved to the prone position because of tracheostomy. Therefore, we decided to initiate VV-ECMO therapy.

Bedside insertion of cannulas for VV-ECMO

A 14 × 17-inch flat-panel detector (FPD) was placed behind the chest and a 10 × 12-inch FPD was placed behind the right inguinal area (Fig. 1). A portable X-ray system (FUJIFILM DR CALNEO AQRO, FUJIFILM, Tokyo, Japan) was placed on the patient's left side while the operator stood on the patient's right side. Before disinfection of the puncture site, we checked whether the FPD was in the appropriate position by capturing images. During the procedure, we repeatedly captured and examined the images using the portable X-ray system to ensure the correct location of wires and cannulas whenever necessary at each step. The FUJIFILM DR CALNEO AQRO system allowed us to capture repeated images approximately 5–10 seconds after each shot while leaving the FPDs and to check the images directly on the monitor while continuing the procedures. First, before puncturing, a needle was placed at the planned puncture position and a photograph was taken to confirm the correctness of the puncture position (Fig. 2**A**). After using the echo-guided technique to puncture the right femoral vein, we carefully advanced the wire from the femoral vein to the inferior vena cava and then to the superior vena cava while checking the wire tip on the two FPDs to prevent the wire from migration (Fig. 2**B,C**). When taking images of the chest after taking images of the inguinal area, there is no need to move the portable X-ray system itself; images can be taken simply by manipulating the arm of the system. We also punctured the right internal jugular vein and delivered the wire to the inferior vena cava (Fig. 2**D**). Next, after dilating the vessel using a dilator over the guidewire and into the vessel, the drainage cannula (24 Fr) was inserted over the guidewire from the femoral vein to the right atrium (Fig. 2**E,F**). After that, the infusion cannula (18 Fr) was inserted (Fig. 2**G**). Finally, the drainage cannula position was changed to just below the inferior vena cava-right atrium junction (Fig. 2**H**). We successfully inserted the cannulas and initiated VV-ECMO without any complications.

Follow-up

Respiratory status improved after 9 days of VV-ECMO management, and VV-ECMO was successfully removed. The next day, he could be weaned off mechanical ventilation management. He was transferred to the hospital for rehabilitation purposes because his weakness was significant.

Discussion

In this study, we presented a method of cannulation for ECMO using a portable X-ray system at the bedside, which could minimize the risk of spreading infection and avoid the need for transporting patients with unstable respiratory conditions. With this method, we succeeded in inserting large size of canulations without any complications.

In order to perform safe cannulation using fluoroscopy for avoiding the complications associated with large-diameter cannulation, patients have to be transported to the catheterization laboratory or hybrid operation room. However, transportation of patients may contaminate these rooms and spread COVID-19 outside these rooms because they are usually maintained in a positive pressure environment. And, considering the time and effort required to transport the patient safely when using fluoroscopy, our method is superior because the preparation, such as placing the X-ray equipment, takes less time and effort. In addition, a patient is exposed to radiation doses corresponding to the number of X-ray images taken, but this amount is definitely less than using fluoroscopy. The time required for cannulation is about one hour or less, which is almost the same as the method using fluoroscopy. And, as for another method, C-arm fluoroscopy may be useful in cases with no imaging system in the catheterization laboratory or hybrid operation room [5], although it usually cannot be used in the ward owing to space constraints, insufficient room shielding, and insufficient protection for other patients and staff. Moreover, the usefulness of cannulation supported by transesophageal echocardiography has been demonstrated [6]. However, the visualization of the wire is limited to the area around the heart, evaluation of wire motion in the abdomen is difficult, and the method using transesophageal echocardiography requires the technique of an operator. And, in some situations, a blinded introduction of VV-ECMO is sometimes employed; however, it has a high risk of bleeding due to migration of the wire and may not achieve adequate

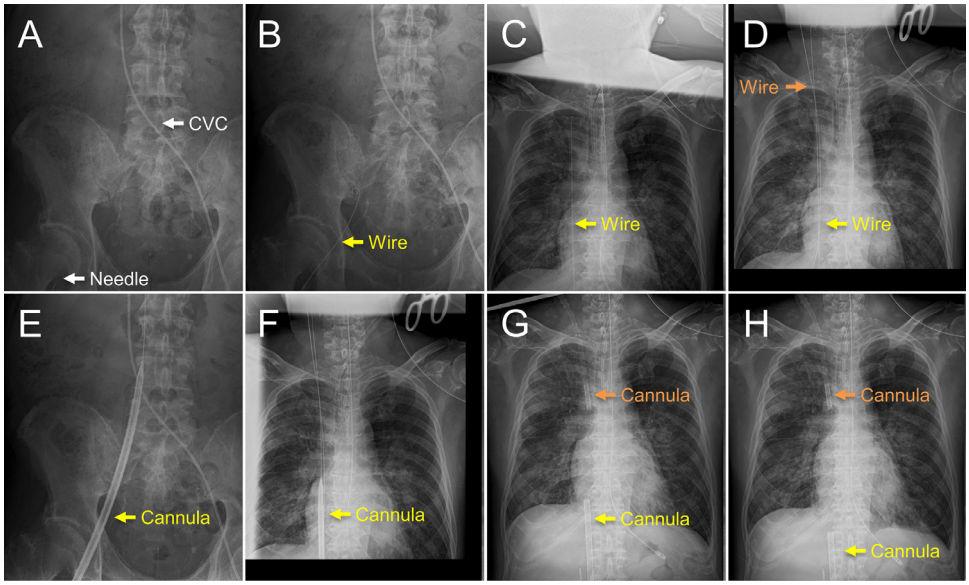

Fig. 2. Portable X-ray images taken during the insertion of cannulas for veno-venous extracorporeal membrane oxygenation. (A) An appropriate site for puncturing the femoral vein was confirmed. (B) The wire was advanced from the femoral vein to the inferior vena cava and then to the superior vena cava. (C) The wire was advanced from the right internal jugular vein to the inferior vena cava. (E-F) The drainage cannula was inserted from the femoral vein to the right atrium. (G) The infusion cannula was inserted. (H) The drainage cannula position was changed to just below the inferior vena cava-right atrium junction.
CVC, central venous catheter.

oxygenation due to the inability to cannulate in the proper position. With our method, we can confirm that the wire and the cannula are being inserted properly by repeatedly acquiring the images, so that the procedure can be performed safely. The position of the cannulas is essential for VV-ECMO to exert its full oxygenation function. Cannulas can be placed in an appropriate position using this method.

The position of FPDs can be changed depending on the case, and this method can be applied in cases of VA-ECMO or diseases besides COVID-19. In the catheterization laboratory or hybrid operation room, other procedures can be performed at the same time. However, if only ECMO insertion is required, it can be performed by the bedside using our method.

In conclusion, our findings suggest that ECMO cannulation can be performed easily and safely in the ward using the method presented in this study because images can be repeatedly captured and evaluated using a device used in routine medical care.

Declaration of Competing Interest

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