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PICC Insertion could be an optimal choice of central venous access in prone position mechanically ventilated COVID-19 ARDS patient

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ABSTRACT

During the management of critically ill covid-19 patients obtaining an appropriate centrally inserted central catheter (CICC) can be a prime necessity. Traditionally, a CICC is inserted in a supine position. However, a CICC may not be possible in some COVID-19 patients with severe hypoxia or sudden clinical deterioration who need urgent intubation and immediate proning. Therefore, CICC in pronated COVID-19 ARDS patients is challenging. Recent studies limited to case reports have shown that peripherally inserted central catheters (PICC) are safer in pronated ARDS patients. PICC lines minimize mechanical complications and lower catheter-related bloodstream infections when compared to standard CICC. However, there is a scarcity of evidence showing the efficacy of PICC in pronated COVID-19 ARDS patients, possibly due to the complex precautionary safety measures, insertion techniques, and expertise team deficit. Herein, we present a 57-year-old male as a case of COVID-19 ARDS, mechanically ventilated in a prone position with existing subcutaneous emphysema. Our case illustrates PICC insertion challenges in the prone position, ultrasound guidance in PICC insertion to comprehend the vein's diameter for accurate vein needling in proportion to the external catheter diameter, and intracavitary electrocardiographic (ECG) navigation method to confirm catheter tip location. So that chest X-ray and radiology risk of contamination is avoided. Long-term research urged to validate the efficacy of PICC in this group of patients.

Keywords: Central Venous access devices (VAD) Central venous access devices (CVAD), Centrally inserted central catheter (CICC), peripheral inserted central catheter (PICC), Blood gas analyses (BGA), Subcutaneous emphysema (SE), Electrocardiography (ECG), Intracavitary electrocardiography (IC-ECG).

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Introduction

The rapid global transmission of novel coronavirus has alarmed the health care system for urgent revision of current clinical methods. As an outcome, many standard clinical maneuvers, treatment protocols, and policies are revised and refined to decrease the risk of virus exposures and transmissions.[1] In particular, utilizing modern medical technologies and associating with the clinical procedures may enhance health care professionals' safety and patient safety, thereby reducing morbidity, mortality, and cost values. The standard first-line invasive procedure of hospitalized patients is to obtain venous access through appropriate venous access devices (VAD). Generally, VAD is classified into peripheral venous access device (PVAD), central venous access device (CVAD). The peripheral venous access (PVAD) is sub-classified into short peripheral cannula (<6cm), long peripheral cannula (6-15cm), and midline catheters (>15cm). Further, the central venous access device (CVAD) classified into a femoral inserted central catheter (FICC), subclavian, and internal jugular centrally inserted central catheter (CICC), and peripheral inserted central catheter (PICC).[2] According to the database of the United States of America, approximately five million CVAD inserted annually.[3] Although the absolute number of CVAD insertions in covid patients has not been reported yet, it is vivid to believe that all critically ill COVID-19 ARDS patients claim a CVAD for the optimal management of their illness. COVID-19 ARDS is relevant to the customary ARDS pathology. It begins with increased capillary permeability and hyaline membrane formation characterized by interstitial widening and edema, resulting in a protein-rich fluid collection in the alveoli of lungs resulting in oxygen impairment as patients advance further into their covid sickness leading to lung fibrosis which is the significant character of COVID-19 ARDS. [4] Patients in ICU may need CICC, and the standard position of CICC insertion is supine. However, in some covid-19 ARDS patients, CICC is not possible in a supine position.[5] In particular, patients with severe hypoxia or any sudden clinical deterioration may need urgent, rapid sequence intubation and immediate proning. Considering the proning therapy in such a group of patients is vital as it improves regional ventilation, oxygenation, and alveolar recruitment. Therefore, perfusion redistribution increases and the recruitment of perfused tissue of dorsal regions exceeds the ventral derecruitment and enhancing the ventilation and perfusion ratio.[6] CICC is highly recommended for the extended treatment of covid-19 ARDS patients. Since it holds long-life durability, with various benefits of continuous multiple high flow infusions including sedation, muscle relaxants, vasopressors, and infusions of solutions with pH greater than 9 and lesser than 4 (*e.g*., dopamine, vancomycin, levofloxacin), or hyperosmolar parenteral nutrition (whose osmolarity exceeds 800-900 mOsm/L) and allowing frequent blood sampling.[7] The insertion of CICC (internal jugular or subclavian vein) in mechanically ventilated prone patients is challenging. Moreover, it is critical to turn the prone patient to supine as it may disrupt the regional ventilation, resulting in oxygenation impairment, hemodynamic instability, and life-threatening events. Recent studies have demonstrated that PICC is safer in prone ARDS patients. It minimizes the risk of pulmonary-pleural complications and catheter site contamination as it is isolated from the patients' oral and tracheal secretions. Additionally, it lowers the exposure risk of a patient's nasal, oral and tracheal secretions to the operator, his associates and non-contraindicated to the anticoagulated patients. Furthermore, PICC can preserve the upper central regions (internal jugular and subclavian vein) for prospective dialysis and ECMO cannulation if needed.[8]

Herein, we report an innovative, unique, rare PICC line insertion in a prone position mechanically ventilated patient with existing subcutaneous emphysema to treat COVID-19 ARDS disease. We describe our challenges concerning the prone patient, operator, and associates' precautionary safety measures. Also, ultrasound guidance is essential to determine the vein's diameter for cannulation combining modified seldinger technique approach for accurate vein needling. Following insertion, it is imperative to check the location of the tip of the central venous catheter by non-radiological methods, such as intracavitary electrocardiography (IC-ECG). Thereby, x-ray radiation is avoided.

Case report

The 57-year-old male COVID-19 positive with a medical history of diabetes mellitus type 2 presented to the emergency department (ED) after 6 days of home quarantine with symptoms of progressive shortness of breath, chest tightness, dry cough, fever, and myalgia. His initial vitals are Glasgow coma scale (GCS) 15/15, respiratory rate 36 breath per minute (bpm) using accessory muscles, temperature 39 ^{0}C, heart rate 116 bpm, blood pressure 130/88 mmHg. Oxygen saturation on room air was 60 % treated with a non-rebreathing mask of 15 l/min. Oxygen saturation rose to 88%. Initial blood gas analyses were Ph; 7.39 Pco2; 45.7 Po2; 56 HCO3; 25 So2; 68.7. On physical examination, mild jugular distension, the weight of 90kg, the height of 174cm, and BMI of 29.7 kg/m2. On auscultation, severe bronchospasm and diffuse bilateral wheezes. Anterior-posterior x-ray reveals COVID-19 pneumonia. In ED, two short peripheral venous access obtained on both hands to administer intravenous fluids and methylprednisolone of 120 mg/kg and repeated back-to-back nebulized salbutamol 2.5 mg, ipratropium bromide 0.5 mg, and budesonide 0.5 mg were given for his bronchospasm. The repeated ABG showed pH: 7.29 PaCO2:50.7 PaO2: 48 HCO3; 20.7 So2 63.6. Despite the therapy, the patient's condition deteriorated, and he was diagnosed with acute hypoxic respiratory failure associated with COVID-19 pneumonia and transferred to ICU for close observation.

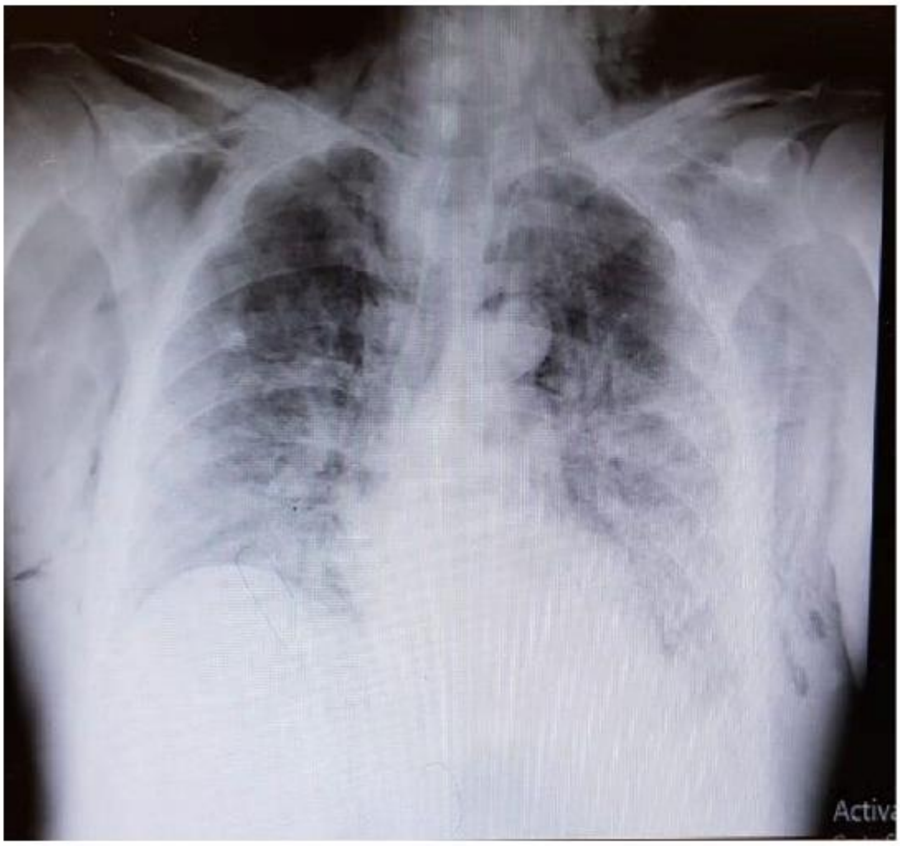

Figure 1 Depicts COVID-19 ARDS X-ray with diffuse subcutaneous emphysema

Figure 2 A view of a prone patient with right arm tourniquet

A high flow nasal cannula (HFNC) 60LPM with fio2 100% was initiated, and the patient admirably responded, with spo2 of 91%. After 48 hrs of HFNC, the patient started to deteriorate with spo2 of 70% and an increased respiratory rate of 48 bpm using accessory muscles. We decided to hook the patient on NIV (CPAP) ventilation with a peep of 8 cmh2o, pressure support of 15 cmh2o to promote oxygenation and reduce work of breathing. The patient is subjected to nursing in proning and lateral positions periodically. Repeated BGA after 1 hour of NIV was satisfactory. On 3 days of NIV, the patient complained of sudden chest tightness, difficulty breathing, restlessness with spo2 of 68%, respiratory rate of 50 bpm, and hypotension. Dexmedetomidine was commenced on 0.4 mcg/kg/hour, and inotropes (non-adrenaline) escalated to a maximum of 16 mcg/per minute on short periphery venous access to reach targeted mean arterial blood pressure. Repeated BGA showed metabolic acidosis (Ph; 7.23 pCO2;65 PO2 52.9 HCO3; 20.7 So2; 69.9), and Chest X-ray revealed subcutaneous emphysema with severe ARDS. (Figure 1)

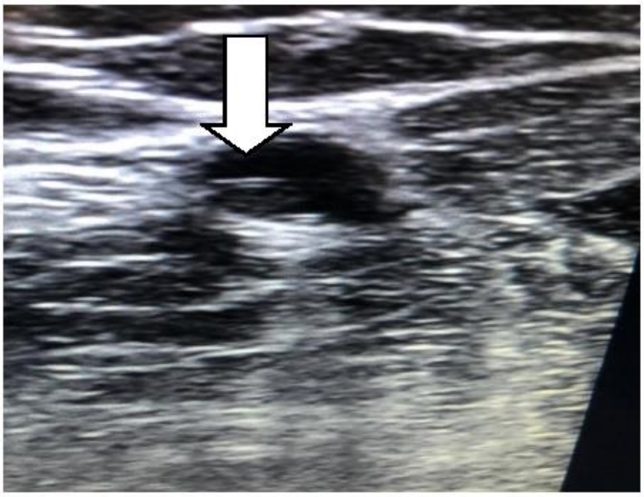

Figure 3 A view of basilic vein (white arrow depicts PICC line) through ultrasound guidance

Figure 4 Navigation ECG technology showing the patient electrocardiogram tracing above and the intravenous tracing below showing maximal P-wave confirming superior vena cava placement.

Following this sudden clinical deterioration, our team decided on elective intubation as a life-saving emergency. With complete personal protective equipment (PPE), the intensivist intubated the patient with a 7.5 Endotracheal tube (Portex, USA) at 22cm level respectively from central incisors and connected to the mechanical ventilator (Maquet servo-i) with PRVC mode tidal volume of 420 ml, peep 12 cmh2o, RR 20 with I:E of 1.2.5. Despite all these measures, oxygen saturation is <60%, and we decided to do immediate prone positioning, and oxygen saturation rose to 91%. However, the patient was sickened from persistent hypotension and could not maintain hemodynamics with a maximum dose of inotropes through short periphery venous access. Therefore, to stabilize him, urgent large-bore central venous access is needed for continuous maximum ionotropic support, vasopressors, sedatives, and muscle relaxants to maintain hemodynamics. In addition to mechanical ventilation and frequent prone therapy is required to improve his oxygenation. We considered that the insertion of CICC in the supine position would interrupt the prone therapy and consequently hinder the improvement of oxygenation. In this clinical setting, we decided to insert PICC in the prone position provided that potential benefits are more than standard central venous catheters (CVC). After guaranteed mechanical ventilation stability in the prone position, the patient's right upper arm was internally rotated, abducted with elbow semi-flexed approximately 70 degrees, forearm pronated, and the tourniquet was applied to the upper right arm (Figure 2). Five lead ECG electrodes were attached to the patient's upper back for continuous ECG monitoring and intravenous catheter tip navigation. By pre-procedural ultrasound guidance, a feasible clot-free basilic vein with a diameter of 4 mm was identified in the lower right arm and planned to insert a PICC through the intravenous catheter navigation method. (Figure 3)

Figure 5 A view of Distal triple lumens of PICC covered with sterile dressings

With precautionary safety measures, a maximal barrier drape was placed to cover the patient and mayo table used at the procedure. Then a sterile PICC tray was prepared (PowerPICC catheter with sherlock Tip positioning system, 5 Fr, triple lumen, US). An estimated PICC length was measured was from the tip of the 3rd finger to the middle of the elbow crease to the most prominent point of the acromion process to the sternal head of the clavicle and to the end of the xiphoid process to place the catheter tip in the superior vena cava and avoid the invasion catheter tip into the right atrium. The ultrasound probe was draped with a double sterile plastic cover, and the depth was set to 3.5cm. Through ultrasound guidance, the patient's right basilic vein accessed by a short-axis out of plane approach followed by a 22 G over needle catheter penetrated the superficial basilic vein using a long axis in-plane approach (6-15 MHz, SonoSite Edge, SonoSite Japan Co., Tokyo, Japan) using modified seldinger technique. Next, a triple lumen PICC catheter (proximal) advanced into a basilic vein, and with the ECG navigation assistance method, reached the superior vena cava (superior Cavo atrial junction) until the maximal P-wave was noticed on the screen (Figure 4).

Furthermore, distal PICC lumens were towards the arm's posterior aspect placed with a sterile dressing (Figure 5). Overall, the procedure time was 20 minutes, resulting in 100% technical success and obviating the necessity for a chest radiograph. The PICC line was used for 21 days continuously. Patients did not develop catheter-related bloodstream infections or upper extremity deep venous thrombosis related to PICC placement. No line malfunction was reported, and no requests were received to replace PICC. Institutional anticoagulation protocol based on d-dimer levels and PTT ratio was followed. the patient was tracheostomized and weaned from the mechanical ventilator and discharged to peripheral hospital on day 22 for rehabilitation and nursing care.

Discussion

The advancement of the healthcare system in this century has extended the human life span significantly. However, the emergence of diverse co-morbidity, new clinical diseases, and its severity has increased frequent hospitalization, and in such circumstances obtaining long-life venous access through appropriate central venous access devices (CVAD) for critically ill patients is imperative. In this perspective, CVAD has become the standard first-line device for central venous access. Studies before the COVID-19 pandemic has shown that annually Clinicians insert millions of CICC, with an overall complication rate of 15% (5% to 19%). such as catheter-related infection (5% to 26%), a thrombotic event (2% to 26%) and power-driven mechanical complications (5% to19%).[9] Power-driven mechanical complications usually happen in the following circumstances 1. insertion of CVAD in an emergency, 2. inserting large catheters size (dialysis), 3. increased number of needle pricks, 4. complex central vein anatomic anomaly, 5. inexperienced operator, which results in hematoma, hemothorax, pneumothorax, arterial-venous fistula, air embolism, nerve injury, left side thoracic duct injury, intraluminal dissection, punctured aorta, and jugular. [10] However, pneumothorax is one of the prime complications of CVAD insertion serving up to 30% of all power-driven mechanical adverse complications. [11]

Likewise, covid-19 patients admitted through this current pandemic were more likely to require high critical care support with prolonged hospitalization and prolonged ICU stay with the provision of a long-life span of venous access, which may put them at greater risk of power-driven mechanical complications and central line-associated bloodstream infections (CLABSI). Moreover, the timeline from COVID-19 diagnosis to the incidence of CLABSI is 18 days on average [12], implying that the CLABSI episodes can befall COVID-19 patients with prolonged hospitalization. According to the US nation's surveillance system for healthcare-associated infections (HAIs) reports during

(COVID-19) pandemic has exhibited the standardized infection ratio (SIR) of CLABSI rate has increased to 39% in the critical care unit.[13] similarly, a study conducted by Kathleen M. et al. reported that in 2 hospitals where the study was conducted report the highest impact on the healthcare-associated infection (HAI) is expected to be CLABSI rates. With the marked increase in CLABSI rates in both hospitals of 420% increase to rate = 5.38 cases per 1,000 central line days, and a 327% increase to rate = 3.79 cases per 1,000 central line days. Also, the proportion of COVID-19 patients with CLABSI events was 5 times greater than for non–COVID-19 patients during the pandemic period. [14] Based on the recent studies above, we decided to keep our patient on limited short peripheral venous access in the ICU since the patient had hemodynamic stability with GCS15/15 and no inotropes requirement. Although barotrauma incidence is rare in NIV, a recent single-center, retrospective, observational cohort study has shown that 21% of 75 patients with COVID-19 treated in an intensive care unit (ICU) sustained barotrauma (including pneumothorax, pneumomediastinum, pneumopericardium, and subcutaneous emphysema). In that, 33% of patients receiving IMV, 8% of patients receiving (NIV). [15] Similarly, our patient-reported surgical emphysema on standard NIV recommended settings and SE were managed conservatively by lowering the NIV pressure. However, our patient's condition has worsened suddenly with a spo2 of 68%. The patient was intubated on 3rd day of his hospitalization and required immediate prone positioning for severe hypoxia. Consequently, spo2 rose to 94%, and the P/F ratio was 114, which correlates to the data presented by Atsushi et al., that among 125 patients, 121 patients (96.8%) are intubated within 14 days of their clinical onset. [16] Also, Tyler et al. stated that after the first prone positioning session, the Pao2/Fio2 ratio increased from 17.9 (7.2) to 28.2 (12.2) kPa within 81 (61–119) minutes in 36 subjects. [17] Although prone positioning improved oxygenation instantly, severe hypotension required immediate central venous access. Generally, intensivists prefer to use Internal jugular, subclavian, femoral vein (CICC) rather than PICC in covid patients. However, few studies report the effectiveness of PICC for central venous access in critically ill patients. [18] CICC insertion with existing SE can worsen further. Furthermore, in the pronated patient, the dressing of a CVAD is inevitably more uncomfortable to manage with difficulty in periodic monitoring of the exit site and the connection/disconnection of the infusion lines. During the maneuvers of pronation-supination, it can result in stretching, drawing, and kicking at CVAD insertion sites. [19] However, no case was reported previously about PICC insertion in the prone position with existing SE like the case we present in this paper.

Intensivists must contemplate the jeopardies of catheter-related complications in selecting the CVAD, which incorporates deep vein thrombosis and bloodstream infections. Although there are no variations in infectious complications between PICC and CICC approaches in critically ill patients. [20] Still, there remains a controversy concerning the thrombotic complications between these approaches of PICC and CICC. Apart from barotrauma, induction of a CICC in sitting or upright positions carries a risk of air embolism. Contrarily, there was no report of PICC-related air embolism. Usually, PICC is inserted in a peripheral vein. A peripheral vein pressure is higher than atmospheric pressure, resulting in no air embolism during PICC insertion. [21] Hence, a patient in the prone position with existing SE can be secured safely by PICC. The Perception of PICC insertion in COVID 19 patients in the prone position is feasible and straightforward with ultrasound guidance. The number of failed attempts decreases to 86% with ultrasound by decreasing the number of attempts and procedure time-outs. Also, several clinical studies have demonstrated a high precision rate for ECG-guided CVC placement with 97.3% sensitivity and 100% specificity. [22]

In summary, The COVID-19 pandemic indeed modified today's clinical practices of Central venous accesses. The positive outcome of this PICC procedure in critically ill covid-19 patients with subcutaneous emphysema who require immediate intubation and prone positioning has significantly created a new awareness to implement expertise, intensivist, and nurses' team to employ the suitable Central venous accessibility. Furthermore, our case highlights that daily prompt investigation of the inserted PICC line integrity, position, and daily catheter dressing care minimize the incidence of PICC-related complications and save resources through ultrasound-guided catheter positioning and IC-ECG to check for catheter tip location abandon the routine use of chest X-ray.

Conclusion

PICC line is a safe procedure and feasible to be done on prone positioned mechanically ventilated patients. In addition, this procedure may be applicable for patients in whom central venous access is not possible in a supine position and patients at the risk of barotrauma.

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Conflict of interest

None

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