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Utilization of ultrasound-guided peripheral intravenous access in the reduction of central venous catheter insertion

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Introduction

Intravenous (IV) catheter placement is the most frequently performed hospital procedure.[1] IV catheters are essential for administering medications, fluids, radiographic contrast media, and collecting blood specimens.[2,3] However, IV catheter placement can be problematic in patients with veins that are not palpable or visible as this may delay the course of treatment. Most studies define difficult venous access as undergoing at least two IV attempts without success or use of other methods of IV placement.[4] Alternative means of IV access include the use of an atypical vein (i.e., external jugular vein), ultrasound-guided peripheral intravenous catheter (USGPIV) placement, intraosseous (IO) device use, or central venous catheter (CVC) placement. Current literature suggests that chronic medical conditions, IV drug abuse, chemotherapy, sickle cell disease, obesity, and dialysis may be contributing factors to difficulty obtaining IV access.[4]

Central venous access is a standard method of obtaining vascular access in the Emergency Department (ED) and the Intensive Care Unit (ICU). As many as 5,000,000 CVCs are placed in the United States per year, most often in patients with a high severity of illness.[5] Central venous monitoring, vasoactive medications, centrally administered medications, total parental nutrition, hemodialysis, and renal replacement therapy are indications for central venous access.[6] However, in patients with difficult venous access, CVC placement is utilized as a rescue method of IV access when peripheral IV catheter insertion attempts are unsuccessful. CVC insertion is an invasive procedure which most commonly utilizes the subclavian, femoral, and internal jugular veins for access. Furthermore, CVC placement is a time-consuming procedure, requiring sterile precautions, and a chest x-ray to confirm placement due to a 40% incidence of mispositioning.[7,8] Although an effective means of vascular access, CVC placement is associated with a greater than 15% complication rate, including pneumothorax, hematoma formation, air embolism, arterial puncture, arrhythmias, vessel damage, thrombosis, and central line associated bloodstream infections.[3,4,8,9] Additionally, CVC complications and associated bloodstream infections lead to increased healthcare costs, extended hospital length of stay, and a source of morbidity for patients.[5]

In order to minimize CVC complication rates, the utilization of USGPIVs may be a promising replacement for CVC insertion in patients with difficult IV access.[5] Performed by a variety of healthcare professionals, bedside ultrasound provides visualization of deeper peripheral vessels that are not discernible by physical examination and allows for the guidance of IV catheter cannulation.[4,8] Complications associated with USGPIV cannulation are similar to those of traditional peripheral IV insertion techniques, including infiltration, arterial puncture, thrombosis, and contact with adjacent nerves.[10] In comparison to traditional landmark techniques, USGPIV appears to be an effective means of vascular access. In a study performed by Keyes et al., USGPIV placement was associated with a 91% success rate in 101 ED patients. Additionally, the study found the average USGPIV procedure length to be 77 seconds.[11] In a comparison of USGPIV to traditional landmark techniques in patients with difficult intravenous access performed by Constantino et al., there was a success rate of 97% for the USGPIV group and a reduction in overall time to cannulation compared to the traditional landmark approach.[2] USGPIV insertion is also associated with higher patient satisfaction in comparison to the traditional landmark approaches in difficult IV access patients.[2,12]

This paper aims to evaluate the evidence from the literature for the use of USGPIV access in the reduction of CVC placement during a patient's hospital stay.

Does USGPIV insertion reduce CVC placement rates?

A retrospective cohort study performed at an urban academic ED using time-series analysis revealed a reduction in CVC placement rates during the implementation of a USGPIV program. During the six-year study, the ED saw 401,532 patients, of whom 1,583 (0.39%) received CVC catheters. The study demonstrated an 80% reduction in CVC rates from 0.81% to 0.16% and revealed that the reduction in CVC placement was more significant among noncritically ill patients, including floor patients, telemetry patients, and discharged patients compared to critically ill patients. Furthermore, there were no CVCs placed in patients discharged from the ED in the final year of the study. However, the proportion of CVC placement in the critically ill population compared to the noncritically ill population increased from 34% to 81% because there was an overall reduction in the number of CVCs placed in the noncritically ill

patients.[5] These findings highlighted that USGPIV use reduces the number of CVCs placed in noncritically ill patients.

Given the increased frequency in CVC placement among patients with difficult intravenous access, a study was conducted to determine the reduction in CVC placement due to USGPIVs in the difficult IV access population. In this prospective, observational study conducted in an urban ED, patients with at least two failed peripheral IV attempts, inability to palpate peripheral veins on physical examination or inability to secure external jugular access were enrolled and underwent USGPIV placement. The study followed the enrolled patients to evaluate for CVC placement and related complications for up to seven days. One hundred patients underwent USGPIV placement with 12 USGPIV failures before ED disposition, of which four required CVC placement. Of the 88 patients with functional USGPIVs in the ED, 72 were admitted, 1 CVC was placed, and 10 PICC lines were required. The study demonstrated an 85% reduction in CVC placement due to USGPIV implementation in difficult IV access patients. This study indicates that USGPIVs may be an effective alternative to CVCs in reducing morbidity in these patients.[8]

Do USGPIVs have a role in the inpatient setting?

The implementation of USGPIVs to reduce CVC placement has been studied primarily in the ED setting. A retrospective cohort review performed by Gregg et al. analyzed the use of USGPIV in adult patients admitted to a surgical ICU (cardiac, trauma, or neurotrauma) who did not indicate a need for CVC requirement. The study reported that there were 77 provider requests for USGPIV placement in 59 ICU patients whose peripheral IV access could not be obtained through traditional techniques. The inability to obtain peripheral intravenous access included edema (95%), obesity (42%), history of IV drug use (8%), and need for emergency access (4%). The study reported a total of 148 peripheral intravenous lines (PIV) requested with 147 PIV successfully placed.[6] Furthermore, the discontinuation of 40 central lines and avoidance of 34 CVCs was reported as a result of placing a PIV, revealing that the implementation of USGPIV insertion reduced unnecessary CVC placement in the ICU setting.[6]

In addition to the ICU, a cohort study in an inpatient medical unit evaluated the effect of the implementation of USGPIV to reduce CVC placement. The study revealed a reduction in the rate of CVCs placed in the USGPIV intervention unit (mean 0.47) compared to the control unit (mean 0.67); however, the difference was not statically significant with a P=0.08. Due to the statistical insignificance, further studies are needed to evaluate the use of USGPIVs in the reduction of central lines on an inpatient medical floor.[3]

How long do USGPIVs last?

As evidenced by the studies above, the use of USGPIVs allows for a reduction in CVC placement in difficult IV access patients. However, there is limited information about the efficacy of USGPIVs continued use over an extended period of time. A prospective observational study performed by Dargin et al. evaluated the survival of USGPIVs beyond the ED. The study enrolled 75 patients and found the median USGPIV survival to be 26 hours, with a 56% survival rate across all settings. In the ED, 47% of the USGPIVs failed within 24 hours, mostly due to infiltration. Only five patients underwent CVC placement, although 63% of operators reported that a CVC would have been necessary without the initial USGPIV access. Additionally, after USGPIV failure, only one central line was placed, and there were no thrombotic or infectious complications.[9] Although the study was statistically significant, selection bias may have occurred due to potentially eligible patients not enrolled in the study or documentation error. The results of this study indicate that USGPIV placement is an effective means of establishing IV access and reduces the need for more invasive CVC placement in stable ED patients. However, USGPIVs are associated with shorter indwelling times, which is most frequently due to infiltration or dislocation.[9]

Although USGPIV placement is associated with a high failure rate, limited research has been completed to reveal the number of patients who go on to require CVC insertion after USGPIV failure. A retrospective cohort analysis concluded that 43 of 343 (13.1%) patients required CVC placement after USGPIV failure. The study also analyzed the correlation between risk factors for difficult venous access, including diabetes, IV drug abuse, peripheral vascular disease, end-stage renal disease, sickle cell disease and the risk of subsequent CVC placement after USGPIV failure.[1] None of the risk factors associated

with difficult IV access analyzed were predictive of CVC placement. The findings suggested that length of stay and admission to a higher level of care (ICU or step down unit) were the only predictive factors associated with subsequent CVC insertion.[1] While approximately one in eight patients with difficult IV access required subsequent CVCs after admission from the ED with a USGPIV, there was ultimately a reduction in the number of CVCs placed. This result supports the findings that USGPIVs can reduce the number of CVCs placed in difficult IV access patients. Even with the reduction in central line placement, approximately 13% of difficult IV access patients receiving USGPIVs in the ED will go on to require a CVC due to USGPIV failure or the need for more central access for a higher level of care.[1]

Discussion

Evidence reveals that USGPIV insertion reduces the frequency of CVC placement in difficult IV access patients in the ED setting, particularly in noncritically ill patients. The use of USGPIVs in place of central lines has the potential to reduce cannulation time and increase patient satisfaction upon initial insertion. Furthermore, the significance of these studies indicates a potential reduction in morbidity, healthcare costs, and extended length of hospital stay due to the reduction of CVC complications.

The current literature does not provide sufficient evidence to conclude that USGPIV insertion reduces the number of CVCs placed outside of the ED. The study performed by Gregg et al. demonstrated a reduction in CVC placement with the use of USGPIV in patients that did not require central venous access in the ICU.[6] While the study indicates a possible reduction in CVCs, there is not another study that analyzes the use of USGPIV to reduce central lines in the ICU setting. The study performed by Galen et al. indicates there may be a reduction in CVCs due to USGPIV placement in the inpatient setting; however, the research was not statistically significant.[3] Further research is required to evaluate the use of USGPIVs to reduce the number of CVCs placed outside of the ED to identify and quantify the benefits associated with a reduction in CVC placement throughout a patient's hospital stay.

Although the literature demonstrates success in the reduction of CVC insertion due to the implementation of USGPIVs in the ED setting, the evidence denotes that USGPIVs have a high failure rate beyond the ED. While the occurrence is relatively low, difficult IV access patients who received an

USGPIV in the ED setting may go on to require a CVC. Further research is necessary to investigate the repercussions associated with premature USGPIV failure and the need for subsequent CVC insertion.

The current research does not provide enough evidence to support the use of USGPIV access over CVC placement during a patient's hospital stay as the standard of practice. Without further research, USGPIVs may be used to reduce CVC placement among patients in the ED. Beyond the patient's stay in the ED, the decision to utilize USGPIVs in difficult IV access patients remains at the discretion of the provider. The provider should consider the patient's disposition, length of stay, and comorbidities to aid their decision-making process. Until further studies are conducted, the use of USGPIVs in difficult IV access patients remains a potential source of reduced complications, length of hospital stay, and healthcare costs.

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