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Dangers of Peripheral Intravenous Catheterization: The Forgotten Tourniquet and Other Patient Safety Considerations

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Abstract

Intravenous catheterization is a widely used invasive procedure, with applications in both ambulatory and hospital settings. Due to its inherently invasive nature, intravenous (IV) therapy is associated with a number of potential complications, many of which are directly relevant to patient safety (PS). PIV-related morbidity may be due to mechanical or nonmechanical factors. The most frequent nonmechanical peripheral venous catheterization adverse events (PVCAEs) include insertion site pain, phlebitis, hematoma formation, and infusate extravasation. The most common mechanical PVCAE is catheter obstruction/occlusion and dislodgement. Significant complications can also occur with the administration of incorrect type or wrong amount of IV fluids. Moreover, simultaneous infusion of incompatible medications can result in infusate precipitation. Finally, less frequent but significant complications have been reported, including bloodstream and local infections, air embolization, nerve damage, arterial puncture, skin necrosis associated with vasopressor infusions, and limb-threatening forgotten tourniquet events. Taken together, the above complications can lead to substantial patient discomfort, unnecessary or prolonged hospitalization, increased costs, and additional downstream morbidity. Efforts to prevent PVCAEs and improve patient outcomes should involve thorough provider education, clinical vigilance by all involved healthcare providers, health service level strategies, as well as the proactive participation of all stakeholders, including patients and their families.

Keywords: complications, intravenous therapy, peripheral intravenous catheter, patient safety
1. Introduction

Intravenous therapy (IVT) is a treatment modality based on infusing various compatible fluids (e.g., solutions, medications, blood, or blood products) directly into a vein [1–3]. Modern clinical efforts at IVT began in the early seventeenth century, but due to complications and generally poor results, the practice was largely abandoned until the nineteenth-century cholera epidemic [4, 5]. Early publications on IVT date back to the 1880s, when Dr. Thomas Latta described its use during the cholera epidemic in Britain [4, 6]. The standard IV use of saline solutions did not begin until the early 1900s. Further advances in IVT occurred in the 1930s, but this modality was not widely available until the 1950s [3, 7, 8]. It was not until the twentieth century, after the two world wars, and the discovery of blood group types and pyrogens, that clinical use of IVT gained more traction [5, 9]. The introduction of plastic bags and IV catheters in the late twentieth century, combined with modern infection control practices, resulted in IVT becoming a widespread and lifesaving therapeutic option [5, 10]. Intravenous administration of fluids in the emergency setting (e.g., trauma, sepsis) can be a lifesaving maneuver and represents the primary method of ensuring adequate intravascular fluid status for patients who are unable to tolerate enteral nutrition [11, 12]. It is estimated that hundreds of millions of PIV catheterizations are performed worldwide each year [13]. The vast majority of these procedures are conducted by nursing staff, with the remainder performed by specialty teams [14]. Of note, approximately 80% of all hospitalized patients receive IVT [15, 16]. At the same time, the frequency of “idle catheters” (e.g., with no active medication or fluid infusion) can be as high as 16%, with approximately 12% reporting at least one sign/symptom of phlebitis [14]. The results of a more recent retrospective cohort study of 3829 patients by Limm et al. showed that 50% of PIVCs inserted in the ED went unused. Of the 43% of patients with idle catheters then admitted to the hospital wards, these continued to be unused 72 h later [17]. There is an increasing awareness (and concern) of the possible morbidity, including life and limb injury, associated with the highly prevalent usage of IVT [18]. The purpose of this chapter is to provide a comprehensive overview of all major complications and patient safety considerations associated with PIVs and IVT in the adult population. In addition, we provide an illustrative case of a “forgotten tourniquet” to illustrate the importance of patient safety measures in this important area of clinical care.

2. Types of venous access

Safe, dependable venous access for infusions is a critical part of patient care. There are two primary types—peripheral and central venous access. The type of access is selected based on the anticipated duration of IVT, the type of medication or solution to be infused, and patient-specific considerations [19, 20]. The focus of this chapter, the PIV catheter, is a short intravenous catheter placed via venipuncture into a peripheral vein, while central venous catheters are inserted into large veins of the central circulation system (e.g., subclavian, jugular, and femoral). Performed an estimated 150–200 million times annually in North America alone, the impact of PIVs is difficult to comprehend [21]. Moreover, up to 8–23% of patients in the
emergency department experience difficult PIV placement (e.g., multiple attempts, infiltration, and other placement-related complications). These patients are more likely to require central venous access, which includes significantly higher associated morbidity. Ultrasound-guided PIV catheterization can reduce the need for central venous access, thus potentially reducing morbidity [21]. Not only does the ultrasound-guided PIV access decrease the reliance on central venous access, but it also decreases the overall time, number of attempts, and needle redirections compared to more traditional placement methods [22, 23]. While PIVs are the preferred access mode for short-term IVT, central venous access is utilized for long-term administration of medications or parenteral nutrition [23–27]. At times, when PIV access cannot be established or is quantitatively insufficient for the delivery of desired volume or fluid type, central venous access may be the only viable option to consider [15, 28].

3. Indications and common anatomic sites of peripheral intravenous catheterization

PIV catheterization is indicated for short-term use across a broad range of clinical scenarios, including administration of IV fluids, drugs, blood/blood products, dyes, and contrast media [28, 29]. Several factors must be considered when selecting a site for PIV catheterization. Although common sites of insertion are generally described as the lower arm and the dorsum of the hand, superficial veins of the lower limbs can also be used for cannulation in certain clinical situations [30]. The direct and indirect risks of complications can be curtailed by a more thorough assessment of the vascular anatomy prior to choosing the optimal site, based on both infusion- and patient-related factors [31–35]. Carr et al. reported that the antecubital fossa (ACF), the most common insertion site cannulated in their study of 252 ED patients, was associated with the best rates of insertion success (54.78%), but a secondary analysis revealed that these successfully inserted PIVCs repeatedly failed to last for the intended 3-day dwell time after transfer from the ED to the general hospital units [31]. In a project to reduce infusion pump alarms, Matocha [34] reported that occlusion alarms (60%) represented the highest volume of alarms in a medical oncology unit. After intervention, occlusion alarms were reduced by 17% but still represented the highest volume of alarms, which the author hypothesized might be associated with the majority of catheter placements in the antecubital area due to flexion at the site. Decreasing antecubital area placement in the first place through staff education regarding vascular access planning and insertion competency was suggested as one way of reducing occlusion alarms. Alarm frequency may interfere with patients’ sleep, cause unnecessary anxiety, and potentially negatively impact healing [32, 33]. It is imperative to consider the clinical status of the patient carefully before selecting the site. Such assessment should consider the general condition of the veins, tortuosity, locations of valves, bifurcations [36], the size of cannula, type of drug to be administered, infusion rate, and duration of the intended IVT [30]. Intravenous cannula gauge and site of placement are critical factors in defining the success and longevity of PIV cannula [37]. Of note, larger gauge (P = 0.0002, RR = 1.17, 95% CI 1.08–1.27) and forearm placement (P = 0.005, RR = 0.7, 95% CI 0.55–0.9) are among the strongest predictors of longer functional cannula life [38]. Evidence demonstrates the usefulness of multimodality methodology in improving in first-time insertion success rate [2, 37].


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