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# Peripheral venous catheters: an under-evaluated problem

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ABSTRACT

Peripheral venous catheters (PVC) are the most frequently used invasive devices in hospitals. Up to 70% of patients require a peripheral venous line during their hospital stay, and conservative estimates suggest that PVC days account for 15–20% of total patient days in acute care hospitals. Most published studies focus on thrombophlebitis and address the issue of scheduled catheter change, but there is still no consensus on the optimal time point for PVC change, or whether catheter replacement is required at all. Although PVC-associated catheter-related bloodstream infections (PVC-BSI) are far more serious than thrombophlebitis, few studies address this issue, and a large multicentre trial is lacking. Some studies on thrombophlebitis mention that no, or only a few, PVC-BSIs were identified, but such results must be interpreted with caution. Current data available on PVC-BSI suggest incidence density rates of 0.2–0.7 episodes per 1000 device days, which appear low when compared with other catheters. However, some studies report absolute PVC-BSI numbers in the range of central line-associated infections. It remains unclear whether PVC-BSI should be considered a serious healthcare problem or simply a very rare event. More research is needed both to capture the dimension of the problem and to provide efficient control measures.



## 1. Introduction

Peripheral venous catheters (PVC) are the most frequently used invasive device in hospitals. It is estimated that 30–80% of patients receive a peripheral line during their hospital stay [1–6]. Despite the frequent use of this routine device, randomized studies investigating PVC-associated catheter-related bloodstream infections (PVC-BSI) are rare and focus on phlebitis, catheter colonization and catheter patency [7–10]. Although there is abundant literature on catheter-associated bloodstream infection, it concerns mostly central-line devices. Indeed, data on this potentially serious complication can only be obtained from small studies, notably the exemplary report by Maki et al. [11]. We reviewed the literature to determine if complications arising from PVC use are under-evaluated and, in particular, whether the peer-reviewed literature appropriately reflects the wide use of this device, whether potentially harmful complications are well addressed, and the type of prevention and intervention measures proposed.

## 2. Epidemiology

A total of 150 million PVCs are used annually in the USA, and extrapolated catheter days reach 450 million, which is 15 times higher than the cumulative dwell time of central venous lines. At present there are no Europe-wide epidemiological data on PVC use. In 2006, the Swedish Council on Technology Assessment in Health Care conducted a country-wide review of annual PVC use and reported 5 million PVCs. PVC use is a routine procedure, but various studies estimate that 4–28% of the PVCs are not used for treatment and 20% of the catheter days are unnecessary [1,3,12–14]. The rate of unnecessary PVCs reaches almost 50% in the emergency room, where patients are likely to receive a peripheral line as a routine procedure at admission [15]. The mean dwell time of PVCs is 3–4 days, with a median dwell time of 2 days [16–18]. The short dwell time, which approaches the recommendation of the US Centers for Disease Control and Prevention (CDC) for catheter replacement [19], is usually the result of short operating times, short hospital stay or catheter complications such (thrombo-) phlebitis or exit-site infection.

## 3. Complications

### 3.1. Thrombophlebitis

The best described, most frequent PVC complication is phlebitis, or thrombophlebitis when phlebitis is combined with thrombus formation. PVC-associated thrombophlebitis rates range from 2 to 80% [4,5,16,20–37]. This remarkable variation results from distinct study settings and the use of individual rather than universally valid definitions of thrombophlebitis. While all definitions are based on clinical findings such as redness, swelling, tenderness, pain, warmth, palpable cord or purulent discharge, some strict definitions require the presence of almost all clinical signs, but more generous definitions require only the presence of any two clinical signs. The heterogeneous use of thrombophlebitis definitions makes it difficult to compare study results. Scoring systems have been suggested

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to quantify thrombophlebitis [21,25,38–41], but none was widely adopted and they complicate rather than facilitate the situation. The most recent scoring system comes from the US Infusion Nurses Society (INS) [42]. This score has four levels, and the authors comment on what would be an acceptable thrombophlebitis rate (5% when using their own score).

Thrombophlebitis is a process of local vein inflammation and thrombus formation (Fig. 1) [43,44]. It is hypothesized that mechanical irritation of the vascular wall by infusates [45], stiff catheter material [22,23] or bacterial colonization damage the endothelium. This process provokes inflammation of the vascular wall, with fibrin deposition and thrombus formation [43,46,47]. Early thrombus formation is found close to the puncture site (damage of vascular integrity by catheter insertion), whereas late thrombus formation is more often found around the catheter tip (damage of vascular integrity by mechanical irritation from the catheter tip) [48]. Thus, damage of vascular integrity is a prerequisite for thrombophlebitis formation.

### 3.2. Factors associated with thrombophlebitis

Risk factors associated with thrombophlebitis can be classified into four groups: catheter-related; drug-related; patient-related; and healthcare-related.

#### 3.2.1. Catheter-related risk factors

Thrombophlebitis rates increase with catheter dwell time. Although this has been shown unequivocally among adults, especially during the first 3 days, such an association was not significant among neonates and children [20,22,27,49–51]. Catheters with less favourable thrombogenic properties, such as those made from tetrafluoroethylene-hexafluoropropylene (Teflon®, DuPont de Nemours), induce more thrombophlebitis. The difference between Teflon® and polyurethane catheters is 30–45% in favour of polyurethane catheters [22,23]. However, while provoking thrombophlebitis, catheter material may not be associated with local infection (5.4% and 7.6%, respectively). Rigid, less elastic catheters are more likely to irritate the vascular wall, whereas smooth and flexible catheters cause less endothelial damage and are less likely to cause thrombophlebitis than Teflon® catheters [52].

#### 3.2.2. Drug-related risk factors

Infusates with a low pH or high osmolality, such as potassium chloride, phentytoin or chemotherapeutic agents, interfere directly with the integrity of the vein endothelium and damage the vascular wall [22,24,25]. Although heparin flushes have favourable effects and enhance catheter patency, they may cause thrombophlebitis [53]. This mechanism has not yet been elucidated, and other studies were unable to confirm this result [5,23,45]. Thus there is still debate over its risk. It has been suggested that thrombophlebitis may be provoked by particles in infusates. This was concluded by one study when end-line filters were found to reduce thrombophlebitis episodes [33].

#### 3.2.3. Patient-related risk factors

There are some intrinsic risk factors directly associated with thrombophlebitis, such as a high haemoglobin level, a thrombophilic predisposition and poor vein quality [23,54,55]. High haemoglobin levels and thrombophilic predispositions most likely interfere with thrombus formation. The pathogenesis of poor vein quality as a predisposing factor to thrombophlebitis is less evident, but may be seen in the context of fragile vessels, which are more susceptible to mechanical irritation than healthy veins.

#### 3.2.4. Healthcare-related risk factors

It has been shown unequivocally that insertion and maintenance of PVCs by untrained or inexperienced healthcare workers increases the risk of thrombophlebitis [10,24]. A UK study showed that catheter insertion outside the hospital and under emergency conditions does not result in more episodes of thrombophlebitis [56]. However, the same study also showed that PVCs placed by registered emergency-room nurses in that setting had fewer complications than catheters inserted by intermediate emergency medical technicians.

### 3.3. Catheter-associated bloodstream infection

Compared with thrombophlebitis, PVC-associated bloodstream infection (PVC-BSI) or sepsis is a far more serious adverse event of catheterization. The most likely mechanism of PVC-BSI is colonization of the vascular catheter tract followed by biofilm formation (Fig. 1). Such colonization may occur during catheter insertion and when manipulating the catheter for drug administration or blood sampling.

The lack of published studies focusing specifically on PVC-BSI is surprising. The incidence density of PVC-BSI is estimated at approximately 0.2 to 0.7 episodes per 1000 device days [11,13], and an overall proportion of 0.08% of catheter use [5,11]. Although the

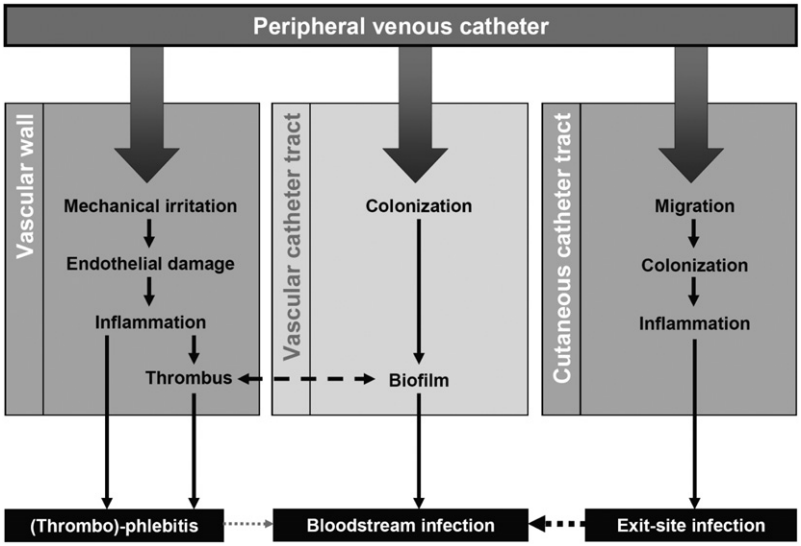


**Fig. 1.** Overview of mechanisms for emerging thrombophlebitis, peripheral venous catheter-associated bloodstream infection and catheter exit-site infection.