Microbiological colonization of peripheral venous catheters: a prospective observational study in a Swedish county hospital

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SUMMARY

Background: Most peripheral venous catheters (PVCs) used in Scandinavia are fitted with an injection port, creating an open PVC system. This port is difficult to disinfect, which may lead to the introduction of micro-organisms upon use.

Aim: To investigate the prevalence of microbiological colonization of the injection port and internal lumen of ported PVCs with a minimum dwell time of 48 h at sample collection.

Methods: Adult patients admitted to different medical and surgical departments and the intensive care unit were invited to participate in this prospective observational study. With the PVC in situ, the injection port and internal lumen were swabbed and cultured separately. Demographic and clinical data were collected to compare patients with colonized and non-colonized PVCs.

Findings: In total, 300 PVCs from 300 patients were analysed. Of these, 33 patients (11.0%) had at least one positive culture. The colonization locations were as follows: port only, 26 (8.7%); internal lumen only, 5 (1.7%); and port and internal lumen, 2 (0.7%). The colonization rate was significantly higher in the injection port than in the internal lumen (P < 0.0001). A ported PVC inserted in the hand incurred a significant risk of colonization (P = 0.03). The odds ratio for colonization among patients in the infectious diseases department was 0.1 (95% confidence interval 0.1–1; P < 0.06) compared with patients in the medical department.

Conclusion: This study showed that 11% of ported PVCs were colonized by micro-organisms, with the vast majority (8.7%) of colonization occurring in the injection port.

Clinical trial registration: ClinicalTrials.gov; ID NCT03351725.

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thrombosis and infection [2]. PVC-related (PVCR) infections cause morbidity, mortality and increased healthcare costs [3,4]. In clinical practice, a PVCR bloodstream infection (BSI) may be overlooked when thrombophlebitis or cultures from PVCs are absent. The incidence of PVCR-BSI has been reported to be 0.1% or 0.5 per 1000 catheter-days [5].

The absolute risk for PVCR-BSI is probably lower than that for central venous catheters; however, because of the widespread use of PVCs, many patients are exposed to the risk of harm [5]. Multi-modal preventive strategies have shown a sustained reduction in PVC-BSIs with decreased morbidity and mortality [4,6]. Measures typically applied for prevention include continuous surveillance of PVC-BSIs, training of healthcare workers, use of sterile gloves, upgradation of skin antisepsis, and introduction of closed intravenous catheter systems.

Regarding the introduction of closed intravenous catheter systems, there is an ongoing debate on how a PVC is best constructed to minimize the risk of PVCR-BSIs [7]. Most PVCs used in Scandinavia are fitted with an injection port (Figure 1) rather than a closed intravenous catheter system. The injection port is difficult to disinfect because of its design, which comprises an elevated and narrow plastic rim surrounding an injection membrane. This may lead to the injection of microorganisms when a PVC is used. However, needleless connectors (NCs) that function as an alternative when using closed PVCs are prone to microbiological colonization, and need to be disinfected meticulously prior to use [8]. Several studies have shown problems with adherence to this routine [9].

The aim of this in-vivo study was to investigate the prevalence of microbiological colonization of the port and the internal lumen of ported PVCs with a minimum dwell time of 48 h at sample collection.

**Methods**

**Setting**

This study was conducted in a general public county hospital with 500 beds supporting most medical, oncological and surgical specialties, except cardiothoracic and neurosurgery.

**Study population**

Patients aged ≥18 years who provided informed consent and were admitted to the medical, surgical or infectious disease departments or the intensive care unit (ICU) and had a PVC dwell time ≥48 h at sample collection were eligible for inclusion. A patient could only be included once in the study. If multiple PVCs were sampled from one patient at different times, only the first PVC sample was included. Exclusion criteria were as follows: the PVC was in situ for <48 h; the inner dimension of the PVC was <0.9 mm, 22 G; or an incomplete culture was obtained from a sample.

**Catheter design and insertion procedures**

All PVCs in this study were polyurethane catheters from two different manufacturers (Becton Dickinson, Franklin Lakes, NJ, USA; B. Braun Medical AB, Melsungen, Germany). During the study period, the PVC insertion protocol included adequate implementation of basic hygiene routines, disinfection of the skin with 0.5% chlorhexidine gluconate in 70% isopropyl alcohol, use of high-purity gloves, and fixation with a transparent dressing. The protocol did not prescribe port disinfection prior to use. After insertion, the PVC type, site and time of insertion were registered in the patient’s electronic medical record.
Furthermore, PVC inspection was performed daily, and routine replacement was performed every 72 h, except in specific cases wherein the replacement was performed later than 72 h for clinical reasons.

**Data collection and microbiological methods**

One nurse at each participating ward was trained to perform the procedures according to the study protocol. While the patient still had the PVC *in situ*, the injection port and internal lumen were swabbed with two separate sterile cotton-tipped swabs moistened with sterile sodium chloride (0.9%). The swabs were placed immediately in a collection tube containing Amies medium with charcoal, and transported to a local microbiological laboratory. The samples were cultured on haematin agar plates and incubated overnight at 37°C in air with the addition of 5% CO₂. Species identification was performed using matrix-assisted laser desorption/ionization-time of flight mass spectrometry (Bruker, Billerica, MA, USA), according to the manufacturer’s instructions. Cultures were categorized as ‘positive’ if at least one colony-forming unit of any bacteria was found.

If the same species of micro-organism was found in the port and the internal lumen, whole-genome sequencing was performed. DNA was extracted from isolated *Enterococcus faecium* and *Staphylococcus aureus* using the EZ1 DNA tissue kit on the EZ1 Advanced XL (Qiagen, Hilden, Germany). Library preparation was performed using Nextera XT library prep kit according to the manufacturer’s instructions. Paired-end sequencing (250 cycles) was performed using a MiSeq instrument (Illumina, San Diego, CA) according to the manufacturer’s instructions. Core genome multi-locus sequence typing (cgMLST) assembly and cluster analysis was performed using SeqSphere (Ridom GmbH, Münster, Germany). The cgMLST schemes were based on 1423 genes for *E. faecium* and 1861 genes for *S. aureus*.

All other data were collected manually for 2019 and 2020 from the patient’s electronic medical record (Table I, II and III). The following data were analysed: age, sex, type of department (medical, surgical, infectious diseases, ICU), Charlson Comorbidity Index (CCI) [10], acute or planned admission to hospital, length of stay, insertion site, PVC size, dwell time at sample collection, time from admission to PVC insertion, if patient was given antibiotics due to a PVCR infection, if patient died from a PVCR infection, and if patient was immunocompromised according to the Acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) score [11].

**Ethics**

This study was approved by the Regional Ethical Review Board of Linköping (2015/477-31).

**Registration**

The study was registered on ClinicalTrials.gov; (ID NCT03351725; Release Date: 15th November 2017).

**Statistical analysis**

This was an exploratory investigation and colonization rates were not known *a priori*; as such, a sample size calculation could not be performed. Descriptive analyses were performed to characterize the patient population. Pearson’s Chi-squared test, Fisher’s exact test, Mann–Whitney U-test and Student’s t-test were used to test for comparisons between groups, depending on whether the data were discrete or continuous, and whether distributions were normal. Logistic regression models were used to predict the odds of PVC colonization based on several potential risk factors. All P-values were two-tailed, and P<0.05 was considered to indicate significance. Data were analysed using SPSS Version 26 (IBM Corp., Armonk, NY, USA).

**Results**

In total, samples were collected from 337 PVCs in 304 patients between May 2016 and January 2018. One patient was excluded due to protocol violation (age <18 years), one was excluded because the PVC had been *in situ* for <48 h, two were excluded because only incomplete cultures were obtained from their samples, and 33 PVCs were excluded because they came from patients who had already been included. Hence, 300 PVCs from 300 patients were analysed. Of these, 33 patients (11.0%) had at least one positive culture.

Patient characteristics are presented in Table I. The median dwell time at sample collection was 3 days (range 2–8 days). Time from hospital admission to PVC insertion was compared between the colonized and non-colonized groups, and no significant difference was found (P=0.22). Comparisons between colonized and non-colonized groups regarding various demographic and clinical factors are shown in Table II.

The positive culture results were as follows: port alone, 26 (8.7%); internal lumen alone, 5 (1.7%); and port and internal lumen, 2 (0.7%). The colonization rate was significantly higher in the injection port than in the internal lumen (P<0.0001). Different species of coagulase-negative staphylococci (CoNS) were found in 30 of 33 (91%) positive cultures. In two cases, indistinguishable strains were found in the port and the internal lumen (*E. faecium* and *S. aureus*). The results of the PVC cultures are shown in Table III. None of the patients with a colonized PVC had a positive blood culture within ±72 h of PVC sample collection. Two patients were treated with antibiotics because of suspected PVCR infection. Both were in the non-colonized group. No patients in this study died from a PVCR infection.

**Discussion**

This study showed that 11% of PVCs were colonized with micro-organisms and that the rate of microbiological
colonization was significantly higher in the injection port than in the internal lumen of the catheter. The only significant risk factor was having a ported PVC in the hand, which differs from previous findings [12]. Almost all micro-organisms found in this study were potential human pathogens.

To the best of the authors’ knowledge, this is the first study to prospectively investigate the microbiological colonization of ported PVCs in vivo, and compare colonization of the injection port with colonization of the internal lumen. This is of importance because ported PVCs are commonly used in Scandinavia. To the authors’ knowledge, only one prospective randomized study has compared complications between two different types of PVCs (open and closed) [7]. This showed that a closed system has lower risk for PVCR-BSI; however, the differences in catheter design between the ported PVC and those in this study make it difficult to compare the results.

Using NCs for PVCs without a port is recommended and commonplace in clinical practice [13]. As opposed to using an injection port, use of an NC enables disinfection of the surface prior to injection. Several studies have shown that although the colonization rate of NCs is between 20% and 50%, appropriate NC disinfection can reduce the rate substantially (0–2%) [12,14,15]. However, the difficulties in following proper disinfection routines in daily clinical practice can lead to high colonization rates and an unintended increase in PVCR-BSI [12]. Moreover, inappropriate NC design and/or low adherence to disinfection routines increases the number of catheter-related BSIs [9]. This should be compared with the port on ported PVCs, which cannot be disinfected properly prior to use. Hence, it is difficult to judge whether the present finding of a colonization rate of 8.7% in the port is higher or lower than the actual rate of colonization of NCs in clinical use. Furthermore, NCs and ported PVCs can be colonized with a biofilm on the internal lumen, and these micro-organisms are not susceptible to external disinfection [12,16].

Of the 300 sampled PVCs, seven positive cultures were found in the internal lumen, of which two had an indistinguishable bacterial strain concurrently in the port. It is possible for micro-organisms to migrate from the port to the internal lumen [16,17]. It is impossible to determine if this was the case in these two patients. In five patients, colonization of the internal lumen of the catheter was present without

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**Table II**

Comparison of all patients with colonized and non-colonized peripheral venous catheters (PVCs).

| Potential risk factor      | Colonization, any N=33 | No colonization N=267 | OR   | 95% CI  | P-value |
|---------------------------|------------------------|-----------------------|------|---------|---------|
| Age, years                |                        |                       |      |         |         |
| 18–69 (ref)               | 12                     | 109                   | 1    | 0.6–2.6 | 0.61    |
| ≥70                       | 21                     | 158                   | 1.2  |         |         |
| Sex, male (%)             | 73                     | 63                    | 0.9  | 0.4–2.1 | 0.87    |
| Department                |                        |                       |      |         |         |
| Medical (ref)             | 18                     | 108                   | 1    |         |         |
| Surgical                  | 14                     | 112                   | 0.8  | 0.4–1.6 | 0.47    |
| Infectious diseases       | 1                      | 43                    | 0.1  | 0.1–1   | 0.06    |
| ICU                       | 3                      |                       |      |         |         |
| CCI, score                |                        |                       |      |         |         |
| 0–4 (ref)                 | 27                     | 217                   | 1    |         |         |
| 5–12                      | 6                      | 50                    | 0.6  | 0.2–1.9 | 0.40    |
| Admission form            |                        |                       |      |         |         |
| Emergency (ref)           | 29                     | 211                   | 1    |         |         |
| Scheduled                 | 4                      | 56                    | 0.6  | 0.2–1.5 | 0.23    |
| Dwell time at sample collection |                |                       |      |         |         |
| 2 days (ref)              | 1                      |                       |      |         |         |
| ≥3 days                   | 0.8                    | 3.2                   | 0.9–10.2 | 0.06    |
| Insertion site            |                        |                       |      |         |         |
| Cubital fossa (ref)       | 4                      | 81                    | 1    |         |         |
| Forearm                   | 12                     | 77                    | 3.2  | 0.9–10.2 | 0.06    |
| Hand                      | 8                      | 40                    | 4.1  | 1.2–14.3 | 0.03    |
| Foot                      | 2                      |                       |      |         |         |
| Unknown                   | 9                      | 67                    | 2.7  | 0.8–9.2 | 0.11    |
| PVC size                  |                        |                       |      |         |         |
| 20 G (ref)                | 17                     | 99                    | 1    |         |         |
| 22 G                      | 3                      | 43                    | 0.4  | 0.1–1.5 | 0.17    |
| 18 G                      | 3                      | 34                    | 0.51 | 0.1–1.9 | 0.31    |
| 17 G                      | 1                      |                       |      |         |         |
| Size not reported         | 10                     | 90                    | 0.64 | 0.3–1.5 | 0.29    |
| Immunocompromised         |                        |                       |      |         |         |
| No (ref)                  | 29                     | 231                   | 1    |         |         |
| Yes                       | 4                      | 36                    | 0.9  | 0.3–2.8 | 0.87    |

OR, odds ratio; CI, confidence interval; ref, reference; G, gauge; ICU, intensive care unit; CCI, Charlson Comorbidity Index.
| Patient no. | Age, years | Sex | Length of stay | CCI score | Diagnosis                                      | Emergency admission | PVC size | PVC insertion site | Dwell time at sample collection (days) | Port/infusion/both | Micro-organisms                              | Number of positive cultures |
|------------|------------|-----|----------------|-----------|-----------------------------------------------|---------------------|----------|-------------------|---------------------------------------|---------------------|---------------------------------------------|---------------------------|
| 14         | 28         | Female | 7 | 1           | Budd Chiari syndrome, postoperative care     | Yes                 | -        | -                 | >2<sup>a</sup>                          | Internal lumen       | S. epidermidis                              | 1                         |
| 20         | 35         | Female | 7 | 0           | Postoperative infection after cholecystectomy | Yes                 | 20 G     | -                 | >2<sup>a</sup>                          | Internal lumen       | S. epidermidis, S. hominis                  | 2                         |
| 31         | 43         | Male   | 3 | 2           | Non-ST-elevation myocardial infarction       | Yes                 | -        | Forearm           | 3                                    | Port                | Rothia spp., S. epidermidis, S. capitis, S. hominis, S. warneri | 2                         |
| 40         | 50         | Female | 6 | 0           | Paroxysmal ventricular tachycardia           | Yes                 | 20 G     | Forearm           | 2                                    | Port                | S. epidermidis, S. capitis, S. hominis, S. warneri | 4                         |
| 52         | 55         | Male   | 28 | 3           | Liver cirrhosis caused by alcohol            | Yes                 | 20 G     | Port              | 4                                    | Port                | S. epidermidis                              | 1                         |
| 57         | 56         | Male   | 3 | 0           | Pulmonary embolism                           | Yes                 | 20 G     | Forearm           | 3                                    | Port                | S. capitis                                  | 1                         |
| 59         | 57         | Male   | 20 | 0           | Ulcerative colitis                           | Yes                 | 18 G     | Hand              | 7                                    | Internal lumen       | S. lugdunensis                              | 1                         |
| 88         | 65         | Male   | 12 | 6           | Malignant tumour in rectum                   | No                  | -        | -                 | 4                                    | Port                | S. epidermidis                              | 1                         |
| 102        | 68         | Male   | 16 | 1           | Chronic leg ulceration                       | Yes                 | 20 G     | Cubital fossa     | 3                                    | Port                | S. epidermidis                              | 1                         |
| 104        | 68         | Male   | 13 | 1           | Atrial fibrillation                          | Yes                 | 18 G     | Cubital fossa     | 2                                    | Port                | S. capitis                                  | 1                         |
| 105        | 68         | Male   | 2  | 3           | Atrial flutter                               | Yes                 | 20 G     | Forearm           | 2                                    | Port                | S. hominis                                  | 1                         |
| 117        | 69         | Male   | 47 | 6           | Atherosclerotic heart disease                | No                  | 20 G     | Hand              | 2                                    | Port                | S. epidermidis                              | 1                         |
| 126        | 70         | Male   | 22 | 1           | Non-ST-elevation myocardial infarction       | Yes                 | 20 G     | Forearm           | 3                                    | Port                | S. epidermidis                              | 1                         |
| 130        | 70         | Male   | 9  | 2           | Heart failure                                | Yes                 | 20 G     | Forearm           | 3                                    | Port                | S. epidermidis                              | 1                         |
| 136        | 71         | Female | 11 | 3           | Pulmonary hypertension                       | Yes                 | 22 G     | Hand              | 4                                    | Both                | S. aureus, S. epidermidis                  | 3                         |
| 147        | 72         | Male   | 13 | 6           | Malignant tumour in colon                    | Yes                 | 20 G     | Hand              | 4                                    | Port                | S. capitis                                  | 1                         |
| 160        | 74         | Male   | 3  | 2           | Atrial fibrillation                          | Yes                 | 20 G     | Forearm           | 2                                    | Port                | S. epidermidis, S. hominis                  | 2                         |
| 178        | 76         | Male   | 11 | 2           | Acute appendicitis                           | Yes                 | 20 G     | -                 | 4                                    | Port                | S. hominis                                  | 1                         |
| 194        | 77         | Female | 4  | 1           | Non-ST-elevation myocardial infarction       | Yes                 | 20 G     | Forearm           | 2                                    | Port                | S. hominis                                  | 1                         |
| 196        | 77         | Male   | 8  | 2           | Malignant tumour in rectum                   | No                  | 20 G     | Hand              | 3                                    | Port                | S. epidermidis                              | 1                         |
| 205        | 78         | Female | 11 | 2           | Malignant tumour in rectum                   | No                  | -        | -                 | >2<sup>a</sup>                          | Port                | S. hominis                                  | 1                         |
| 215        | 80         | Male   | 8  | 1           | Right ventricular failure                    | Yes                 | 20 G     | Forearm           | 5                                    | Port                | S. capitis                                  | 1                         |
| 217        | 80         | Female | 7  | 5           | Mitral insufficiency                         | Yes                 | 20 G     | Cubital fossa     | 2                                    | Port                | S. aureus                                  | 1                         |
| 218        | 80         | Female | 5  | 2           | Paroxysmal atrial fibrillation               | Yes                 | -        | Cubital fossa     | 3                                    | Port                | S. capitis                                  | 1                         |
| 229        | 81         | Male   | 6  | 3           | Aortic valve stenosis                        | Yes                 | 18 G     | Hand              | 2                                    | Port                | S. capitis                                  | 1                         |
| 230        | 81         | Male   | 3  | 1           | Chronic ischaemic heart disease              | Yes                 | -        | Forearm           | 2                                    | Port                | S. epidermidis                              | 1                         |
| 240        | 82         | Male   | 7  | 4           | Bradycardia                                  | Yes                 | 20 G     | Forearm           | 4                                    | Port                | S. hominis                                  | 1                         |
| 257        | 84         | Male   | 6  | 1           | Atrial flutter                               | Yes                 | -        | Internal lumen    | 2                                    | Port                | S. capitis                                  | 1                         |

(continued on next page)
colonization of the port, indicating that the interior surface can be colonized by several mechanisms. The importance of these different routes must be evaluated further.

Most cultures from patients with a colonized PVC showed growth of CoNS (30/33; 90.1%), and nearly all strains could be responsible for PVCR-BSIs. The former is in accordance with previous findings [8]. None of the CoNS strains identified were found in both the port and the internal lumen. The two cases of indistinguishable strains in both locations were caused by S. aureus and E. faecium; these bacteria are known to cause more severe infections than CoNS. It is unknown whether the ability to migrate through the port to the internal lumen differs between different micro-organisms, and this warrants further research.

It has also been shown that introducing bundles with high adherence can decrease the frequency of PVCR-BSI, and even decrease infection-related mortality [4,6]. It is, therefore, of great importance to determine which factors in a bundle are important to decrease PVCR-BSIs successfully. In the authors’ opinion, the question regarding the best PVC design in terms of infection prevention remains unanswered. Additionally, newer PVCs are often more expensive than their predecessors, and introducing PVCs without any evidence from randomized controlled trials regarding their benefit may lead to unmotivated costs. Given the different challenges with disinfection of ports and NCs, it is unclear from the findings which device should be preferred.

Interestingly, patients in the infectious diseases department had an odds ratio for colonization of 0.1 (95% confidence interval 0.1–1; P<0.06) compared with those in the medical department. This may be due to differences in adherence to hygiene routines or higher use of antibiotics in the infectious diseases department.

These data suggest that ported PVCs with associated cleaning difficulties may have higher colonization rates than NCs in which appropriate disinfection adherence is upheld (8.7% vs 0.2%). However, this must be related to the hospital setting as low adherence to disinfection routines may lead to high NC colonization rates (up to 20–50%). In view of the study findings, it may be beneficial to avoid placing PVCs in patients’ hands to further limit the risk of colonization. The 72-h replacement routine should also be challenged, as the study data did not show a significantly higher colonization rate for the 50% of PVCs that were removed >72 h after insertion. The latter suggestion would potentially decrease patient discomfort due to lower frequency of PVC insertions. Together, these changes could enable continuation of the use of ported PVCs. Overall, it is believed that adequate hygiene routines and firm adherence to them are the most important factors for sustaining low rates of colonization and PVCR-BSIs.

This study has some limitations. First, as PVCs were sampled in situ, it was not possible to perform tip cultures that could have provided more information about the migration of micro-organisms along the external part of the PVC. Second, the clinical impact of port colonization in relation to PVCR-BSI is unknown. Third, in this study, the institutional routine was to replace PVCs every 72 h. This may have introduced bias into the colonization data in favour of lower colonization rates. However, half of the PVCs in this study had a longer dwell time than 72 h, and reflect the colonization rate of dwell times between 4 and 8 days. Fourth, this study emphasized the question of whether the port is a problem. The observational

| Patient no. | Age, years | Sex | Length of stay (days) | CCI score | Diagnosis | Emergency admission | PVC insertion size | Port/infusion/both | Dwell time at sample collection (days) | Micro-organisms | Number of positive cultures |
|-------------|------------|-----|----------------------|-----------|------------|---------------------|-------------------|------------------|----------------------------------------|----------------|--------------------------|
| 259         | 84         | Male | 6                    | 3         | Gastrintestinal bleeding | Yes                | Port              | -                | >2                      | S. capitis, S. epidermidis, S. haemolyticus | 3              |
| 265         | 86         | Male | 20                   | 8         | Malignant tumour in duodenum | Yes                | Both              | -                | 2                      | Enterococcus                     | 2              |
| 277         | 88         | Male | 23                   | 2         | Obstruction | Yes                | Port              | -                | 5                      | viridans                | 2              |
| 285         | 89         | Female | 6                    | 2         | Diverticulum in colon without perforation in colon transverse | Yes              | Internal lumen    | -                | >2<sup>a</sup>     | Actinomyces radicidentis, viridans streptococci | 2              |
| 294         | 91         | Male | 18                   | 6         | Diverticulum in colon with perforation in colon transverse | Yes              | Port              | -                | 4                      | Actinomyces radicidentis Streptococci | 2              |

CCI, Charlson Comorbidity Index; G, gauge; <sup>a</sup> missing data. The peripheral venous catheter was in place for >2 days, but the exact insertion time was not registered.

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study design may have modified clinical practice during the study, leading to less use of the port, which may have led to less flushing, possibly leaving more bacteria in the port ready to be caught on the swab compared with the internal lumen. Fifth, for practical reasons, the cultures were not performed on PVCs in consecutive patients, introducing a risk of selection bias. Finally, the departments included in this study have a vested interest in knowledge and research about PVC hygiene routines. Therefore, the results may represent a lower rate of colonization compared with that observed in other general departments of the hospital. In the authors’ opinion, there is an urgent need for a randomized controlled trial comparing ported PVCs and PVCs with NCs investigating PVCR-BSI as the primary endpoint.

In conclusion, this study showed colonization of micro-organisms in 11% of ported PVCs, and the vast majority (8.7%) were found in the injection port. This should be considered and related to other types of PVCs when choosing a ported PVC for insertion and use.

Author contributions

- Study concept: all authors.
- Preparation of the protocol: all authors.
- Principal investigator: DJ.
- Drafting of the manuscript: DJ.
- Application for ethical approval and funding: DJ.
- Statistical analyses with support of independent statisticians: KT and DJ.
- Responsible for recruitment of patients: DJ.
- Data collection: DJ and SM.

All authors helped prepare the final manuscript and agreed to be accountable for all aspects of the work, thereby ensuring that questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved.

Conflict of interest statement

None declared.

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References

[1] Mermel LA. Short-term peripheral venous catheter-related bloodstream infections: a systematic review. Clin Infect Dis 2017;65:1757–62.
[2] Rickard CM, Webster J, Wallis MC, Marsh N, McGrail MR, French V, et al. Routine versus clinically indicated replacement of peripheral intravenous catheters: a randomised controlled equivalence trial. Lancet 2012;380:1066–74.
[3] Pujol M, Hornero A, Saballs M, Argerich MJ, Verdaguer R, Cisnàl M, et al. Clinical epidemiology and outcomes of peripheral venous catheter-related bloodstream infections at a university-affiliated hospital. J Hosp Infect 2007;67:22–9.
[4] Saliba P, Hornero A, Cuervo G, Grau I, Jimenez E, Berbel D, et al. Interventions to decrease short-term peripheral venous catheter-related bloodstream infections: impact on incidence and mortality. J Hosp Infect 2018;100:e178–86.
[5] Maki DG, Kluger DM, Cnich CJ. The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. Mayo Clin Proc 2006;81:1159–71.
[6] García-Gasalla M, Arrizabalaga-Asenjo M, Collado-Giner C, Ventayol-Aguiló L, Socias-Mir A, Rodríguez-Rodríguez A, et al. Results of a multi-faceted educational intervention to prevent peripheral venous catheter-associated bloodstream infections. J Hosp Infect 2019;102:449–53.
[7] González-López JL, Arribi Vilela A, Fernández del Palacio E, Olivares Corral J, Benedicto Martí C, Herrera Portal P. Indwell times, complications and costs of open vs closed safety peripheral intravenous catheters: a randomized study. J Hosp Infect 2014;86:117–26.
[8] Slater K, Cooke M, Whitby M, Fullerton F, Douglas J, Hay J, et al. Microorganisms present on peripheral intravenous needleless connectors in the clinical environment. Am J Infect Control 2017;45:932–4.
[9] Moureau NL, Flynn J. Disinfection of needleless connector hubs: clinical evidence systematic review. Nurs Res Pract 2015;2015:796762.
[10] Charlton ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:372–83.
[11] Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med 1985;13:818–29.
[12] Slater K, Cooke M, Fullerton F, Whitby M, Hay J, Lingard S, et al. Peripheral intravenous catheter needleless connector decontamination study — randomized controlled trial. Am J Infect Control 2020;48:1013–8.
[13] O’Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al.; Healthcare Infection Control Practices Advisory Committee. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis 2011;52:e162–93.
[14] Devrim I, Demiray N, Oruc Y, Sipahi K, Çağlar I, Sarı F, et al. The colonization rate of needleless connector and the impact of disinfection for 15 s on colonization: a prospective pre- and post-intervention study. J Vasc Access 2019;20:604–7.
[15] Hankins R, Majorant OD, Rupp ME, Cavaliere RJ, Fey PD, Lyden E, et al. Microbial colonization of intravascular catheter connectors in hospitalized patients. Am J Infect Control 2019;47:1489–92.
[16] Ryder M. Catheter-related infections: it’s all about biofilm. Topics Adv Pract Nurs eJournal 2005;5.
[17] Raad I. Intravascular-catheter-related infections. Lancet 1998;351:893–8.