



Assessing nursing students' knowledge of evidence-based guidelines on the management of peripheral venous catheters: A multicentre cross-sectional study



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ARTICLE INFO

Keywords:

Prevention
Peripheral venous catheters management
Nursing students
Knowledge
Cross-sectional
Evidence-based guidelines

ABSTRACT

Background: Inserting Peripheral Venous Catheters (PVCs) is one of the most routinely performed invasive procedures in nursing care and, if not well managed, it could expose patients to bloodstream-related infections. Knowledge of guidelines for the management of PVCs is fundamental to arise nurses and nursing students (NSs)' awareness on the importance of recommendations' adherence for clinical practice improvement.

Objective: To determine NSs' theoretical knowledge of evidence-based guidelines for management of PVCs and investigate potential predictive factors associated to recommendations' adherence.

Design: Cross-sectional.

Settings: The study was carried out (March–September 2015) in seven Universities of three Regions of Italy (Marche, Abruzzo, Emilia Romagna).

Participants: A convenience sample of NSs ($n = 1056$) was involved.

Methods: We collected data using a 10-items validated questionnaire assessing: knowledge of NSs' PVC guidelines and socio-demographic characteristics of the sample.

Results: Most participants were female (74.8%), mean age: 22.4 years (DS = 3.9); attending the first, second and third year of Bachelor in Nursing (34.8%; 32.9%; 32.3%, respectively); with at least one year of training experience (32.1%). Most of incorrect answers given by NSs concerned the right way to wash hands before CVPs insertion (33.5%); the replacement of administration set < 24 h when neither lipid emulsions nor blood products have been infused (79.7%); the choice of dressing to cover insertion site (59.3%); the use of steel needles to administer drugs (60.9%); the use of antibiotic ointment (68.7%); the correct concentration of chlorhexidine before PVCs' insertion (70.7%).

In multivariate analysis, a higher level of education and an increased number of years of training experience and wards attended, were associated with better test scores.

“Infusion set removal after 24 h when lipids or blood products are administered” (75.4%).

Conclusions: NSs' overall level of knowledge to some recommendations is inadequate. Nurse educators should emphasize on the importance of Evidence-based guidelines' knowledge in order to promote the translation of theory into practice of NSs.

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1. Introduction

Peripheral venous catheterization is one of the most frequently invasive procedures performed by nurses in the care of millions of hospitalized patients worldwide, usually for medication, fluid infusion and blood components administration (Alexandrou et al., 2012; Zingg and Pittet, 2009; Mermel et al., 2001; McCallum and Higgins, 2012).

However, there is a concern about consequences associated with this procedure, as vein inflammation, obstruction of the catheter and phlebitis: a condition leading to an increased risk of catheter-related bloodstream infections (CRBSI) (Maki and Ringer, 1991; Bregenzer et al., 1998; White, 2001; Cornely et al., 2002; Karadeniz et al., 2003; Webster et al., 2007; Pratt et al., 2007; Uslusoy and Mete, 2008; Cicolini et al., 2009; Lee et al., 2009; Forni et al., 2010; Rego Furtado, 2011; Mestre Roca et al., 2012; Cicolini et al., 2014a, 2014b), longer admissions, additional healthcare costs, discomfort and morbidity for patients (McCallum and Higgins, 2012).

It has been widely acknowledged that the risk of phlebitis could be influenced by different factors: those related to patient, such as thrombophilic predisposition, high haemoglobin levels and poor veins' quality (Zingg and Pittet, 2009), which are often resistant to modification; and those related to devices: catheters' material (Madan et al., 1992; Gaukroger et al., 1998) and size (Maki and Ringer, 1991), indwelling time (Tager et al., 1983; Maki and Ringer, 1991; Lai, 1998) type of infusate (Maki and Ringer, 1991; Webster et al., 2010; O'Grady et al., 2011), and site of insertion (Comparcini et al., 2017; Cicolini et al., 2014a, 2014b). Also, the risk of patient harm seems to be associated with a lack of skill proficiency in registered nurses (Zamanzadeh et al., 2015; Milutinović et al., 2015; Meeder et al., 2016). Inadequate skill performance may also have negative consequences for nurses which feel themselves frustrated, are at risk of making mistakes (Zamanzadeh et al., 2015), and could decide to leave the profession (Aoyama et al., 2013).

2. Background

Interventions to prevent complications related to the use of Peripheral Venous Catheters (PVCs) play a pivotal role to improve patient outcomes, reduce health care costs (O'Grady et al., 2011), and adverse events (Johansson et al., 2008). In this vein, nurses' knowledge of international evidence-based guidelines for the prevention of intravascular catheter-related infections is extremely important in guiding the care process on healthcare institutions (Meesterberends et al., 2010) and, also, to support clinical decisions-making (Lohr and Field, 1992; O'Grady et al., 2011). Unfortunately, in spite of their utility, guidelines are not always observed by healthcare professionals (Grol and Grimshaw, 2003; Meesterberends et al., 2010; van Gaal et al., 2010). Among predictive factors negatively influencing guidelines compliance, authors reported: lack of knowledge, negative attitudes, barriers linked to the organisation, and operator-colleague/patient interactions (Grimshaw et al., 2004).

Recent studies on research utilization in newly graduated registered nurses showed that about 50% of nurses considered their use of research in clinical practice as low or very low (Forsman et al., 2009; Forsman et al., 2010). Although several challenges remain regarding the transition from education into practice, factors associated with adherence to guidelines recommendation and research utilization in clinical settings are strongly emphasized in the context of nursing education (Hegarty et al., 2009).

To date, evidences on students' knowledge in the management of PVCs are limited and, to our knowledge, only the study of Ahlin et al. (2017) assessed NSs' knowledge and skills of PVCs insertion using a validated questionnaire (Ahlin et al., 2013). However, this study was monocentric in design, the instrument used for data collection was based on local guidelines, and authors did not analyze data by considering areas of clinical placement, training experience, and year of

education of NS. Also, items of the questionnaire (Ahlin et al., 2013) were specifically tailored to assess steps followed by students before, during and after the insertion of catheters, without considering aspects about management of such devices.

Assessing that students have achieved adequate levels of knowledge in this procedure at different levels of the nursing education is of importance to not only prevent complications and support patient safety, but, also for the learning outcomes' certification, in accordance with the Bologna Declaration (Spitzer and Perrenoud, 2006a, 2006b; Ohlén et al., 2011). It is therefore essential that nursing students (NSs) acquire the theoretical and practical knowledge during the course of their studies and skills necessary to manage PVCs safely and effectively, according to recent guidelines, as it is considered a common tasks in health care (Ahlin et al., 2017). In fact, opportune teaching and training of this procedure is included in nursing programs (Spitzer and Perrenoud, 2006a, 2006b; Ohlén et al., 2011).

To our knowledge, this is the first study specifically tailored to analyze nursing students' knowledge of evidence-based guidelines on the prevention of PVCs-related infections, in order to ensure progress in implementing recommendations to improve the quality of nursing practice. Although students cannot be expected to have the same knowledge and skills of nurses, our findings could be useful to improve students' experience in clinical placement and for their future role as competent nurses (Simonetti et al., 2015).

Thus, the main aim of this multicenter study was to assess nursing students' knowledge of evidence-based guidelines on the prevention of PVCs-related infections. Potential associations between level of knowledge and demographic characteristics were also investigated.

3. Methods

3.1. Design and Setting

A multicentre cross-sectional study was performed in seven Italian Universities of Marche, Abruzzo and Emilia Romagna Regions, between March and September 2015.

3.2. Study Population

We used a convenience sample: all students enrolled in the first, second, third year of the Bachelor in Nursing who attended theoretical lessons about management of PVCs (expected from the first year of the Degree program) and signed the informed consent were included. NSs who did not accept to participate or who do not signed the informed consent were excluded from the study.

3.3. Ethical Considerations

The study was approved by the Ethics Committee of the University of the Coordinating Center [blinded for referee].

3.4. Study Procedures and Data Collection

In each participating center a previously trained researcher, was personally responsible for participants' recruitment and information about the purpose of the study. After enrollment, the researcher personally administered a validated and self-reported questionnaires (Cicolini et al., 2014a, 2014b) to each students. The researcher asked the participants to individually fill out and return the instrument within 15 min, and supervised the test's fulfillment in order to avoid other resources consultation by participants. After that, the researcher collected each filled questionnaire in an envelope inside a special urn, to guarantee the confidentiality and anonymity.

3.5. Instrument Description

The structured questionnaire used in this study of Cicolini et al. (2014a, 2014b) was an adapted and validated Italian version of a previous questionnaire of Labeau et al. (2008a, 2008b), and included two parts:

- (i) *General information.* Socio-demographics information was collected: Nursing School (University Campus); age; gender; year of education (categorized in three periods: 1st year, 2nd year, 3rd year). Students were also asked to provide information as years of training experiences (none, one year, two years, three years); the number of ward attended and which one.
- (ii) *Knowledge Assessment.* 10 multiple choice items related to PVC management, selected from CDC guidelines (O'Grady et al., 2011) and reflecting themes expressing relevance for clinical practice (1) PVC replacement; (2) hand hygiene; (3) aseptic technique; (4) selection of catheters; (5) catheter site dressing regimens (time of replacement); (6) catheter site dressing regimens (type of dressing); (7) skin preparation; (8) catheter site dressing regimens (antibiotic ointment); (9) replacement of administration sets (lipid emulsion infusions); and (10) replacement of administration sets (neither lipid emulsions and nor blood product infusions).

The instrument provided four alternative responses: one correct answer (given one point); two distractors or alternative responses and the answering option “I do not know”, to avoid guessing.

The maximum score's value was 10 and the minimum was 0, indicating the higher and lower knowledge of guidelines, respectively.

3.6. Sample Size

The reliability of the instrument was tested in three studies, which enrolled 762, 3405 nurses, and 933 (Labeau et al., 2008a, 2008b; Cicolini et al., 2014a, 2014b), respectively. However, no study assessed the knowledge of NSs on PVCs' recommendations using this tool. Our primary outcome was the rate of correct answers, among the four possible, in each item of the questionnaire; given the lack of literature data, we assumed a rate of correct answer of 70%, and we considered acceptable a variation of $\pm 5\%$ from the mean value. Therefore, a minimum of 341 subjects were requested to achieve lower and upper 95% confidence intervals of 65% and 75%, respectively. The secondary outcome of this study was to compare the level of knowledge of NSs according to year of course. Assuming an expected difference of 10% (65% first vs. 75% third year) in the rate of correct answers between the first and the third year and a two-tailed alpha error of 5%, a minimum of 349 subjects for each year of course were requested to achieve an 80% statistical power. Given that we expected a drop-out rate of 5%, we planned to enrol a total of 1074 subjects.

3.7. Data Analysis

Categorical variables were synthesized as frequencies and percentages. Continuous variables were summarized as mean, standard deviation (SD) and interquartile range (IQ). Significance of differences in score value between different categories was evaluated with Mann–Whitney *U* test or Kruskal–Wallis test, as appropriate. After Kruskal–Wallis test, post hoc analysis was performed by Mann–Whitney *U* test on each pair of categories adjusting the *p* value with the Bonferroni method.

The statistical significance was set at *p* value < 0.05. All statistical analyses were performed with SPSS® 20.0 (SPSS Inc., Chicago, Illinois).

Table 1
Overall characteristics of the sample.

Characteristics	N (%)
Overall sample	1056 (100)
Age (year), mean \pm SD	22.4 \pm 3.9
Nursing schools	
Ascoli Piceno	143 (13.6)
Fermo	129 (12.2)
Macerata	150 (14.3)
Ancona	296 (28.0)
Pesaro-Urbino	182 (17.2)
Imola	69 (6.5)
Pescara	87 (8.2)
Gender	
Female	790 (74.8)
Male	266 (25.2)
Year of education	
1	368 (34.8)
2	347 (32.9)
3	341 (32.3)
Training experience	
None	60 (5.7)
One year	339 (32.1)
Two years	355 (33.6)
Three years	302 (28.6)
Number of wards attended by NSs	
None	66 (6.3)
1–2	394 (37.3)
3–5	300 (28.4)
≥ 6	296 (28.0)
Department's type attended by NSs ^a	
Medical dept	852 (80.7)
Surgical dept	781 (74.0)
Maternal-child dept	245 (23.2)
Mental health dept	99 (9.4)
Critical dept	295 (27.9)
Primary Health Care Services	245 (23.2)

^a Total > 100% due to the possibility to choose more than one response categories.

4. Results

4.1. Characteristics of the Sample

Seven Universities from three different Regions of the Center of Italy accepted to participate, and a total of 1056 students attending the Bachelor of Science in Nursing completed the questionnaire (response rate (78.3%)). Most participants were female (74.8%), with a mean age of 22.4 (± 3.9) years, attended the Campus of Ancona (38.4%), were enrolled in the first (34.8%), second (32.9%), third (32.3%) year of the course, had two year of training experience (33.6%), attended at least 1–2 departments (37.3%) and had training experiences in Medical and Surgical departments (80.7% and 74.0%, respectively). Demographics and participants' characteristics are summarized in Table 1.

4.2. Knowledge

In general, among four options of 10 items of the questionnaire, none achieved 100% correct answers, and the mean knowledge score was 55.42%. Multiple choice questions, response possibilities, and respective answers are reported below and shown in detail in Table 2.

The highest percentages of correct answers were obtained in the item number one: “When it is recommend to routinely replace PVCs” (95.6%), three: “The recommendation to use an aseptic technique during connecting/disconnecting the infusive line” (78.8%), five: “When it is recommended to change the dressing on the PVC insertion site” (77.2%), nine: “Infusion set removal after 24 hours when lipids or blood products are administered” (75.4%).

On the contrary, a high rate of incorrect answers can be observed to the questions related to the use of steel needles to administer drugs

Table 2
NSs' answers on multiple-choice questions regarding prevention of peripheral venous catheters-related infections.

Item	% of answers
1. It is recommended to replace peripheral venous catheters (PVCs) routinely...	
A Yes, every 24 h	1.9
B Yes, every 12 h	0.6
C ^a Yes, every 72–96 h	95.6
D I do not know	1.9
2. It is recommended to perform an antiseptic handwash before insertion of PVCs...	
A No, it's sufficient to wash hands with a non-antimicrobial soap	27.6
B No, you do this only for invasive procedures	5.6
C ^a Yes, always	66.5
D I do not know	0.3
3. It is recommended to use an aseptic technique during connecting/disconnecting the infusive lines...	
A ^a Yes, always	78.8
B No, it's sufficient to wash hands with an antimicrobial soap	17.8
C No, because it increases the risk of infection	0.8
D I do not know	2.6
4. It is recommended to use steel needles (butterfly type) for the administration of drugs...	
A ^a No, because they might cause tissue necrosis if extravasation occurs	39.1
B Yes, if I have to inject drugs for a short time	52.0
C Yes, always	0.9
D I do not know	8.0
5. It is recommended to change the dressing on the catheter insertion site...	
A On a daily basis	6.0
B Every 3 days	15.7
C ^a When indicated (soiled, loosened, ...)	77.2
D I do not know	1.1
6. It is recommended to cover up the catheter insertion site with...	
A Polyurethane dressing (transparent, semipermeable)	50.9
B Gauze dressing	7.1
C ^a Both are recommended because the type of dressing does not affect the risk for catheter-related infections	40.7
D I do not know	1.3
7. It is recommended to disinfect the catheter insertion site with...	
A ^a Chlorhexidine gluconate solution with alcohol	29.3
B > 0.5% chlorhexidine solution with alcohol	63.3
C 10% alcohol	0.8
D I do not know	6.6
8. It is recommended to apply an antibiotic ointment at the insertion site of a PVC...	
A Yes, because it decreases the risk for catheter-related infections	4.6
B ^a No, because it causes antibiotic resistance	31.3
C No, because it does not decrease the risk for catheter-related infections	43.7
D I do not know	20.4
9. When lipid emulsions are administered through a PVC it is recommended to replace the administration set...	
A ^a Within 24 h	75.4
B Every 72 h	8.6
C Every 96 h	1.3
D I do not know	14.7
10. When neither lipid emulsions nor blood products are administered through a PVC it is recommended to replace the infusion set...	
A Every 24 h	17.4
B Every 72 h	53.9
C ^a Every 96 h	20.3
D I do not know	8.4

^a Correct answer according to CDC guidelines.

(60.9%), the recommended product to disinfect the PVC insertion site (70.7%), the use of antibiotics at the insertion site of PVC (68.7%), the replacement of infusion set when neither lipids nor blood products are administered (79.7%). Approximately half of the students answered correctly to the question number six: “The right dressing to cover up the

Table 3
Median score (IQ) on ten questions according to NSs' characteristics.

Characteristics	Median (IQ)	K-W p-value
Total cohort	6 (5–7)	–
Gender		0.497 ^a
Female	6 (5–7)	
Male	5 (5–6)	
Year of education		< 0.001
1	5(4–6)	
2	6 (4–6)	
3	6 (5–7) [§]	
Training experience		< 0.001
None	4 (3–5)	
One year	5 (4–6)	
Two years	6 (4–6)	
Three years	6 (5–7) [*]	
Wards attended by NSs		< 0.001
None	4 (3–5)	
1–2	5 (4–6)	
3–5	6 (4–7)	
≥6	6 (5–7) [°]	

^a Mann-Whitney's test.

[§] $p < 0.05$ test post-hoc vs. 1st and 2nd year of course.

^{*} $p < 0.05$ test post-hoc vs. none, one year and two year of experience.

[°] $p < 0.05$ test post-hoc vs. none, 1–2, 3–5 attended ward.

PVC insertion site” (40.7%), and two: “The antiseptic handwash before insertion of PVC” (66.5%).

The median score was 6 (IQ: 5–7) on 10 questions. There were no statistically significant differences in scores between genders ($p = 0.497$). Differences in scores showed, however, to be statistically significant when related to the year of education ($p < 0.001$), training experience ($p < 0.001$) and number of wards attended by NSs ($p < 0.001$).

In particular, the median score increases with the year of education (5 for 1st year and 6 for 2nd and 3rd year), the training experience (4 for none, 5 for one year and 6 for two and three years of experience), and the number of wards attended by NSs (4 for none, 5 for one-two and 6 for three-five or > 6 wards attended by NSs) (Table 3).

5. Discussion

Recommendations to prevent and reduce intravascular catheter-related infections has been widely acknowledged as important tool to the application of some control strategies (i.e.: hand hygiene, skin antiseptics, type of infusion, type of catheter and dressing, time of replacement of catheters and infusions sets) to reduce the transmission of infections related to the use of PVCs. Adequate knowledge of guidelines, especially from nurses and nursing students who are and will be responsible for the insertion and maintenance of these devices, are crucial to prevent and reduce infection rates, hospitalization and morbidity for patients and costs.

This cross-sectional survey showed important results regarding knowledge of current guidelines for the management of PVCs among a sample of Italian NSs and the association with year of education, training experience and number of ward attended by students.

The self-reported responses to the questionnaire revealed an unsatisfactory level of knowledge of CDC's main recommendations (O'Grady et al., 2011) (mean score = 6), especially regarding the use of steel needles for the administration of drugs, the use of antibiotic ointment at the insertion site, the time of replacement of infusion set when neither lipid emulsions nor blood products are administered through a PVC. Potential explanations for these NSs' failure could be a lack or insufficient formal education on negative implications for clinical practice (i.e. phlebitis, discomfort, additional costs and increase of length of stay) derived from a poor level of knowledge of guidelines. Possible solutions could concern the implementation of educational

courses, targeted to the most frequent errors, in order to achieve improvement even in the short term. On the contrary, only for items on time of replacement of PVCs, dressing changes and replacement of administrations set used for lipid emulsion infusion the majority of NSs answered correctly. These results are in line with those reported to a large previous survey on a population of Italian nurses by Cicolini et al. (2014a, 2014b) and Labeau et al. (2009), who conducted a similar study on a population of a European intensive care nurses managing central venous catheters.

We assume that in everyday clinical practice, the lack of knowledge could be translated into a poor adherence to the guidelines with regard to the following points: (a) discriminate between disadvantage and advantages of different devices for administration of drugs; (b) understand which prevention should be used (disinfection, replacement of infusion sets, correct handwash), even though, we have to underline that literature suggested that high knowledge levels, did not necessary translate into good clinical practice (Karadeniz et al., 2003).

By analysing the relationship between NSs' characteristics and knowledge of guidelines, we observed that students who attended the second or third class of the Degree Program, with more than one year of training experience, or who attended different wards, scored significantly higher in knowledge scores than did those with lower/any years of education/training experience or who did not attend any hospital wards (all $p < 0.001$). These correlations were also founded in previous researches on similar/equal topics (Simonetti et al., 2015; Ahlin et al., 2017) or on a sample of nurses (Cicolini et al., 2014a, 2014b; Labeau et al., 2009) and could be explained because of the exposition of students to clinical setting during their training program, that could have increase their level of knowledge. In fact, it is well recognized the importance of clinical experience in NSs' learning process' growth (McNamara, 2015) that can lead to professional competence acquisition (Kline and Hodges, 2006). Others elements in clinical courses that should be taken into account to improve motivation to learning are student involvement, individualization, feedback, discussions, and the sense of task accomplishment (Smedley, 2010; Bengtsson and Ohlsson, 2010; Henderson et al., 2012). Also, educational programs should not be limited to acquisition of theoretical knowledge, but also explain why following current guidelines might be important for the patient (Manzoli et al., 2012).

In different studies, no associations between level of education and higher knowledge score were founded (Pieper and Mott, 1995; Pieper and Mattern, 1997).

5.1. Limits

To precisely appreciate the findings of the study, some limitations should be considered. First, the cross-sectional design do not allow to determine a causal effect of detected items, but only associations in the analysis of potential predictors of knowledge. Second, potential bias (under-reporting) due to the use of a self-report questionnaire. Third, we had not considered the influence of teacher's education on NSs' knowledge; a such an issue may foster further researches.

However, the strength of this multicenter study is the large sample size that allows a fairly good representativeness of the overall population of Italian NSs.

6. Conclusions

In conclusion, this research underlines the necessity to adjust the level of NSs' knowledge of some of evidence-based recommendations on PVCs' management, this could lead to a low adherence to guidelines in clinical practice, with negative consequences for patients' safety.

Since, we observed a correlation between level of education/training experience and better knowledge score, nursing educators should reinforce the role of education as well as that one of training programs in hold cooperation with hospital ward (placement location)

in order to arise the knowledge and promote the translation of theory into practice. This aspect could allow students to acquire core competencies to become professional nurses.

Also, in order to raise the awareness of students and to monitor their learning process, surveys like the present could be carried out on a regular basis in many Nursing Degree Courses, so that the instrument applied in this study could be periodically administered in a simple manner, for the purpose of eventually identify educational needs and apply proper solutions, according to clinical risk management perspectives.

The results of this study provided important insight for nurse educators on which priorities to set in their educational/training programs (antibiotic and steel needle use, replacement time of infusion set).

Further research would be necessary to expand the knowledge on this topic in order to compare the Italian context with other international settings.

Authors' Contributions

All authors participated in all phases of the study (design, data collection and interpretation of the results). PDG made the statistical analysis; GC, VS, DC, designed the study, and wrote the manuscript; DM and RT collected data.

All authors had full access to data and are responsible for the integrity and the accuracy of the data.

Conflict of Interest Statement

No conflict of interest has been declared by the authors.

Funding Statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgements

Authors acknowledge all Nurse Directors of the seven Italian Nursing Degree Courses for their support during data collection.

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