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Research Article

Improving patient safety during insertion of peripheral venous catheters: an observational intervention study

Verbesserung des Patientenschutzes beim Legen peripherer Venenkatheter: eine Beobachtungs- und Interventionsstudie

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Abstract

Background: Peripheral venous catheters are frequently used in hospitalized patients but increase the risk of nosocomial bloodstream infection. Evidence-based guidelines describe specific steps that are known to reduce infection risk. However, the degree of guideline implementation in clinical practice is not known. The aim of this study was to determine the use of specific steps for insertion of peripheral venous catheters in clinical practice and to implement a multimodal intervention aimed at improving both compliance and the optimum order of the steps.

Methods: The study was conducted at University Hospital Hamburg. An optimum procedure for inserting a peripheral venous catheter was defined based on three evidence-based guidelines (WHO, CDC, RKI) including five steps with 1A or 1B level of evidence: hand disinfection before patient contact, skin antisepsis of the puncture site, no palpation of treated puncture site, hand disinfection before aseptic procedure, and sterile dressing on the puncture site. A research nurse observed and recorded procedures for peripheral venous catheter insertion for healthcare workers in four different departments (endoscopy, central emergency admissions, pediatrics, and dermatology). A multimodal intervention with 5 elements was established (teaching session, dummy training, e-learning tool, tablet and poster, and direct feedback), followed by a second observation period. During the last observation week, participants evaluated the intervention.

Results: In the control period, 207 insertions were observed, and 202 in the intervention period. Compliance improved significantly for four of five steps (e.g., from 11.6% to 57.9% for hand disinfection before patient contact; $p<0.001$, chi-square test). Compliance with skin antisepsis of the puncture site was high before and after intervention (99.5% before and 99.0% after). Performance of specific steps in the correct order also improved (e.g., from 7.7% to 68.6% when three of five steps were done; $p<0.001$). The intervention was described as helpful by 46.8% of the participants, as neutral by 46.8%, and as disruptive by 6.4%.

Conclusions: A multimodal strategy to improve both compliance with safety steps for peripheral venous catheter insertion and performance of an optimum procedure was effective and was regarded helpful by healthcare workers.

Keywords: compliance, hand hygiene, peripheral venous catheter, insertion, standard operating procedure

Zusammenfassung

Hintergrund: Periphere Venenkatheter werden häufig bei hospitalisierten Patienten angelegt, doch sie erhöhen das Risiko einer nosokomialen Sepsis. Evidenzbasierte Empfehlungen beschreiben spezifische Schritte, die nachweislich das Infektionsrisiko reduzieren. Wie häufig

diese Schritte jedoch in der klinischen Praxis umgesetzt werden, ist nicht bekannt. Ziel dieser Studie war es, die Häufigkeit der Umsetzung dieser spezifischen Schritte zur Anlage peripherer Venenkatheter in der klinischen Praxis zu bestimmen und mit einer multimodalen Intervention sowohl die Compliance als auch den optimalen Ablauf der Schritte zu verbessern.

Methode: Die Studie wurde an der Universitätsklinik Hamburg Eppendorf durchgeführt. Der optimale Ablauf des Legens peripherer Venenkatheter wurde auf Basis von drei evidenzbasierten Empfehlungen definiert (WHO, CDC, RKI), der fünf Schritte mit dem Evidenzgrad 1A oder 1B enthält: Händedesinfektion vor Patientenkontakt, Hautantisepsis der Punktionsstelle, keine Palpation der desinfizierten Punktionsstelle, Händedesinfektion vor aseptischer Tätigkeit und sterile Abdeckung der Punktionsstelle. Der Ablauf der Anlage peripherer Venenkatheter durch Mitarbeiter wurde in vier Abteilungen (Endoskopie, zentrale Notaufnahme, Pädiatrie, Dermatologie) von einer Pflegekraft beobachtet und aufgezeichnet. Eine multimodale Intervention mit fünf Elementen wurde durchgeführt (Fortbildungsveranstaltung, Übung am Dummy, e-learning, Tablett und Poster sowie direktes Feedback). Danach erfolgte eine zweite Beobachtungsphase. In der letzten Woche der Beobachtung wurde eine Evaluation der Intervention durch die Mitarbeiter vorgenommen.

Ergebnisse: In der Kontrollphase wurden 207 Anlagen peripherer Venenkatheter beobachtet, in der Interventionsphase waren es 202. Die Compliance verbesserte sich bei vier der fünf Schritte signifikant (z.B. von 11,6% auf 57,9% bei der Händedesinfektion vor Patientenkontakt; $p<0,001$, Chi-Quadrat-Test). Die Compliance der Hautantisepsis der Punktionsstelle war sowohl vor als auch nach der Intervention hoch (99,5% vorher und 99,0% nachher). Die Umsetzung der spezifischen Schritte in der optimalen Reihenfolge verbesserte sich auch (z.B. von 7,7% auf 68,6%, wenn drei der fünf Schritte durchgeführt wurden; $p<0,001$). Die Intervention wurde von 46,8% der Teilnehmer als hilfreich bewertet, 46,8% bewerteten sie neutral und 6,4% als störend.

Schlussfolgerung: Eine multimodale Strategie kann sowohl die Compliance Patientenschutz-relevanter Schritte beim Legen peripherer Venenkatheter als auch die Umsetzung eines optimalen Ablaufs wirksam verbessern. Die Mitarbeiter bewerteten die Intervention als hilfreich.

Schlüsselwörter: Compliance, Händehygiene, periphere Venenkatheter, Insertion, Standardarbeitsanweisung

Background

Prevention of primary septicemia in hospitalized patients is a global challenge [1]. Central venous catheters have a high risk of causing septicemia despite a high standard for asepsis during insertion [2]. Many patients are likely to have a peripheral venous catheter inserted during hospitalization and these catheters are associated with nosocomial bloodstream infections [3], [4]. In Germany, insertion of peripheral venous catheters is a fairly simple procedure performed by doctors and nurses in specific steps. Optimum patient safety requires implementing a standard operating procedure (SOP) based on evidence-based guidelines, e.g., from the CDC, RKI or WHO [5], [6], [7]. The CDC recommends preventing intravascular catheter-related infections using a hospital-specific initiative that combines multifaceted strategies to improve compliance with evidence-based recommended practices (category IB) [7]. The aim of our study was to develop an SOP for the insertion of peripheral venous catheters and to determine if a multimodal intervention enhanced compliance with five specific safety-relevant SOP steps.

Methods

Setting

The study took place at the University Hospital Eppendorf, Hamburg, Germany, a tertiary care hospital with 1,346 beds. A total of 80,000 patients are admitted per year for inpatient treatment; 263,000 are seen as outpatients with approximately 113,000 admitted to the central emergency admission department. Selected for study were the following departments that were considered likely to frequently insert venous catheters: endoscopy

Table 1: Specific safety steps of the institutional standard operating procedure for insertion of a peripheral venous catheter and justification by evidence-based medicine guidelines

Activity	Evidence Category	Comment	References
Hand disinfection before patient contact	WHO: IB CDC: IB RKI: IA	Use of a tourniquet is indispensible during direct patient contact.	[5-7]
– Inform patient – Position arm – Material check – Tourniquet			
Skin antisepsis at puncture site	CDC: IB RKI: IB		[5, 7]
– Proper application time for skin antiseptic			
No palpation of disinfected puncture site	CDC: IB RKI: IB	According to CDC guidelines, palpation of the disinfected puncture site may be done if "aseptic technique is maintained."	[5, 7]
Hand disinfection before aseptic procedure	WHO: IB CDC: IB RKI: IA	After touching the patient and the immediate environment (tourniquet), hand disinfection is necessary before venous catheter insertion.	[5, 6]
– Protective gloves – No-touch technique puncture – Pull back of cannula into sharp container – Sterile lock or connection of infusion		Protective gloves were not considered essential because they are recommended for healthcare worker safety and not for patient safety.	
Sterile dressing on puncture site	CDC: IA RKI: IB		[5, 7]
– Fixation of catheter – Disposal of gloves – Hand disinfection after patient contact – Disposal of utilities		Hand disinfection after patient contact was not considered relevant because it did not improve the safety of the patient undergoing the procedure.	

unit, central emergency admission department, pediatrics, and dermatology.

SOP evaluation

Guidelines from CDC, RKI and WHO were reviewed for all details relevant for peripheral venous catheter insertion. Recommendations in categories IA or IB were considered indispensable for patient safety and included in the SOP. Five specific steps relevant for patient safety were identified (Table 1) for observation for compliance and the intervention. All other steps including use of protective gloves (which were not in categories IA or IB) were observed and documented but not further analyzed (Table 1).

Observation

All observations were made by a study nurse. During the control period, the study nurse observed procedures without healthcare workers knowing the reason for observation. Observations were performed during the morning shift for about 6 hours per day. The pediatric department was usually visited between 7:00 and 8:00, followed by 1 hour of observation in the dermatology department, 2 to 3 hours in the endoscopy unit, and 1 to 2 hours in the central emergency admission department.

Intervention

The intervention consisted of five elements for insertion of a venous catheter that focused on aspects of patient safety. The intervention was performed with doctors and nurses in all four studied departments. The intervention was:

1. A teaching session accredited by the Medical Chamber of Hamburg, performed between the baseline period and the intervention period.
2. A dummy training how to insert a peripheral venous catheter offered to all four departments between the baseline period and the intervention period. Six trainings of 30 min were given to healthcare workers in the dermatology unit, three trainings of 3 to 4 h were given to workers in the endoscopy unit, and three trainings of 15 min were given to healthcare workers from the central emergency admission department. The pediatric department did not request this training.

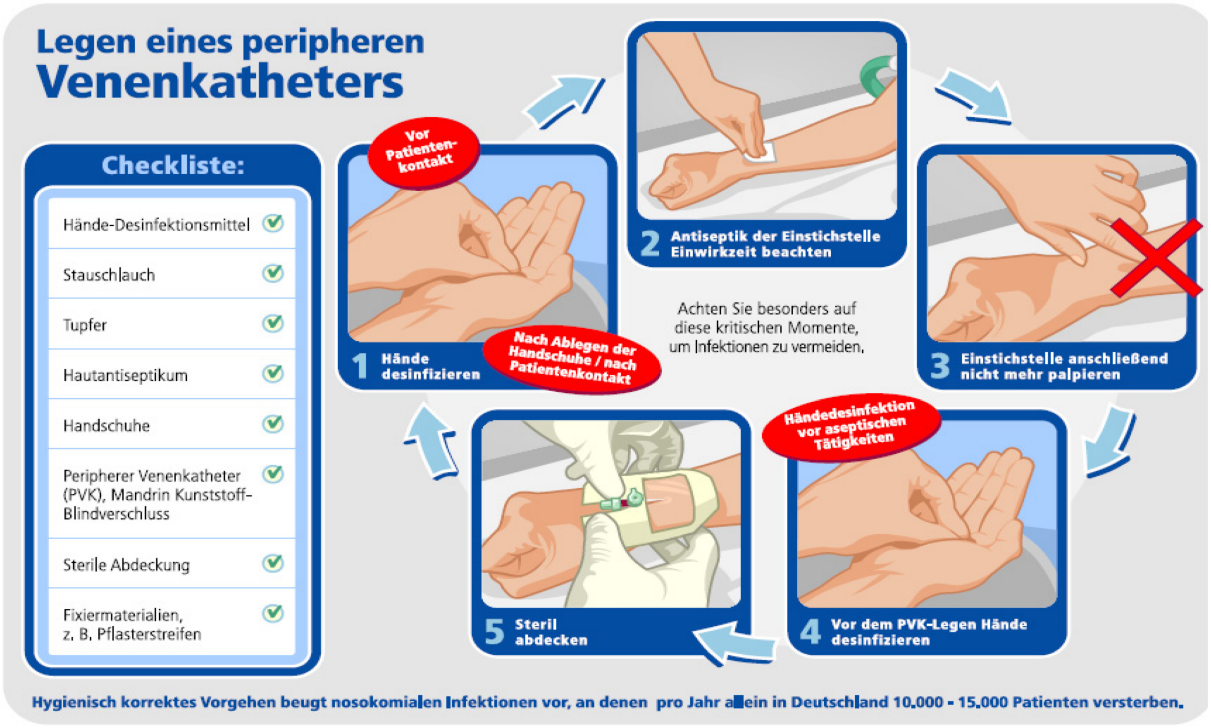

Figure 1: Tablet or poster used as part of the intervention showing a checklist (what do I need for insertion of a peripheral venous catheter?) and the five most important steps for patient safety

3. An e-learning tool with animated graphics for users to learn the correct process for inserting a venous catheter. The tool was available throughout the intervention period.
4. A tablet and poster; the poster was a checklist ("What do I need to take with me for insertion of a venous catheter?") with the five intervention steps presented as pictures (Figure 1). Pictures were chosen so that healthcare workers with low knowledge of the German language could understand the most relevant steps. The poster was located in the preparation room and on a tablet used to collect catheter insertion items before going to the patient. Both the tablet and poster were available throughout the intervention period.
5. Direct, open feedback from the study nurse to the healthcare workers during the intervention period if mistakes were observed. The aim of the feedback was to find out what would help the healthcare workers perform the procedure correctly (e.g., location change of the hand rub dispenser).

During the last week of the intervention, all healthcare workers from the four studied departments were invited to give feedback on the overall intervention and each component using a standardized form. The overall feedback was classified as "very helpful", helpful", "neutral", "disruptive" and "very disruptive".

Data documentation and statistics

Recorded data were: number of observations (ongoing), day (date and weekday), type of ward, profession, and all 18 steps described in Table 1. A datasheet with all steps was prepared in advance. During the observation, the study nurse noted when a specific step was performed and recorded the sequence of the steps on the datasheet. Comments were possible for each observation.

Data were analyzed using IBM SPSS Statistics 19 (SPSS Inc., Chicago, USA). Compliance was calculated as the relative frequency between the number observed and necessary activities. The chi-square test was applied to determine the significance of differences between baseline and intervention period values. A p-value <0.05 was considered significant.

Results

During the baseline period of August through October 2012, we observed 207 attempts to insert a peripheral venous catheter, most in the endoscopy unit (n=113), followed by the central emergency admission department (n=64), the pediatric wards (n=22) and the dermatology ward (n=8). Compliance was 11.6% overall for hand disinfection before patient contact; 99.5% for skin antisepsis at the puncture site; 33.3% for no palpation of the puncture site; 0.5% for hand disinfection before aseptic procedure; and 24.6% for use of sterile dressing to cover the puncture site (Table 2).

During the intervention period from November 2012 through March 2013, we observed 202 attempts to insert a peripheral venous catheter, mainly in the endoscopy unit (n=82), followed by the central emergency admission department (n=59), the pediatric wards (n=38), and the dermatology ward (n=23). After the intervention, compared to baseline, compliance was significantly higher

Table 2: Compliance rates for different types of activity before and after the intervention according to the department

Type of activity	Department	Compliance rate before intervention	Compliance rate after intervention	p-value
Hand disinfection before patient contact	All	11.6% (24 of 207)	57.9% (117 of 202)	<0.001
	Endoscopy	3.5% (4 of 113)	46.3% (38 of 82)	<0.001
	Central emergency admission	6.3% (4 of 64)	74.6% (44 of 59)	<0.001
	Pediatrics	59.1% (13 of 22)	52.6% (20 of 38)	0.628
	Dermatology	37.5% (3 of 8)	65.2% (15 of 23)	0.171
Skin antisepsis at puncture site	All	99.5% (206 of 207)	99.0% (200 of 202)	0.548
	Endoscopy	100%	98.8% (81 of 82)	0.239
	Central emergency admission	98.4% (63 of 64)	98.3% (58 of 59)	0.954
	Pediatrics	100%	100%	n.a.
	Dermatology	100%	100%	n.a.
No palpation of disinfected puncture site	All	33.3% (69 of 207)	66.3% (134 of 202)	<0.001
	Endoscopy	25.7% (29 of 113)	63.4% (52 of 82)	<0.001
	Central emergency admission	39.1% (25 of 64)	72.9% (43 of 59)	<0.001
	Pediatrics	45.5% (10 of 22)	61.5% (23 of 38)	0.258
	Dermatology	62.5% (5 of 8)	69.6% (16 of 23)	0.731
Hand disinfection before aseptic procedure	All	0.5% (1 of 207)	45.5% (92 of 202)	<0.001
	Endoscopy	0%	43.9% (36 of 82)	<0.001
	Central emergency admission	0%	44.1% (26 of 59)	<0.001
	Pediatrics	0%	39.5% (15 of 38)	0.001
	Dermatology	12.5% (1 of 8)	65.2% (15 of 23)	0.01
Sterile dressing on puncture site	All	24.6% (51 of 207)	73.3% (148 of 202)	<0.001
	Endoscopy	3.5% (4 of 113)	80.5% (66 of 82)	<0.001
	Central emergency admission	67.2% (43 of 64)	79.7% (47 of 59)	0.119
	Pediatrics	0%	50% (19 of 38)	<0.001
	Dermatology	50% (4 of 8)	69.6% (16 of 23)	0.319

Table 3: Compliance rates for different types of activity before and after the intervention according to the profession

Type of activity	Profession	Compliance rate before intervention	Compliance rate after intervention	p-value
Hand disinfection before patient contact	All	11.6% (24 of 207)	57.9% (117 of 202)	<0.001
	Doctors	13.0% (17 of 131)	44.9% (62 of 138)	<0.001
	Nurses	9.2% (7 of 76)	85.9% (55 of 64)	<0.001
No palpation of disinfected puncture site	All	33.3% (69 of 207)	66.3% (134 of 202)	<0.001
	Doctors	22.1% (29 of 131)	60.1% (83 of 138)	<0.001
	Nurses	52.6% (40 of 76)	79.7% (51 of 64)	0.001
Hand disinfection before aseptic procedure	All	0.5% (1 of 207)	45.5% (92 of 202)	<0.001
	Doctors	0.8% (1 of 131)	39.1% (54 of 138)	<0.001
	Nurses	0% (0 of 76)	59.4% (38 of 64)	<0.001
Sterile dressing on puncture site	All	24.6% (51 of 207)	73.3% (148 of 202)	<0.001
	Doctors	4.6% (6 of 131)	68.8% (95 of 138)	<0.001
	Nurses	59.2% (45 of 76)	82.8% (53 of 64)	0.002

Table 4: Frequency of the correct order of five specific steps before and after the intervention while a peripheral venous catheter is inserted

	Number of performed activities		Correct sequence	
	Before intervention (n=207)	After intervention (n=202)	Before intervention	After intervention
One of five activities	**66 (31.9%)**	**21 (10.4%)**	**n.a.**	**n.a.**
Hand disinfection before patient contact	0	0		
Skin antisepsis of puncture site	66 (100%)	20 (95.2%)		
No palpation of puncture site after antisepsis	0	1 (4.8%)		
Hand disinfection before antiseptic procedure	0	0		
Protective gloves	0	0		
Two of five activities	**77 (37.2%)**	**40 (19.8%)**	**31 of 77 (40.3%)**	**26 of 40 (65.0%)***
Hand disinfection before patient contact	1 (1.3%)	7 (17.5%)		
Skin antisepsis of puncture site	77 (100%)	40 (100%)		
No palpation of puncture site after antisepsis	16 (20.8%)	14 (35%)		
Hand disinfection before antiseptic procedure	0	4 (10%)		
Protective gloves	55 (71.4%)	15 (37.5%)		
Three of five activities	**52 (25.1%)**	**35 (17.3%)**	**4 of 52 (7.7%)**	**24 of 35 (68.6%)****
Hand disinfection before patient contact	11 (21.2%)	19 (54.3%)		
Skin antisepsis of puncture site	51 (98.1%)	35 (100%)		
No palpation of puncture site after antisepsis	40 (76.9%)	19 (54.3%)		
Hand disinfection before antiseptic procedure	0	15 (42.9%)		
Protective gloves	51 (98.1%)	17 (48.6%)		
Four of five activities	**12 (5.8%)**	**62 (30.7%)**	**1 of 12 (8.3%)**	**36 of 62 (58.1%)*****
Hand disinfection before patient contact	12 (100%)	47 (75.8%)		
Skin antisepsis of puncture site	12 (100%)	61 (98.3%)		
No palpation of puncture site after antisepsis	12 (100%)	56 (90.3%)		
Hand disinfection before antiseptic procedure	0	29 (46.8%)		
Protective gloves	12 (100%)	55 (88.7%)		
Five of five activities	**0**	**44 (21.8%)**	**0**	**44 (100%)**

* p=0.012, ** p=<0.001, *** p=0.003

for hand disinfection before patient contact (57.9%; p<0.001, chi-square-test; Table 2), no palpation of the puncture site (66.3%; p<0.001), hand disinfection before aseptic procedure (45.5%; p<0.001) and use of a sterile dressing to cover the puncture site (73.3%; p<0.001). A significant increase in compliance was seen in nurses and doctors for all four types of activities (Table 3).

In a second step, the sequence of the five activities considered relevant for patient safety was evaluated. During the baseline period, the majority of processes were done for two of the five activities (37.2%; Table 4), followed by one of five (31.9%), and three of the five activities (25.1%). After the intervention, the majority of processes were done for four of the five activities (30.7%), followed by five of the five activities (21.8%) and two of the five activities (19.8%), indicating a substantial shift towards a higher process-compliance. The correct order of activities improved significantly between the baseline and in-

tervention periods, e.g., from 7.7% to 68.6% when three of the five activities were done. Overall, healthcare workers had higher awareness of the optimum order of individual activities. All processes with three and four activities and an incorrect order (92.2% in the baseline period, 38.1% in the intervention period) were analyzed to identify the main mistakes. In 96.6% (baseline period) and 89.2% (intervention period) of the processes, gloves were donned before skin antisepsis, causing neglect of hand disinfection before the aseptic procedure.

During the last week of observation, healthcare workers in all four departments were asked to evaluate the intervention including its components and 47 responded. Overall, 46.8% described the intervention as helpful, 46.8% as neutral, and 6.4% as disruptive.

Discussion

Since the publication of the WHO guidelines in 2009, there has been a global awareness about improving compliance in hand hygiene [6]. The description of the "five moments in hand hygiene" has helped to improve our understanding of the importance of hand hygiene for patient safety [8]. Many efforts have been undertaken to improve guideline compliance, especially before aseptic procedures [9], [10], [11], [12]. In this study, we achieved a significant increase in compliance to hand disinfection guidelines both before patient contact (46.3% increase) and before aseptic procedures (45.0% increase). Other studies have also reported significant rates of improvement for compliance in hand hygiene [13]. In addition, we also achieved significant improvements in compliance to the guidelines stating no palpation of the puncture site (33.0% increase) and use of sterile dressings to cover the puncture site (48.7% increase). These steps, which have a recommendation category of IA or IB, have not been studied before. In one department, sterile dressings were not easily available for the healthcare workers; this was discovered during the observation and discussion after the teaching session. The sterile dressings were made available, easily correcting a structural deficit.

Nevertheless, helping healthcare workers understand when the hand disinfection occurs in the workflow was not simple. This explains studies that evaluate how to improve processes such as chest tube dressing [14] or dialysis connection and disconnection [15]. Clinical procedures that are simple and straightforward provide an opportunity to prepare an SOP based on evidence-based guidelines. The principle is to help healthcare workers understand why steps should be done in a specific order and to help workers internalize the procedure so they can be done automatically. Five specific steps, done in an optimum order, were considered relevant to patient safety. Whenever two or more steps were observed, a significant increase in following the optimum order was found. Of interest, the optimum order for all five steps was 0% before the intervention and 100% after the intervention. This result indicated excellent internalization of the procedure by the healthcare workers. We could not determine which of the intervention components had the most impact on improvement; however, based on individual feedback after the observation, we propose that personal feedback by the study nurse was seen as helpful because it was support rather than control.

Examining data on the order of steps showed that the major mistake was early use of gloves, which resulted in healthcare workers thinking that hand disinfection before the aseptic procedure was not necessary. Donning gloves probably had two aims: self-protection (preventing possible contact with blood) and patient protection (from healthcare worker flora). In some departments, creating awareness that wearing a protective glove did not replace hand disinfection was difficult. However, improvement of the order of steps after the intervention indicated that many healthcare workers understood the need for hand disinfection. Most guidelines clearly recommend distinguishing hand disinfection from using protective gloves. Nonetheless, infectious complications after insertion of a peripheral venous catheter are equally low whether healthcare workers perform hand disinfection or put on gloves [16]. Therefore, donning gloves at the beginning of the procedure could be sufficient for patient safety. Thus, easing work processes for healthcare workers without jeopardizing patient safety could result in new possibilities and further evolution of evidence-based recommendations for aseptic procedures.

In this study, compliance from doctors was lower than from nurses. Doctors are described as having lower compliance to hand hygiene than nurses [11], [13]. Nevertheless, doctors also significantly improved in our study, indicating that behavior change is possible among different professional groups. Improving compliance among doctors might be particularly important because they often act as role models for other professional groups, especially in hand hygiene [17].

Improving processes by highlighting the correct practice for central venous catheter insertion and maintenance significantly reduces the incidence of primary bloodstream infections [18]. Patients receiving a peripheral venous catheter are also likely to benefit, probably to a lower extent. Our approach could be a blueprint for other patient-care activities that are closed procedures and can easily be standardized. More complex patient care activities are unlikely to be eligible for our approach.

Conclusions

A multimodal strategy to improve compliance with patient safety steps and performance of an optimum procedure was effective and was regarded as helpful by healthcare workers.

Notes

Competing interests

Claudia James and Prof. Dr. Günter Kampf are paid employees of Bode Chemie GmbH, Hamburg, Germany.

Authors' contributions

All authors designed the study, GR collected the data, GK and KG analyzed the data, GK wrote the manuscript, and all authors read and approved the final manuscript.

Acknowledgements

The study was funded with a restricted grant by the BODE SCIENCE CENTER, Bode Chemie GmbH, Hamburg, Germany. The sponsor participated in the study design, analysis and interpretation of data, writing of the manuscript and the decision to submit the manuscript for publication.

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Please cite as
Kampf G, Reise G, James C, Gittelbauer K, Gosch J, Alpers B. Improving patient safety during insertion of peripheral venous catheters: an observational intervention study. GMS Hyg Infect Control. 2013;8(2):Doc18.
DOI: 10.3205/dgkh000218, URN: urn:nbn:de:0183-dgkh0002183

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Published: *2013-11-06*