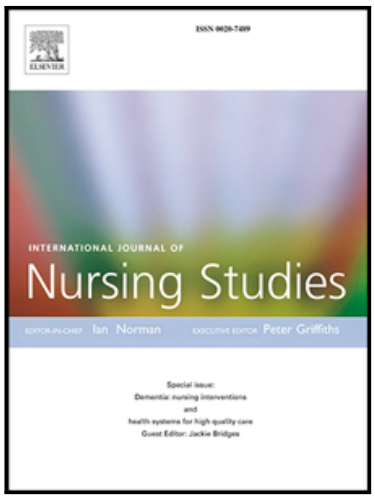

Peripheral intravenous catheter dressing and securement practice is associated with site complications and suboptimal dressing integrity: A secondary analysis of 40,637 catheters

Amanda Corley , Assoc Prof Amanda Ullman , Gabor Mihala , Dr Gillian Ray-Barruel , Dr Evan Alexandrou , Prof Claire Rickard

PII: S0020-7489(19)30216-0
DOI: https://doi.org/10.1016/j.ijnurstu.2019.103409
Reference: NS 103409

To appear in: *International Journal of Nursing Studies*

Received date: 3 May 2019
Revised date: 9 August 2019
Accepted date: 22 August 2019

Please cite this article as: Amanda Corley , Assoc Prof Amanda Ullman , Gabor Mihala , Dr Gillian Ray-Barruel , Dr Evan Alexandrou , Prof Claire Rickard , Peripheral intravenous catheter dressing and securement practice is associated with site complications and suboptimal dressing integrity: A secondary analysis of 40,637 catheters, *International Journal of Nursing Studies* (2019), doi: https://doi.org/10.1016/j.ijnurstu.2019.103409

Peripheral intravenous catheter dressing and securement practice is associated with site complications and suboptimal dressing integrity: a secondary analysis of 40,637 catheters.

Amanda Corley[a,b,c,d], Assoc Prof Amanda Ullman[a,b,d] a.ullman@griffith.edu.au; Gabor Mihala[a, f, g] g.mihala@griffith.edu.au, Dr Gillian Ray-Barruel[a, b, e] G.Ray-Barruel@griffith.edu.au, Dr Evan Alexandrou[a, h, i] E.Alexandrou@westernsydney.edu.au, Prof Claire Rickard[a, b, c, d] c.rickard@griffith.edu.au

[a]AVATAR Group, Menzies Health Institute QLD, Griffith University, 170 Kessels Rd, Nathan, 4111, Queensland, Australia

[b]School of Nursing and Midwifery, Griffith University, 170 Kessels Rd, Nathan, 4111, Queensland, Australia

[c]The Prince Charles Hospital, Rode Rd, Chermside, 4032, Queensland, Australia

[d]Centre of Clinical Nursing, Royal Brisbane and Women's Hospital, Butterfield St, Herston, 4006, Queensland, Australia

[e]QEII Jubilee Hospital, Kessels Rd & Troughton Rd, Coopers Plains, 4108, Queensland, Australia

[f]Centre for Applied Health Economics, Menzies Health Institute QLD, Griffith University, 170 Kessels Rd, Nathan, 4111, Queensland, Australia

[g]School of Medicine, Griffith University, 170 Kessels Rd, Nathan, 4111, Queensland, Australia

[h]Department of Intensive Care, Liverpool Hospital, 75 Elizabeth St, Liverpool, 2170, New South Wales, Australia

[i]School of Nursing and Midwifery, Western Sydney University, 161-169 Macquarie St, Parramatta, 2150, New South Wales, Australia

Corresponding Author

Amanda Corley

The Prince Charles Hospital

Level 3 CSB

Rode Road

Chermside QLD 4032 Australia

+61 7 3139 5772

a.corley@griffith.edu.au

@AVATAR_grp

Abstract

Background: With over 2 billion peripheral intravenous catheters used globally each year, avoiding complications is crucial for patients and healthcare organisations. Effective catheter dressing and securement is a key nursing strategy to reduce catheter failure and resultant patient harm.

Objectives: To describe global catheter dressing and securement practices and policy; and identify factors associated with catheter insertion site complications, and suboptimal dressing and securement.

Design: Secondary analysis of a global cross-sectional study of peripheral intravenous catheter characteristics, management and outcomes.

Setting: Four hundred and seven rural, regional and metropolitan hospitals in 51 countries

Participants: Paediatric and adult patients with 40,637 catheters.

Methods: Patient-, catheter-, and institution-related factors which could be associated with catheter site complications and suboptimal dressings were extracted from the parent database. Global trends in catheter dressing and securement policy and practice were described. Potential predictors of catheter and dressing complications were explored using logistic regression.

Results: Dressing and securement practices, and local hospital policy regarding dressing change frequency varied. One fifth of dressings (21%, n=8519) were not clean, dry and intact. The prevalence of catheter insertion site complications was 16% (n=6503), with signs of phlebitis commonly observed (11.5%, n=4,587). Compared to non-bordered polyurethane dressings, sterile gauze and tape dressings were associated with fewer insertion site complications (odds ratio 0.58, 95% confidence interval 0.50-0.68) and better dressing integrity (odds ratio 0.68; 95% confidence interval 0.59-0.77); whereas, compared with no securement, non-sterile tape at the insertion site was associated with more site complications (odds ratio 2.39, 95% confidence interval 2.22-2.57) and poorer dressing integrity (odds ratio 1.64, 95% confidence interval 1.51-1.75). Two 'bundled' dressing and securement combinations were associated with fewer site and dressing complications, when compared with the reference category. Local catheter care guidelines which advocate 4th hourly insertion site inspection and dressing replacement between 1-3 days were associated with better catheter dressing integrity.

Conclusion: Modifiable risk factors for peripheral intravenous catheter site and dressing complications were identified and are amendable to further interventional testing.

Keywords: Bandages; Catheterisation, Peripheral/adverse effects; Phlebitis/prevention and control; Polyurethanes/therapeutic use; Surgical tape.

Contribution of the Paper

What is already known about the topic?

- Peripheral intravenous catheters are the most commonly-used medical device in hospitalised patients however up to 69% require removal before therapy is complete.
- Optimal dressing and securement of peripheral catheterss is a key nursing strategy to reduce complications and failure.

What this paper adds:

- Peripheral intravenous catheters insertion site complications and suboptimal dressing integrity are prevalent globally.
- Non-sterile tape at the catheter insertion site is associated with significantly more insertion site complications and poorer dressing integrity, and should not be used.
- Two 'bundled' dressing and securement combinations were associated with fewer insertion site and dressing complications and are worthy of further investigation.

Introduction

Peripheral intravenous catheters deliver intravascular fluids and medications to hospitalised patients on a short-term basis. They are the most common medical device with up to 70% of inpatients requiring one or more during their hospital stay (1). Despite their importance and widespread use, up to 69% are removed before therapy is complete, due to dislodgement, phlebitis, occlusion, infiltration or infection (2-6). Catheter failure is an under-recognised patient safety issue and, as a result, is under-resourced. With over 2 billion peripheral intravenous catheters used globally each year, the impact of catheter failure on patients and healthcare organisations is substantial, and includes treatment delay; potentially avoidable pain and distress; increased morbidity from complications; and increased workloads and health care costs (7).

Effective catheter dressing and securement is a key nurse-led strategy to reduce complications and failure, but remains under-investigated. Optimal dressings and securements reduce complications by 1) anchoring the catheter to the skin, maintaining position in the vessel (8); 2) reducing micro-motion of the catheter, thereby minimising vessel wall irritation, thrombosis and occlusion, and entry of skin bacteria into the insertion wound (9-13) and 3) providing a physical barrier between the insertion site and environment, thus reducing microbial colonisation (14). Significantly more adverse events are experienced by patients with unclean dressings and poorly secured catheters (15). Furthermore, dressing disruption, due to poor durability and/or soiling, substantially increases the risk of catheter-related bloodstream infection (16). Evidence guiding clinicians on the most effective dressing and securement methods to prevent catheter failure and resultant patient harm is lacking (8), with a recent Cochrane review identifying a paucity of high-quality evidence informing practice and, hence, uncertainty remains (8).

Dressing and securement choice is a modifiable risk factor for catheter complications, and recent data indicates more than one fifth of dressings are soiled, wet and/or loose (17). Therefore, further examination of a large global data set of catheter insertion, management practices and outcomes (17) may assist in identifying which particular dressing and securement approaches modifies this risk. In this secondary data analysis, we sought to: describe global catheter dressing and securement practices and policy; investigate the relationship between cathetercomplications and insertion site dressings or securements; and identify risk factors associated with suboptimal catheter dressings. In doing so, we aim to inform clinical practice and guideline development, and generate robust hypotheses amenable to future interventional testing.

Materials and Methods

Study design and participants

We conducted a secondary analysis of data from a global cross-sectional study of adult and paediatric inpatients conducted between 1 June 2014 and 31 July 2015 (17). This study described peripheral intravenous catheter characteristics, insertion details, management practices and device outcomes. Ethical approval was gained from the Griffith University Human Research Ethics Committee (NRS/34/13/HREC). For each participating site, ethics committee or institutional review board approval was required prior to data collection. All patients with a catheter *in situ* on the study day and able to provide verbal consent were included.

Data were collected at both an individual hospital level (e.g. guidelines), and catheter level (e.g. device type), on purpose-designed data collection forms which had previously been internally and externally validated in a pilot study conducted in 13 countries (18). Internal validity testing of the data tools was initially undertaken amongst the authors of the pilot study and again once the pilot study results were reviewed. To strengthen reliability, data at each site was collected by medical or nursing staff who had previous experience with peripheral catheter site assessment and had been provided education on the study protocol and data collection forms. Additionally, after cleaning and collation, the collected data were returned to each participating site to confirm accuracy.

The secondary data analysis focused on dressing and securement data. Patient-, catheter-, and institution-related factors that could be associated with catheter and dressing complications were chosen *a priori* and subsequently extracted (Table 1). The selection of these factors was based on previous literature (15, 19-21) and international clinical practice guidelines (11, 22-24). Additionally, world regions were based on the United Nations geopolitical groupings (25) as well as World Health Organisation regional groupings (26) Some regions were broken down further (for example, the Pacific region into South Pacific, and Australia and New Zealand) due to the significant disparity of economic development amongst the countries within that region. It also helped to better describe variable characteristics as some countries contributed numerous hospitals and some only one. Each country was also classified according to the World Bank economic regions (27).

Patient- related factors	Peripheral intravenous catheter-related factors	Institution-related factors
• **Age (Adult/ Paediatric)** • **Gender** • **Ward/unit**	• Anatomical site • Inserter • Place of insertion • Dressing/s • Securement/s • Dressing integrity • Site assessment in last 24 hrs • Site assessment findings – No symptoms – Symptoms of complications (pain/tenderness on palpation, redness >1cm from insertion site, swelling>1cm from insertion site, purulence, itch/rash under dressing, blistering/skin tears under dressing, bruising/dried blood, palpable hard vein cord beyond intravenous tip, streak/red line along vein, induration/ hardness of tissues >1cm, leaking, extravasation/infiltration, partial/complete dislodgement)	• Geographic region • Economic region • Specialist intravenous team • Hospital guidelines regarding frequency of: – Catheter resite – Dressing change – Site assessment

Table 1. Variables analysed in secondary data analysis cm, centimetre.

The research questions guiding this analysis were:

1. What types of dressings and securements are used globally?
2. What recommendations are made in hospital guidelines regarding dressing change frequency?
3. What dressing and securement practices are associated with catheter site complications?
4. What patient-, catheter - and institutional- factors are associated with suboptimal dressing integrity?

The outcomes of interest in this analysis were: variations in global catheter dressing and securement practice and policy; site complications, defined by one or more of the signs or symptoms listed in Table 1; and suboptimal dressing integrity, defined as dressings which were wet, loose and/or soiled. Supplementary Table 1 details the potential predictors analysed by outcome of interest.

Additionally, four dressing and securement combinations commonly seen in clinical practice were formulated *a priori* ensuring compliance with current best practice guidelines and were analysed to determine any association with the outcomes of interest:

1. Transparent dressing, and sterile tape around catheter
2. Transparent dressing, and insertion site sutureless securement device
3. Transparent dressing, and (sterile tape around catheter *or* Non-sterile tape over dressing), & splint/bandage/tubular net
4. Sterile gauze & tape, and (sterile tape around catheter *or* non-sterile tape over dressing *or* non-sterile tape around admin. set *or* splint/bandage/tubular net)

Findings are reported as per the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (28).

Statistical analysis

Data management and analyses were performed using STATA (version 15.1, StataCorp, College Station, Texas). Relevant fields were extracted from the parent data set, and further data cleaning was performed as appropriate. The cohort's demographic and clinical characteristics were reported descriptively, appropriate to their distribution. Associations between peripheral intravenous catheter complications and dressing/securement type (excluding their combinations) were explored using univariable logistic regression; for associations between complications and dressing and securement combinations we used multivariable logistic regression, where the effects of potential patient-related predictors were tested (using the less than ± 10% change in effect size rule) (29). The associations between sub-optimal dressing integrity and patient-, catheter-, and institution-related factors were explored using univariable logistic regression. Results of logistic regressions were presented with odds ratios and 95% confidence intervals. The statistical significance level ($p<0.05$) was not adjusted for multiple comparisons, due to the exploratory nature of the research questions. Imputation for missing data was deemed not appropriate due to its non-random nature. The impact of individual catheter dressings and securements on the outcomes of complications and dressing integrity were also viewed in terms of clinical significance by way of an *a priori* minimally important difference set at 5%, a level which the investigators believe would be of benefit to patients with peripherally inserted catheters.

Results

For this secondary data analysis we included 407 rural, regional and metropolitan hospitals in 51 countries providing data on 40,637 peripheral intravenous catheters. The largest contributor of hospital sites was Australia (69 hospitals) with Spain and the United States of America having the most catheters (n=5,553, 14%; and n=5,048, 12% respectively). The mean age of patients was 55 years (standard deviation 25) with 51% being male. At the time of assessment, the median dwell time for those catheters with an insertion time documented was 1.5 days (interquartile range 1.0–2.5 days).

Global trends in dressing and securement practice

Globally, transparent polyurethane dressings covered 79% (n=31,968) of all catheters; 57% (n=23,087) simple polyurethane, and 22% (n=8,881) bordered polyurethane dressings. Hospitals in North America, Australia/New Zealand and the South Pacific had the highest incidence of transparent polyurethane dressings use at over 90%. One in six catheters (13%, n=5,169) were covered by non-sterile tape alone, most commonly in Asian and South American regions where it was the second most used dressing (n = 3,475, 33% of regional usage; and n=747, 31% of regional usage, respectively). Sterile gauze and tape dressings made up only 6% of global dressing usage, and were most commonly used in the South Pacific, Middle East and Europe. The use of chlorhexidine gluconate dressings or discs was limited (0.2% of global cathetersdressings).

The most common methods of catheter securement globally were sterile tape around the catheter hub (n=9938, 27%) and/or non-sterile tape over the primary dressing (n=9,243, 25%). In Australia/New Zealand and the Middle East, sterile tape around the hub secured almost half of the catheters (47% and 46% respectively). Insertion site sutureless securement devices were more popular in North American hospitals (n=1,084, 22%), compared with global usage of only 10% (n=3,699). One in five catheters globally were secured with non-sterile tape around the catheter hub, a practice more prevalent in Asian hospitals with almost half secured in this way (n=4,259, 46%). Splints, bandages or tubular nets were used to cover 14% of catheters (n=5087), more commonly in Europe and the South Pacific (n=3,262, 28%; and n=33, 26%, respectively). The primary dressing was the only securement method in 17% (n=6,205) of catheters globally.

Hospitals in low-income regions were less likely to use polyurethane dressings, particularly bordered dressings, than middle- to high-income countries (low income regions: n=125, 7% of regional dressing use, versus high income countries: n=7,593, 29% of regional use). Low-income countries were 18 times more likely to use non-sterile tapes as primary dressings, than high-income countries

(55% of regional securement use; versus 3%). Similarly, non-sterile tape around the catheter hub was uncommon in high-income regions (n=2,667, 11%), compared with over half of all catheter secured this way (n=890, 51%) in low income regions.

Non-sterile tape as securement around the catheter hub was also common in paediatric patients with nearly one third secured in this way (n=1,216, 31% of paediatric securement use) compared with only one fifth of catheters in adult patients (n=6,053, 19%). Paediatric patients were also more likely than adult patients to have tape alone securing their catheter (n=939, 22%; versus n=3,904, 11%, respectively) and also have a splint and/or bandage covering the catheter (n=1,258, 33%; versus n=3,762, 12%). Tables 2 and 3 provide more detail regarding variation in dressing and securement practices globally.

	Simple polyurethane dressings	Bordered polyurethane dressing	Non-sterile tape only	Sterile gauze & tape	Chlorhexidine Gluconate dressing
Frequency	23087 (57)	8881 (22)	5169 (13)	2604 (6)	98 (<1)
Geographical region					
Australia and New Zealand	4089 (70)	1654 (28)	29 (1)	49 (1)	3 (<1)
Asia	5211 (50)	830 (8)	3475 (33)	208 (2)	9 (<1)
Africa	1873 (67)	215 (8)	510 (18)	95 (3)	26 (1)
Middle East	312 (59)	102 (19)	33 (6)	84 (16)	0
Europe	7510 (57)	3218 (24)	340 (3)	2083 (16)	18 (<1)
North America	2841 (54)	2367 (45)	34 (1)	10 (<1)	31 (1)
South America	1138 (47)	482 (20)	747 (31)	49 (2)	11 (<1)
South Pacific	111 (85)	13 (10)	1 (0)	26 (20)	0
Economic region					
High-income	15616 (59)	7593 (29)	880 (3)	2198 (8)	52 (<1)
Middle-income	6811 (54)	1163 (9)	3335 (27)	402 (3)	44 (<1)
Lower-income	658 (38)	125 (7)	954 (55)	4 (<1)	2 (<1)
Age group					
Adult	20528 (58)	8136 (23)	3904 (11)	2313 (7)	87 (<1)
Paediatric	2221 (53)	601 (14)	939 (22)	254 (6)	9 (<1)
Catheter insertion site					
Antecubital veins	3384 (55)	1733 (28)	660 (11)	297 (5)	13 (<1)
Foot	451 (54)	117 (14)	188 (23)	36 (4)	1 (<1)
Forearm	7018 (55)	2770 (22)	1582 (13)	1081 (9)	38 (<1)
Hand	8183 (62)	2648 (20)	1453 (12)	713 (5)	26 (<1)
Neck / Head	71 (53)	14 (10)	41 (32)	6 (5)	0
Upper arm	817 (48)	400 (23)	301 (18)	151 (9)	6 (<1)
Wrist	2975 (54)	1137 (21)	909 (17)	299 (6)	12 (<1)
Inserted by					
Vascular access team	570 (56)	418 (41)	10 (1)	14 (1)	1 (<1)
Nurse	15371 (54)	5621 (20)	4635 (16)	2304 (8)	60 (<1)
Doctor	3931 (68)	1282 (22)	272 (5)	151 (3)	15 (<1)
Technician	458 (42)	446 (41)	121 (11)	19 (2)	8 (1)
Inserted in					
Ambulance	284 (53)	188 (36)	26 (5)	37 (7)	1 (<1)
Emergency department	4318 (58)	1909 (26)	646 (8)	475 (6)	15 (<1)
General Ward/Clinic	12202 (55)	4482 (20)	3425 (15)	1435 (7)	40 (<1)
Intensive/Coronary Care	1371 (54)	505 (20)	424 (17)	138 (5)	15 (<1)
Operating Room					
Radiology	2644 (60)	974 (22)	456 (10)	261 (6)	7 (<1)
	243 (54)	87 (20)	42 (9)	78 (17)	1 (<1)

Table 2. Variation in dressing type by region, patient- and peripheral intravenous catheter-factors (N=40 637). Frequencies and row percentages (%) shown. Frequencies may not add up to totals due to missing data for some variables. Row percentages may not add to 100% as not all results reported.

	Sterile tape around hub	Non-sterile tape around hub	Non-sterile tape over dressing	Insertion site sutureless securement device	Splint/ bandage/ tubular net	Non-sterile tape around administration set	Administration set securement device	Site dressing only
Frequency (%)	9938 (27)	7612 (21)	9243 (25)	3699 (10)	5087 (14)	5437 (15)	1203 (3)	6205 (17)
Geographical region								
Australia & New Zealand	2571 (47)	554 (10)	1354 (25)	254 (5)	720 (13)	534 (10)	74 (1)	1225 (22)
Asia	1098 (12)	4259 (46)	2473 (27)	1072 (12)	477 (5)	1131 (12)	423 (5)	904 (10)
Africa	859 (35)	391 (16)	145 (6)	357 (14)	212 (9)	108 (4)	269 (11)	678 (27)
Middle East	236 (46)	65 (13)	210 (41)	7 (1)	37 (7)	171 (33)	33 (7)	107 (21)
Europe	4435 (39)	984 (9)	2025 (18)	825 (7)	3262 (28)	1590 (14)	196 (2)	2042 (18)
North America	626 (13)	716 (14)	2338 (47)	1084 (22)	252 (5)	1081 (22)	183 (4)	722 (15)
South America	112 (5)	640 (28)	684 (30)	93 (4)	94 (4)	798 (35)	25 (1)	472 (21)
South Pacific	1 (1)	3 (2)	14 (11)	7 (6)	33 (26)	22 (17)	0	55 (43)
Economic region								
High-income	7735 (32)	2667 (11)	6346 (27)	2257 (9)	4425 (19)	3799 (16)	492 (2)	4408 (18)
Middle-income	2153 (20)	4055 (37)	2582 (24)	1051 (10)	616 (6)	1587 (15)	674 (6)	1746 (16)
Lower-income	50 (3)	890 (51)	315 (18)	391 (23)	46 (3)	49 (3)	37 (2)	51 (3)
Age								
Adult	9045 (28)	6053 (19)	7874 (25)	3285 (10)	3762 (12)	4838 (15)	1076 (3)	5816 (18)
Paediatric	759 (20)	1216 (31)	1238 (32)	337 (9)	1258 (33)	508 (13)	95 (3)	318 (8)
Catheter insertion site								
Antecubital Veins	1733 (31)	963 (17)	1356 (24)	500 (9)	555 (10)	785 (14)	109 (2)	1178 (21)
Foot	163 (21)	219 (29)	245 (32)	62 (8)	173 (23)	86 (11)	24 (3)	87 (11)
Forearm	2895 (26)	2229 (20)	2874 (26)	1138 (10)	1536 (14)	1838 (17)	312 (3)	1883 (17)
Hand	3375 (28)	2547 (21)	3007 (25)	1389 (11)	1861 (15)	1655 (14)	578 (5)	2001 (16)
Neck / Head	22 (18)	40 (32)	37 (30)	6 (5)	19 (15)	15 (12)	4 (3)	9 (7)
Upper arm	421 (27)	341 (22)	354 (23)	170 (11)	297 (19)	250 (16)	35 (2)	222 (14)
Wrist	1263 (26)	1214 (25)	1287 (26)	403 (8)	626 (13)	776 (16)	134 (3)	769 (16)

Inserted by								
Vascular Access Team	135 (14)	129 (13)	403 (41)	444 (45)	127 (13)	270 (27)	13 (1)	112 (11)
Nurse	6365 (25)	6239 (24)	6602 (26)	2524 (10)	3729 (15)	4156 (16)	768 (3)	3555 (14)
Doctor	1765 (33)	643 (12)	1055 (20)	349 (7)	713 (14)	490 (9)	342 (7)	1374 (26)
Technician	195 (20)	146 (15)	266 (28)	86 (9)	49 (5)	117 (12)	11 (1)	333 (35)
Inserted in								
Ambulance	128 (26)	65 (13)	116 (24)	38 (8)	72 (15)	83 (17)	6 (1)	122 (25)
Emergency department	2031 (30)	979 (14)	1691 (25)	665 (10)	949 (14)	1089 (16)	208 (3)	1399 (21)
General Ward/Clinic	4861 (24)	4910 (25)	5095 (26)	2083 (10)	3031 (15)	3026 (15)	785 (4)	2910 (15)
Intensive/Coronary Care	624 (28)	544 (24)	537 (24)	211 (9)	243 (11)	335 (15)	61 (3)	417 (18)
Operating Room								
Radiology	1221 (31)	638 (16)	1001 (25)	440 (11)	401 (10)	565 (14)	79 (2)	831 (21)
	138 (34)	80 (20)	123 (30)	20 (5)	56 (14)	57 (14)	9 (2)	62 (15)

Table 3. Variation in securement type by region, patient- and PIVC-factors (N = 40,637).

Frequencies and row percentages (%) shown. Frequencies may not add to totals due to missing data for some variables. Rows will add to > 100% as multiple securement options could be chosen for each catheter.

Hospital guideline recommendations regarding dressing change

Most participating hospitals had peripheral intravenous catheter insertion and maintenance guidelines for staff responsible for catheter care (95%, 375 hospitals) and 80% of these guidelines included a recommendation regarding frequency of dressing change (Supplementary Table 2). Nearly half of the guidelines recommended catheter dressings be changed as required (47%, 158 sites) rather than at a prescribed frequency. The next most frequent recommendation was to change catheter dressings every 72 hours and as required (19%, 65 sites) and 96 hours and as required (14%, 47 sites). Global recommendations regarding frequency of dressing change were fairly similar however hospital guidelines in Australia and New Zealand were more likely to recommend 72 hourly and as required changes than any other region.

Frequencies and row percentages (%) shown. Not all sites stating they had a guideline provided an answer regarding dressing change frequency.

Associations between dressing and securement products and peripheral intravenous catheter site complications

The overall prevalence of catheter site complications was 16% (n=6503). Signs of phlebitis were the most prevalent, with pain or tenderness observed in 8% of catheters assessed (n=3148), and redness and swelling evident in 2% (n=849) and 1.5% (n=590) respectively.

Table 4 details the association between dressings and securements, alone or in combination, with catheter insertion site complications. Using simple polyurethane dressings as the reference category, sterile gauze and tape dressings were associated with significantly fewer site complications (odds ratio 0.58, 95% confidence interval 0.50–0.68), specifically with less phlebitis symptoms, dislodgement and leaking from the catheter. In contrast, using non-sterile tape only as a primary dressing was associated with more site complications overall (odds ratio 2.39, 95% confidence interval 2.22–2.57), and in particular, phlebitis symptoms of pain (odds ratio 4.26, 95% confidence interval 3.90–4.65); streak along vein (odds ratio 4.09, 95% confidence interval 2.92–5.73); palpable hard vein cord (odds ratio 3.83, 95% confidence interval 2.89–5.07); swelling (odds ratio 2.13, 95% confidence interval 1.74–2.61); and redness (odds ratio 1.76, 95% confidence interval 1.47–2.12). Compared with simple polyurethane dressings, bordered polyurethane dressings were also significantly associated with more catheter site complications (odds ratio 1.18, 95% confidence interval 1.09–1.26).

An insertion site sutureless securement device was the only catheter securement method significantly associated with fewer overall site complications (odds ratio 0.77, 95% confidence

interval 0.66–0.90), particularly less bruising and dried blood around the insertion site and less dislodgement. Fewer catheter dislodgements were associated with placing sterile or non-sterile tape around the hub (odds ratio 0.52, 95% confidence interval 0.32–0.85; and odds ratio 0.37, 95% confidence interval 0.20–0.68, respectively), or non-sterile tape over the primary dressing (odds ratio 0.50, 95% confidence interval 0.29–0.87). Non-sterile tape around the catheter hub was significantly associated with more PIVC site complications (odds ratio 2.26, 95% confidence interval 2.06–2.47).

To assess the clinical significance of the association between dressing and securement products and site complications, overall complication rates were calculated by dressing and securement type. Gauze and tape dressings met the 5% minimally important difference limit, and were associated with a 7% reduction in site complications. The use of non-sterile tape as a dressing was associated with an increase in insertion site complications by 10%. No other dressing or securement type met the 5% minimally important difference limit.

Three of the four dressing and securement combinations were significantly associated with decreased catheter site complications compared with the reference combination (simple polyurethane plus non-sterile tape over the dressing). A sterile gauze and tape dressing used in conjunction with tapes or a tubular bandage was the least likely to be associated with site complications adjusted odds ratio 0.55, 95% confidence interval 0.44–0.68); with a transparent dressing (either simple or non bordered) plus sterile tape around the catheter hub (adjusted odds ratio 0.71, 95% confidence interval 0.62–0.81) or a insertion site sutureless securement device (adjusted odds ratio 0.57, 95% confidence interval 0.48–0.69) also significantly associated with fewer site complications. Specifically, these dressings and securement combinations were associated with fewer phlebitis symptoms; and less bruising and dried blood around the insertion site.

	n	Any clinical symptoms[a]	Pain or tender on palpation	Bruising or dried blood	Redness >1cm	Swelling >1cm	Leaking	Palpable hard vein cord	Part/complete dislodgement	Streak or red line in vein
Frequency		5,846	3,148	1,589	849	590	337	254	209	185
Dressing type alone										
Simple polyurethane dressing *	22,803									
Bordered polyurethane dressing	8,760	1.18 (1.09-1.26)	1.16 (1.05-1.28)	1.16 (1.04-1.31)	1.33 (1.12-1.57)	^	^	^	0.55 (0.37-0.81)	^
Non-sterile tape only	5,079	2.39 (2.22-2.57)	4.26 (3.90-4.65)	0.31 (0.24-0.40)	1.76 (1.47-2.12)	2.13 (1.74-2.61)	0.62 (0.42-0.91)	3.83 (2.89-5.07)	0.57 (0.35-0.93)	4.09 (2.92-5.73
Sterile gauze & tape	2,362	0.58 (0.50-0.68)	0.79 (0.64-0.96)	0.35 (0.25-0.49)	0.62 (0.42-0.92)	0.48 (0.29-0.81)	0.27 (0.12-0.62)	^	0.41 (0.18-0.92	^
Securement type alone										
No securement*	9,183									
Sterile tape around hub	5,890	^	^	^	^	^	^	^	0.52 (0.32-0.85)	2.74 (1.48-5.06)
Non-sterile tape around hub	5,066	2.26 (2.06-2.47)	4.11 (3.67-4.61)	0.41 (0.32-0.51)	1.44 (1.14-1.80)	2.08 (1.58-2.74)	^	4.62 (3.04-7.01)	0.37 (0.20-0.68)	5.83 (3.32-10.2)
Non-sterile tape over dressing	4,638	1.14 (1.03-1.27)	1.18 (1.01-1.37)	^	^	1.94 (1.46-2.58)	^	^	0.50 (0.29-0.87)	2.73 (1.43-5.20)
Insertion site sutureless securement device	2,149	0.77 (0.66-0.90)	^	0.55 (0.41-0.74)	^	^	^	^	0.34 (0.14-0.84)	^
Splint/bandage/tubular net	1,984	^	^	^	^	^	^	^	^	^
Non-sterile tape around administration set	1,614	1.32 (1.14-1.53)	1.67 (1.38-2.03)	^	^	1.59 (1.04-2.45)	^	2.21 (1.13-4.32)	^	5.01 (2.44-10.3)
Administration set securement device	784	^	^	0.48 (0.30-0.79)	^	^	^	2.66 (1.17-6.06)	^	^
Dressing & securement combinations		[b]		[b]						
Simple polyurethane dressing & Non-sterile tape over dressing*	2,771									
Simple or bordered polyurethane dressing, & sterile tape around hub	5,583	0.71 (0.62-0.81)	^	0.62 (0.50-0.78)	0.72 (0.53-0.98)	0.47 (0.33-0.68)	^	^	^	^
Simple or bordered polyurethane dressing, & insertion site sutureless seurement device	2,075	0.57 (0.48-0.69)	^	0.44 (0.32-0.62)	0.61 (0.41-0.93)	0.48 (0.29-0.78)	0.48 (0.25-0.94)	^	^	^
Simple or bordered polyurethane dressing, **&** sterile tape around hub *or* non-sterile tape over dressing, **&** splint/bandage/tubular										

net	1,945	^	^	^	0.62 (0.40-0.94)	0.44 (0.26-0.74)	^	0.27 (0.08-0.91)	^	^
Sterile gauze & tape, **&** sterile tape around hub *or* non-sterile tape over dressing *or* non-sterile tape around administration set *or* splint/bandage/tubular net	1,174	0.55 (0.44-0.68)	^	0.32 (0.21-0.50)	0.56 (0.33-0.95)	0.42 (0.22-0.80)	0.21 (0.07-0.69)	^	^	^

Table 4. Peripheral intravenous catheter insertion site symptoms and their associations with dressings and securements.

Unadjusted odds ratios & confidence intervals shown unless otherwise noted; cm, centimetre; *, reference category; ^ not significant at p≥0.05; [a] any complication listed in this table (infrequently experienced complications [i.e. n≤150] were not included in this column i.e extravasation/infiltration, itch/rash under dressing, induration/hardness of tissues >1cm, blistering/skin tears under dressing and purulence); [b] adjusted for age.

Variables associated with suboptimal dressing integrity

Over one fifth of catheter dressings (21%, n=8519) were not clean, dry and intact at the time of assessment, with 9% (n=3451) having loose or lifting edges and a 9% soiled with blood or other discharge. Univariate analysis of potential risk factors for suboptimal dressing integrity (Table 5) demonstrated that sterile gauze and tape dressings were associated with the fewest dressing complications (odds ratio 0.68, 95% confidence interval 0.59–0.77). Non-sterile tape used as a primary dressing was found least likely to be clean, dry and intact (odds ratio 2.01, 95% confidence interval 1.87–2.16). Similarly, non-sterile tape used to secure around the catheter hub was most associated with poor dressing integrity (odds ratio 1.64, 95% confidence interval 1.51–1.75). Securement methods significantly associated with clean, dry and intact dressings were an insertion site sutureless securement device (odds ratio 0.65, 95% confidence interval 0.56–0.75) or administration set securement device (odds ratio 0.63, 95% confidence interval 0.50–0.79). Two of the four dressing and securement combinations were associated with optimal dressing condition (a transparent polyurethane dressing and insertion site sutureless securement device [odds ratio 0.57, 95% confidence interval 0.48–0.67]; and a sterile gauze and tape dressing used in conjunction with tapes or a tubular bandage [odds ratio 0.88, 95% confidence interval 0.78–0.99).

The use of sterile gauze and tape dressings and sutureless securement devices met the 5% minimally important difference limit and were less associated with poor dressing integrity by 5.5% and 5.2% respectively from the cohort average of 21.1%. Non-sterile tape use, whether as a primary dressing or as a securement method around the catheter hub, was associated with greater likelihood of poor dressing integrity by 9% and 5.1% respectively.

Potentially modifiable risk factors associated with suboptimal dressings were catheter placement in the antecubital fossa (odds ratio 1.84, 95% CI 1.28–1.71) or wrist (odds ratio 1.47, 95% confidence interval1.35–1.59); catheter inserted in the ambulance (odds ratio 1.84, 95% confidence interval 1.52–2.24); no catheter insertion and maintenance guidelines (odds ratio 2.58, 95% confidence interval 2.38–2.81); and no documented site assessment within the last 24 hours (odds ratio 1.63, 95% confidence interval 1.54–1.72). Factors protective of suboptimal dressing condition were: insertion by a specialist vascular access team (odds ratio 0.63, 95% confidence interval 0.52–0.76); insertion in a critical care unit (odds ratio 0.75, 95% confidence interval 0.66–0.84); and non-clinically indicated catheter resiting (odds ratio 0.36, 95% confidence interval 0.32–0.40; to odds ratio 0.59, 95% confidence interval 0.46–0.75). Non-modifiable factors associated with poor dressing integrity included male sex and increasing age (odds ratio 1.26, 95% confidence interval 1.12–1.41

for 19-39 year olds; compared with odds ratio 1.89, 95% confidence interval 1.60–2.22 for ≥90 years).

	n	Odds ratio (95% Confidence interval)
Dressing type alone		
Simple polyurethane dressing *	21,918	-
Bordered polyurethane dressing	8,574	1.17 (1.09-1.25)
Non-sterile tape only	4,965	2.01 (1.87-2.16)
Sterile gauze & tape	2,316	0.68 (0.59-0.77)
Securement type alone		
No securement *	8,968	-
Sterile tape around hub	5,702	-
Non-sterile tape around hub	4,921	1.64 (1.51-1.75)
Non-sterile tape over dressing	4,504	1.12 (1.03-1.23)
Insertion site sutureless securement device	2,094	0.65 (0.56-0.75)
Splint/bandage/tubular net	1,915	-
Non-sterile tape around administration set	1,578	-
Administration set securement device	756	0.63 (0.50-0.79)
Dressing & securement combinations		
Simple polyurethane dressing & non-sterile tape over dressing *	2,670	-
Simple or bordered polyurethane dressing, & sterile tape around hub	5,411	0.88 (0.78-0.99)
Simple or bordered polyurethane dressing, & insertion site sutureless securement device	2,025	0.57 (0.48-0.67)
Simple or bordered polyurethane dressing, **&** sterile tape around hub *or* non-sterile tape over dressing **&** Splint/bandage/tubular net	1,883	-
Sterile gauze & tape, **&** sterile tape around hub *or* non-sterile tape over dressing *or* non-sterile tape around administration set *or* splint/bandage/tubular net	1,150	-
Age group		
0 to 18 years *	4,206	-
19 to 39 years	6,389	1.26 (1.12-1.41)
40 to 59 years	8,970	1.34 (1.21-1.49)
60 to 89 years	17,926	1.62 (1.47-1.78)
90 years & above	1,226	1.89 (1.60- 2.22)
Female gender:		
Male *	19,757	-
Female	19,066	0.88 (0.84-0.93)
Inserted in:		
Hand *	12,718	-
Forearm	12,195	-
Antecubital fossa	5,979	1.84 (1.28-1.71)

Wrist	5,269	1.47 (1.35-1.59)
Upper arm	1,654	-
Foot	796	0.73 (0.58-0.90)
Inserted by:		
Nurse *	27,497	-
Doctor	5,470	-
Technician	1,068	1.48 (1.28-1.71)
Vascular access team	1,001	0.63 (0.52-0.76)
Inserted at:		
Ward *	21,407	-
Emergency department	7,140	1.24 (1.16-1.32)
Operating room	4,248	-
Intensive or critical care unit	2,469	0.75 (0.66-0.84)
Ambulance	513	1.84 (1.52-2.24)
Radiology/procedure room	436	-
PIVC insertion/maintenance guideline:		
Exists *	28,696	-
Does not exist	2,815	2.58 (2.38-2.81)
PIVC replacement frequency in guideline:		
Clinically indicated *	2,815	-
At every 24 to 72 hours	6,403	0.36 (0.32-0.40)
At every 72 to 96 hours	12,857	0.37 (0.34-0.41)
At every 96 or more hours	403	0.59 (0.46-0.75)
Dressing replacement frequency in guideline:		
As needed*	10,243	-
At every 24 to 72 hours	2,838	0.80 (0.71-0.90)
At every 72 to 96 hours	8,245	-
At every 96 or more hours	1,504	1.53 (1.35-1.75)
Site assessment frequency in guideline		
At every time catheter is used *	1,966	-
At every 4 hours	3,295	0.84 (0.72-0.98)
At every 8-12 hours	11,032	1.34 (1.18-1.53)
Once a day	2,912	-
Site assessment in last 24 hours		
Yes*	21,168	-
No	14,289	1.63 (1.54-1.72)

Table 5. Suboptimal dressing integrity and association (unadjusted) with selected patient-, peripheral intravenous catheter-, and institution-related factors

*, reference category; -, not significant at p≥0.05, or cannot be calculated.

Discussion

This secondary data analysis of a global cross-sectional study of 40,637 peripheral intravenous catheters reveals much about global dressing and securement practice and policy; the role of dressing and securement products on the development of catheter site complications; and also which products and practices are associated with poor dressing integrity. Concerningly, insertion site complications were evident in 16% of catheters and suboptimal dressing integrity affected over one in five catheters. Using non-sterile tape at the catheter insertion site was found to be a patient safety risk, associated with increased likelihood of catheter site and dressing complications. Sterile gauze and tape dressings were infrequently used but were least associated with site complications and most likely to be intact. Of interest, dressing and securement combinations (or bundles) were associated with fewer site and dressing complications and could be amenable to testing in future research.

Variation existed in dressing and securement practice globally. Transparent polyurethane dressings were the most frequent method to cover peripheral catheters yet low income regions used them least, choosing to use non-sterile tape only to secure the catheter, a decision likely driven by cost. However, paediatric patients were twice as likely to have non-sterile tape securing their catheter compared with adult patients, exposing this population to increased risk of infection (30). The use of chlorhexidine gluconate-impregnated products, shown to reduce catheter-related bloodstream infections in central venous access devices (31), was very low with only 0.2% of catheters dressed with these dressings. Clinical practice variation across the 51 countries providing data to this analysis may reflect the lack of robust evidence-based recommendations informing peripheral intravenous catheter dressing and securement international guidelines (11, 22-24). Further high quality research testing is urgently needed to inform safe and effective practice globally.

Given the relatively short median dwell time (1.5 days, interquartile range 1-2.5) of the catheters analysed, a concerning number of complications were identified (16%) with phlebitis symptoms noted in 11.5% of catheters. The application of non-sterile tape in direct contact with the catheter insertion wound was a likely contributing factor to these complications. This practice resulted in: 4-fold higher odds of pain and tenderness at the insertion site, the development of a palpable vein cord, and the presence of a streak or red line along the vein; and double the odds of insertion site swelling. Non-sterile tape is a vector for microorganisms (30, 32, 33), substantially increasing risk of insertion site and bloodstream infection. Alarmingly, 1 in 10 catheters in this study was covered with non-sterile tape alone, and 1 in 5 was secured with non-sterile tape under the primary dressing,

practices more widespread in paediatric settings and lower income countries. While non-sterile tape is attractively cheaper, the potential harm imposed on patients by this practice outweighs any short-term economic advantage. Placing non-sterile tape at the insertion site is at odds with current global clinical practice guidelines (11, 22-24) and should not be a part of modern evidenced-based nursing practice.

Dressings and securements associated with fewer peripheral intravenous catheter site complications were simple polyurethane dressings, sterile gauze and tape dressings, an insertion site sutureless securement device, and an administration set securement device. A recent randomised controlled trial found simple polyurethane dressings to be as effective as other more advanced dressing and securement types, and considerably less expensive (34). Therefore, simple polyurethane is a viable catheter site dressing option, in the absence of evidence regarding a superior alternative. Whilst only used for a small proportion of catheters (6%), sterile gauze and tape dressings were associated with fewer site complications and better dressing integrity than any other dressing or securement product analysed in this study. Early studies found sterile gauze and tape at least as effective as transparent dressings in preventing infection (35, 36) however no recent randomised controlled trial have assessed its clinical- or cost-effectiveness compared to more contemporary dressing and securement options. Importantly though, the lower rate of site complications observed with gauze and tape dressings may be due to assessors' inability to visualise complications (particularly redness, swelling, bruising, and itch/rash under the dressing) as the insertion site and surrounding area was obscured by the opaque dressing. Global practice guidelines (11, 22-24) advocate insertion site visualisation so clinicians can easily observe, detect and act on complications early. Testing of this dressing type in a rigorous study would require frequent dressing changes (i.e. at least second daily), particularly in patients who cannot indicate pain or tenderness at the insertion site which is an early and reliable sign of phlebitis (37, 38).

Of concern, one in five of the included catheters was covered with a dressing which was damp, soiled and/or loose. Ensuring clean, dry and intact catheter dressings assists in preventing complications by maintaining sterility underneath the dressing, as well as catheter securement to prevent micro-motion or pistoning (39, 40). There is clearly an opportunity for practice improvement though education regarding the importance of optimal dressing integrity and the role it plays in ensuring safe care for patients with peripheral intravenous catheters. A number of modifiable factors were associated with poor dressing integrity. Non-sterile tape as a method of dressing and/or securement was associated with poorer dressing integrity and should not be used.

Documentation of insertion site assessment less often than once per day, an institution-related factor affecting care, was strongly associated with suboptimal dressing integrity. Furthermore, the presence of a hospital guideline regarding catheter maintenance and care and, more specifically, one which advocates site assessment more frequently than once per shift (i.e. more than every 8-12 hours) was significantly associated with better dressing integrity. This finding highlights the importance of regular catheter assessment by nurses, particularly with a validated evidence-based tool which prompts timely removal and identification of complications (41).

Peripheral intravenous catheters inserted by a vascular access specialist were less likely to have soiled or damaged dressings. There is emerging evidence regarding the benefits of catheter insertion by a specialist in achieving first insertion attempt success and preventing catheter failure (42) and our findings confirm that investment by hospitals in such a service improves patient safety by reducing dressing complications, and ultimately complications overall. Dressings were more likely to be clean, dry and intact if the catheter was routinely replaced (that is, when not clinically indicated, most commonly at 72 hours) rather than replaced when clinically indicated (5). This suggests that in hospitals which replace catheters when clinically indicated, rather than routinely, local guidelines should emphasize that dressings too should be changed when clinically indicated (when soiled, wet or loose). Conversely, catheters inserted in the ambulance setting or emergency department were associated with poorer dressing integrity, echoing the findings of a previous study (20) and likely reflecting the emergent nature of insertion. Efforts to improve dressing integrity and durability should, where possible, begin in the pre-hospital and emergency settings to prevent subsequent catheter complications.

The poor durability of current peripheral dressing regimes is supported by data that demonstrates that up to two-thirds require additional reinforcement to prolong longevity (20, 34). However, the use of tapes and additional securements may mitigate some of the frequently experienced complications which ultimately lead to catheter failure (15, 20). A recent study has shown that any additional reinforcement to the primary PIVC dressing was significantly associated with less occlusion, phlebitis and dislodgement, regardless of this being tape, secondary dressings or bandages/splints (20). Three of the four dressing and securement bundles tested in our study were significantly associated with fewer insertion site complications, particularly phlebitis symptoms; and two of the four were associated with less disruption to dressing integrity. In addition to existing evidence (15, 20), this finding provides further support that a bundled approach to dressing and securement may be worthy of testing in a randomised study. Indeed, a recent 4-arm randomised controlled trial which failed to establish a superior peripheral intravenous catheter dressing and

securement method recommended that multiproduct dressing and securement combinations (securement bundles) should be assessed for their effect on catheter failure rates (34). Vascular access device insertion and maintenance bundles are effective in reducing catheter-related bloodstream infection and phlebitis (43-45). A bundled securement intervention could be a simple and inexpensive method of enhancing dressing durability and reducing catheter failure, but requires testing to determine clinical- and cost-effectiveness.

Despite the data from this analysis being sourced from the largest prospectively-collected data set of peripheral intravenous catheter insertion and maintenance practices and catheter site outcomes, there are limitations. Firstly, the cross-sectional study design of the parent study (17) and the collection of data at one time point only did not allow for follow-up on outcomes therefore catheter site outcomes are limited to those seen on the data collection day. Secondly, causality for outcomes cannot be determined in a cross-sectional study. Thirdly, despite enrolling sites from 51 countries from a mix of metropolitan, regional and remote settings, the study cohort may not be truly representative of global population of hospitalised patients with a catheter *in situ*.

Conclusion

Many peripheral intravenous catheters had complications present, in addition to suboptimal dressings. Non-sterile tape use at the insertion site was identified as a risk factor for catheter insertion site and dressing complications and this practice should not occur. Sterile gauze and tape dressings, securement devices, catheter insertion by a vascular access specialist, and the presence of hospital catheter guidelines were among factors found to be protective of complications. The concept of peripheral intravenous catheter dressing and securement bundles appears promising but requires rigorous testing to determine their impact on failure rates which continue to be an under-recognised cause of significant patient harm.

Conflicts of interest statement

None

Acknowledgments

We would like to acknowledge the One Million Global Peripheral Intravenous Catheter (OMG PIVC) study team for the original concept and study design (Niall Higgins, Steven Frost, Peter Carr, Sheila Inwood, Frances Lin, Laura Alberto and Leonard Mermel); BD and 3M for their unrestricted funding support for the parent OMG study, and BBraun for study documents translation support for the

parent OMG study. We would also like to thank the staff and patients of the participating hospitals for contributing to the OMG PIVC study.

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