

Skin Glue Reduces the Failure Rate of Emergency Department–Inserted Peripheral Intravenous Catheters: A Randomized Controlled Trial

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Study objective: Peripheral intravenous catheters are the most common invasive device in health care yet have very high failure rates. We investigate whether the failure rate could be reduced by the addition of skin glue to standard peripheral intravenous catheter care.

Methods: We conducted a single-site, 2-arm, nonblinded, randomized, controlled trial of 380 peripheral intravenous catheters inserted into 360 adult patients. The standard care group received standard securement. The skin glue group received standard securement plus cyanoacrylate skin glue applied to the skin insertion site. The primary outcome was peripheral intravenous catheter failure at 48 hours, regardless of cause. Secondary outcomes were the individual modes of peripheral intravenous catheter failure: infection, phlebitis, occlusion, or dislodgement.

Results: Peripheral intravenous catheter failure was 10% lower (95% confidence interval -18% to -2%; $P=.02$) with skin glue (17%) than standard care (27%), and dislodgement was 7% lower (95% confidence interval -13% to 0%; $P=.04$). Phlebitis and occlusion were less with skin glue but were not statistically significant. There were no infections.

Conclusion: This study supports the use of skin glue in addition to standard care to reduce peripheral intravenous catheter failure rates for adult emergency department patients admitted to the hospital. [Ann Emerg Med. 2016;■:1-6.]

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INTRODUCTION

Background

Peripheral intravenous catheters are the most commonly used medical invasive device in hospitals today, inserted in up to 80% of all hospitalized patients during their stay and frequently initiated in the emergency department (ED).^{1,2} Premature device failure is reported to occur in 33% to 69% of devices because of infection, phlebitis, occlusion, or dislodgement.³ A major contributing factor to device failure is inadequate fixation of the peripheral intravenous catheter to the patient's skin, causing not just dislodgement but also micromotion, leading to vein irritation (phlebitis or occlusion) and entry of skin bacteria into the entry site (infection).³ Peripheral intravenous catheter failure frequently occurs after 48 hours postinsertion, suggesting that improvements in securement can be targeted at this timeframe. Borderless polyurethane transparent dressings have typically been used to secure peripheral intravenous catheters, although alternative products such as cloth-bordered polyurethane dressings and commercial

securement devices are becoming more prevalent. Despite this, a recent Cochrane review concluded that there is a lack of high-quality evidence and continued uncertainty about the best methods to dress and secure peripheral intravenous catheters.³

A novel approach for improved peripheral intravenous catheter fixation is the use of medical-grade skin glue (cyanoacrylate) at the insertion site. Skin glue has been reported to be effective for securing central venous, epidural, and peripheral arterial catheters, with improved fixation compared with standard polyurethane dressings.⁴⁻⁸ The arterial catheter failure rate was reported in 2 randomized pilot studies to decrease from 21% to 11%⁷ and from 20% to 6%⁸ when skin glue was used. A pilot study of peripheral intravenous catheters inserted in a ward setting showed a reduction in failure rates from 38% to 14%.⁹ In addition, cyanoacrylate has antimicrobial properties; in vitro testing shows direct inhibition of Gram-positive organisms, suggesting potential benefit in preventing infection.^{6,10} A large trial in an ED setting,

Editor's Capsule Summary*What is already known on this topic*

Peripheral intravenous catheters are commonly inserted in the emergency department (ED) but often fail later from dislodgement, phlebitis, or other causes.

What question this study addressed

Does the use of a skin adhesive glue to secure a peripheral intravenous line improve failure rates compared with standard securing measures?

What this study adds to our knowledge

In this randomized trial of 380 intravenous line ED insertions, addition of skin adhesive glue decreased catheter dislodgement (7% less) and overall failure (10% less) at 48 hours compared with standard approaches, and without harm.

How this is relevant to clinical practice

Adding a drop of adhesive helps peripheral intravenous catheter stabilization, though the cost-effectiveness depends on the adhesive chosen.

comparing skin glue with the current best evidence comparator, was needed to clarify the potential role of skin glue with peripheral intravenous catheters.

Importance

Peripheral intravenous catheter failure is associated with disruption to therapy such as hydration, antibiotics, and analgesia, as well as the increased cost, anxiety, and discomfort of reinsertion. Costs to the health system include increased staff time, consumables, hospital length of stay, and adverse event management. Given that more than 100 million peripheral intravenous catheters are inserted every year in the United States alone, a small reduction in device failure will translate to a large improvement in care, outcomes, flow, and costs.¹ Systemic sepsis caused by peripheral intravenous catheter infection occurs in less than 0.1% of peripheral intravenous catheters, but the subsequent effect on morbidity, mortality, and hospital costs is large, such that small reductions in these infections are important.^{11,12}

Goals of This Investigation

We hypothesized that the addition of skin glue to the insertion site of peripheral intravenous catheters in the ED would reduce the device failure rate at 48 hours.

MATERIALS AND METHODS**Study Design and Setting**

We conducted a single-site, 2-arm, nonblinded, randomized, controlled trial of superiority from November 2012 to March 2013. Enrollment was rapid initially and at the end of this period but was halted in between by a funding interruption. Caboolture Hospital is a 160-bed community hospital 50 km north of Brisbane, with 52,000 ED presentations annually. Approval was obtained from the hospital human research ethics committee before commencement, and the trial was prospectively registered with the Australian and New Zealand Clinical Trials Registry.

Selection of Participants

Screening of eligible patients by one of 3 trained ED research nurses occurred 16 hours per day, 7 days a week. Screening took place only after a patient was identified as requiring hospital admission to exclude those being discharged home from the ED. Patients were eligible for enrollment if they were aged 18 years or older, had a patent upper limb peripheral intravenous catheter inserted through healthy intact skin by an emergency physician or ED nurse, and gave written informed consent. Peripheral intravenous catheter patency was confirmed by a 10-mL 0.9% saline solution flush. Exclusion criteria were known allergy or irritation to skin glue or standard peripheral intravenous catheter securement material; presence of infection near the peripheral intravenous catheter, upper limb phlebitis, or venous thrombosis; high likelihood of intentional peripheral intravenous catheter removal (eg, agitated patients); and non-English-speaking patients without an interpreter.

Interventions

All patients had their preexisting peripheral intravenous catheter dressing and anchoring tapes carefully removed by the research nurse. Patients were then randomized with Randomizer for Clinical Trials software (Medsharing, Fontenay-sous-Bois, France) in a 1:1 ratio, with no blocking or stratification, to either standard peripheral intravenous catheter securement (standard care group) or standard peripheral intravenous catheter securement plus the addition of skin glue to the peripheral intravenous catheter insertion site (skin glue group).

Patients in the standard care group received peripheral intravenous catheter securement with cloth-bordered transparent polyurethane dressing and tape (Tegaderm IV Transparent Film Dressing 1633; 3M, St Paul, MN). The dressing was labeled with the time, date, and study name (Figure 1).

Patients in the skin glue group received 1 drop of cyanoacrylate glue (single-use Histoacryl; B Braun, Melsungen, Germany) at the peripheral intravenous catheter skin insertion site and 1 drop under the peripheral intravenous catheter hub (Figure 2; Video 1, available online at <https://youtu.be/DEW8mNLzw8A>). The glue was allowed to dry (<30 seconds), and then peripheral intravenous catheter tape and dressing were applied in a manner identical to that for the standard care group. Blinding was not possible because of the subtle glue color and appearance present at intervention and follow-up.

Methods of Measurement

All peripheral intravenous catheters were BD Insyte Autoguard (Becton Dickinson & Company, Franklin Lakes, NJ), inserted after skin cleansing with Solu-I.V. swabs (2% chlorhexidine, 70% alcohol; Solumed, Quebec, Canada). Ongoing care of the peripheral intravenous catheter was in accordance with the Queensland Department of Health state guideline.¹³ Skin glue was easily removed before peripheral intravenous catheter removal by use of commercial adhesive removal wipes (Uni-Solve; Smith & Nephew, Hull) (Video 2, available online at https://youtu.be/_LJ5YzL3sXc).

Baseline demographic and possible confounder details were collected at enrollment (Table 1). Anticoagulation was defined as the use of warfarin or novel oral anticoagulants. Antibiotic use included any oral or intravenous antibiotics administered from the day preceding enrollment through follow-up at 48 hours. Immunosuppression was defined as the presence of words related to “neutropenia” or “immunosuppression” in the clinical record.



Figure 1. Securement with transparent cloth-bordered polyurethane dressing and tape applied to all study participants.

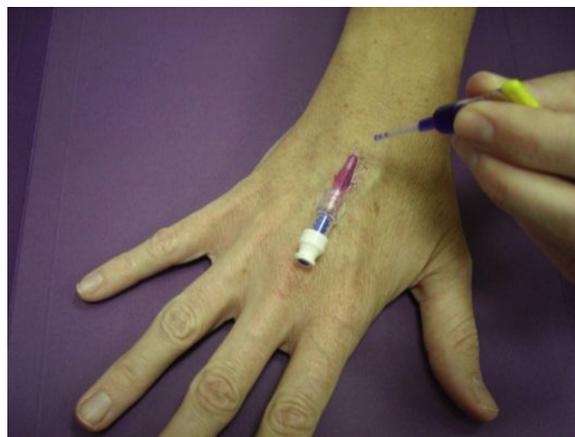


Figure 2. Application of skin glue: 1 drop to the skin insertion site and 1 drop under the peripheral intravenous catheter hub.

Outcome Measures

The primary outcome was peripheral intravenous catheter failure at 48 hours, defined as a composite of one or more of infection, phlebitis, occlusion, or dislodgement. This composite outcome was considered the most meaningful from the patient’s perspective because he or she is concerned more with the fact that the device failed than how it failed. Consistent with related studies, the following definitions were applied: infection, clinical impression of cellulitis or pus at the peripheral intravenous catheter site; phlebitis, 2 or more symptoms of pain, redness, swelling, or palpable venous cord; occlusion, inability to flush 10 mL of

Table 1. Patient and PIVC characteristics.

Number of Patients (n=360)	Standard Care 184	Skin Glue 176
Age, mean, y	57	60
Women	83	82
Immunosuppressed	1	1
Anticoagulated	14	19
Antibiotics	58	61
INR ≥ 1.5	0	2
Number of PIVCs (n=380)	195	185
Right side of body	118	91
Inserted by physician	128	137
Insertion site		
Antecubital	119	96
Dorsum of hand	54	52
Forearm	22	37
PIVC gauge		
14	0	2
16	1	0
18	54	47
20	128	120
22	5	9
24	7	7
Hours from insertion to intervention, median	3.8	3.6
Hours from intervention to follow-up, median	47	48

INR, International normalized ratio; PIVC, peripheral intravenous catheter.

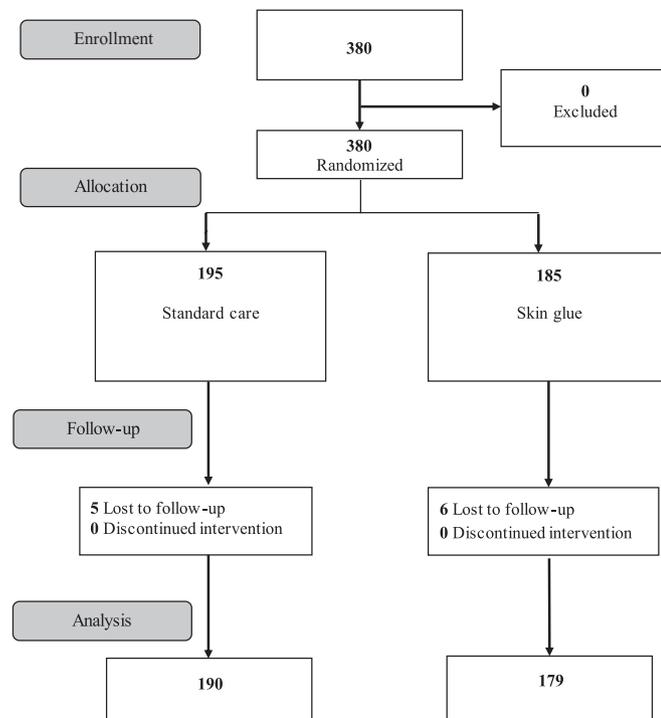


Figure 3. Tracking of study devices.

0.9% saline solution or history of peripheral intravenous catheter removed because “it was not working”; and dislodgement, subcutaneous extravasation or history of “it fell out.”^{14,15} Outcomes were assessed by the research nurses either in person (if the patient was still in the hospital) or by telephone if the patient was already discharged (no direct visualization possible) at 48 hours or more after enrollment (Table 1).¹⁶ Replacement of the peripheral intravenous catheter during the initial 48 hours for any reason was considered a device failure. Secondary outcomes were the individual modes of peripheral intravenous catheter failure: infection, phlebitis, occlusion, and dislodgement. These were identified by a combination of direct visualization, chart review, and standard patient questionnaire.

Primary Data Analysis

The sample size of 174 patients per group was determined by assuming a single peripheral intravenous catheter per patient and hypothesizing rates of 11% and 4% peripheral intravenous catheter failure in the control and intervention groups, respectively, with 80% power ($\alpha=.05$). All data were entered directly into a portable tablet at collection (iPad; Apple, Cupertino, CA) with Form Connect software (v1.5.4; Form Connections, Laguna Niguel, CA) and then exported into Stata (version 12.1; StataCorp, College Station, TX). Peripheral intravenous catheter devices were the unit of measurement

and analysis was by intention to treat. Time until intervention was calculated as the time from original peripheral intravenous catheter insertion until application of study peripheral intravenous catheter dressing.

Given the low rate of loss to follow-up (2.8% per device; 0.83% per patient) and similar occurrence in both groups, only those devices or patients with complete outcome data were included in the analyses. Absolute differences of outcome rates were calculated with 95% confidence intervals. Statistical significance was declared at $P<.05$.

Given that there were multiple devices observed for some patients, per-patient analyses were also undertaken according to the patient’s first peripheral intravenous catheter.

RESULTS

Characteristics of Study Subjects

A total of 380 peripheral intravenous catheter devices (360 patients) were both enrolled and allocated. There was no discontinuation or crossover, 11 patients were lost to follow-up, and data for 369 patients were analyzed (Figure 3).

Main Results

Peripheral intravenous catheter failure was 17% in the skin glue group versus 27% with standard care ($\Delta=-10\%$; 95% confidence interval -18% to -2% ; $P=.02$). The secondary outcome of peripheral intravenous catheter failure by dislodgement was 7% less frequent (95% confidence interval -13% to 0) in the skin glue group (7.0%) versus standard care (14%). Peripheral intravenous catheter failure by phlebitis and occlusion were similar in both groups. There were no peripheral intravenous catheter failures caused by infection (Table 2).

The per-patient analysis yielded similar results for both the primary and secondary outcomes in the skin glue ($n=170$) and standard care ($n=179$) groups (infection, phlebitis, occlusion, or dislodgement failures 28 versus 51, infection 0 versus 0, phlebitis 5 versus 9, occlusion 14 versus 20, and dislodgement 12 versus 25).

Table 2. Results of primary and secondary outcomes.

	Standard Care, No. (%)	Skin Glue, No. (%)	Difference (95% CI), %
Primary outcome			
PIVC failure	52 (27)	31 (17)	-10 (-18 to -2)
Secondary outcomes			
Infection	0	0	0
Phlebitis	9 (5)	6 (3)	-1 (-5 to 3)
Occlusion	20 (11)	15 (8)	-2 (-8 to 4)
Dislodgement	26 (14)	13 (7)	-7 (-13 to 0)

CI, Confidence interval.

LIMITATIONS

The randomized controlled trial design was unavoidably nonblinded. Anecdotally, no patients declined the approach for enrollment, but formal screening logs were not kept. The data were collected at a single site with local case-mix and procedural practices potentially influencing translatability, although the study site ED triage practices and hospital admission rate are consistent with national Australian benchmarks. The use of sclerotic medications (eg, 50% dextrose, potassium chloride), use of anticoagulants, number of peripheral intravenous catheter accesses, and dwell time were not measured and are potential confounders.

Average hospital length of stay is 2.7 days at our facility, so some patients were discharged before personal review by the research nurse. Outcome assessment for discharged patients occurred by telephone (n=209), including standardized questionnaire, chart review, and discussion with ward staff, but not direct visualization, which may have provided different information to the inpatient assessments by research nurses (n=171). However, it has been previously shown that discharged patients are successfully able to report peripheral intravenous catheter complications.¹⁶ Failure rates were assessed at 48 hours, not at peripheral intravenous catheter removal. Many were removed before this time, so observed failure rates may reflect a shorter period. Peripheral intravenous catheter failure rates increase with dwell time¹⁷, so outcomes beyond 48 hours are likely higher but cannot be extrapolated from this study.

DISCUSSION

To our knowledge, this study is the first randomized controlled trial using skin glue to secure peripheral intravenous catheters in the ED setting. The standard peripheral intravenous catheter and ED processes, and failure rates in our control group (28%) consistent with those in recent literature (33% to 37%), suggest generalizability of the results.³

Patients in the skin glue group experienced a 10% absolute reduction (37% relative reduction) in device failure. This indicates a number needed to treat of 10 to prevent 1 peripheral intravenous catheter failure. Most of this reduction was due to a lower rate of dislodgement, which was statistically significant (even though the study was not powered to detect differences in secondary outcomes). The skin glue group also experienced trends to reduction in rates of phlebitis and occlusion.

The exclusion of patients who had a high likelihood of intentional peripheral intravenous catheter removal (eg, agitated patients) potentially excluded patients who

may have benefited the most. This exclusion may have underestimated the dislodgement benefit of skin glue. The relatively short follow-up time, with many peripheral intravenous catheters removed before 48 hours, is also likely to have underestimated the benefit of skin glue. In patients with longer peripheral intravenous catheter dwell times, failure is expected to increase, with the skin glue benefit likely to be more pronounced over time.

The technique of skin glue application is rapid and simple to perform in a busy ED setting. Adverse skin reactions to the glue or its removal were assessed by daily communication with ward staff, a 24-hour telephone reporting number, and questioning during patient follow-up. There were no reported incidents of skin adverse events, although there were occasional comments of a “pulling” feeling during removal. When these occurred, patients stated the glue dissolution wipe was applied too briefly, or the patients had very hairy arms.

Significant reduction in peripheral intravenous catheter failure rates is expected to have beneficial effects on patient comfort and outcomes, along with hospital flow and costs. The financial effect awaits a future cost-benefit analysis. Considerations include skin glue cost (approximately 30% the cost of a peripheral intravenous catheter replacement), peripheral intravenous catheter replacement consumables and staff time, prolonged hospital length of stay, more intensive care for patients experiencing serious peripheral intravenous catheter complications, peripheral intravenous catheter complication funding penalties, and patient complaint- or satisfaction-related costs.

In summary, this study supports the use of skin glue in addition to standard care to reduce peripheral intravenous catheter failure rates for adult ED patients admitted to the hospital.

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Author contributions: SB, JFF, and CMR conceived the study. SB, KS, MS, and SC designed the trial. SB and KS obtained research funding. SB, KS, and MS supervised the conduct of the trial and data collection and managed the data, including quality control. KS undertook recruitment of patients. MS and GM provided statistical oversight and analyzed the data. CMR provided clinical trial advice. JFF and CMR provided research mentoring. SB drafted the article, and all authors contributed substantially to its revision. SB takes responsibility for the paper as a whole.

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