Original research article

JVA The Journal of Vascular Access

Short peripheral intravenous catheter securement with cyanoacrylate glue compared to conventional dressing: A randomized controlled trial

The Journal of Vascular Access
1–12

DOI: 10.1177/11297298211024037
journals.sagepub.com/home/jva
SAGE

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Abstract

Background: Short peripheral intravenous catheters (PIVCs) fail prior to completion of therapy in up to 63% of hospitalizations. This unacceptably high rate of failure has become the norm for the most common invasive procedure in all of medicine. Securement strategies may improve PIVC survival.

Methods: We conducted a prospective, single-site, parallel, two-arm randomized controlled investigation with a primary outcome of catheter failure comparing securement with standard semi-permeable dressing and clear tape (SPD) to standard semipermeable dressing and clear tape with cyanoacrylate glue (SPD + CG). Adult emergency department patients with a short PIVC and anticipated hospital duration ⩾ 48 h were enrolled and followed until IV failure or completion of therapy for up to 7 days. Secondary outcomes included complications and cost comparisons between groups. Primary outcome was assessed by intention to treat and per protocol analyses.

Findings: 350 patients were enrolled between November 2019 and October 2020. PIVC survival for SPD + CG was similar to SPD group with the absolute risk difference of IV failure in the intention-to-treat (−5.8%, $p = 0.065$) population and improved in the per protocol (−8.1%, $p = 0.04$) population, respectively. Kaplan-Meier survival analysis indicated there was a significant benefit of the SPD + CG at greater than 2 days of hospitalization ($p = 0.04$). Prior to 48 h, there was no survival enhancement to either group ($p = 0.98$) in the intention to treat population. In a multivariable analysis with piecewise Cox regression, when the IV was functional greater than 48 h, the risk of IV failure in the SPD + CG was 43% less than the SPD group (adjusted hazard ratio [HR] 0.57, 95% confidence interval [CI] 0.34 to 0.97; $p = 0.04$). Cumulative cost related to IV during hospitalization was similar between groups with a lower incremental rescue cost in the SPD + CG group.

Interpretation: SPD combined with cyanoacrylate glue provides similar benefit to patients compared to SPD alone and potentially improves short PIVC survival when the IV was inserted >48 h. As this strategy is cost neutral, it could be considered in admitted patients, particularly those with longer anticipated hospital durations.

Keywords

IV securement, tissue adhesive, IV failure, dressing, cost analysis, cyanoacrylate glue

Date received: 1 March 2021; accepted: 18 May 2021

Introduction

Up to 90% of hospitalized patient require a short peripheral intravenous catheter (PIVC) for therapy with many patients relying on a functional vascular access to receive lifesaving intravenous therapies. Generally, short PIVCs have high failure rates with 17%–63% of the PIVCs failing

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prior to completion of therapy. Dislodgment, infiltration/extravasation, and phlebitis are common complications that lead to early failure.[1–9] PIVC reinsertions are common and an unfortunate part of a routine workday for clinical staff. It is unfathomable that a technology over 75 years old with a failure rate of up to 63% is the accepted standard across the globe.

If venous access is lost, patients may experience treatment delays, dissatisfaction from repeat needle-sticks, and health complications if the patient's condition becomes critical. PIVC failure can result in a number of negative health/quality outcomes including phlebitis and infections and/or skin necrosis from caustic medication infiltration; utilization of invasive procedures such as peripherally inserted central catheters (PICC) and centrally inserted central catheters (CICC); and wasted medical/nursing time.[10,11]

Because failure rate is high, it is important to approach insertions methodically to improve survival rates. One area of opportunity is securement of the catheter. Accidental dislodgment is a cause of early IV failure reported in 3.7% to 10% of catheter failures that is directly related to securement.[5,12] Additionally, poor securement may indirectly impact other more commonly occurring PIVC related complications such as phlebitis, infiltration, and occlusion evident in 16.1%, 23.9%, and 18.8% respectively.[5,13] Inadequate fixation of the catheter to the patient's skin may facilitate catheter micro-motion leading to vein irritation and skin bacteria entry into the insertion site resulting in infiltration, phlebitis, occlusion, and even infection.[14,15]

Standard practice for securement involves placement of a standard semipermeable dressing and clear tape. A variety of additional devices are available on the market including cyanoacrylate glue, specially designed securement dressings, and suture-less securement devices. The limited available evidence suggests the use of cyanoacrylate glue is equivocal as a securement strategy with an unclear impact on PIVC survival and complications.[13,15–17] Bugden et al. reported the most favorable outcomes for securement with cyanoacrylate glue with a reduction in catheter dislodgment by 7% and peripheral IV failure by 10% in an emergency department (ED) population.[8] However, this investigation used a hard endpoint of 48 h to assess for PIVC failure. As newer guidelines recommend use of PIVCs as long as clinically indicated rather than routine replacement as a measure to avoid phlebitis or infection, PIVCs are expected to dwell longer.[18–20] The Agency for Healthcare Research and Quality reported the average hospital length of stay was 4.6 days in 2016 highlighting the inadequacy of using a 48-h cut-off in any analysis of PIVC failure.[21,22] Rather, it is our objective to evaluate the impact of securement with tissue adhesive on survival of PIVCs throughout the hospital encounter beginning in the ED.

Materials and methods

Study design

We conducted a prospective, single-site, parallel, two-arm randomized investigation of catheter survival testing two securement strategies. Specifically, standard semipermeable dressing two 3/8 inch by 4 inches (Tegaderm; 3M, Maplewood, MN) and clear tape (Tegaderm; 3M, Maplewood, MN) was compared to standard semipermeable dressing and clear tape with cyanoacrylate glue, (20% butyl, 80% octyl combination) SecurePortIV™ (Adhezion Biomedical; Springridge, PA) (SPD + CG). In comparison with the standard of care strategy, we anticipated that the experimental (new) care strategy provided at least the same benefit to the patient. This study was conducted in the United States at a large, academic suburban tertiary care center with 1100 hospital beds and 130,000 annual emergency room visits. The study was approved by Beaumont Institutional Review Board. This study is registered with clinicaltrials.gov: NCT04086693.

Selection of participants

Trained research associates recruited a convenience sample of ED patients meeting inclusion criteria. ED patients aged at least 18 years with anticipated hospitalization of greater than 48 h and an ED placed 18 or 20 gauge 1.16 inch PIVC in the antecubital fossa, forearm, wrist, or hand were eligible for enrollment. Patients were enrolled within 8 h of IV placement. Patients admitted to the high acuity progressive unit and those screened and approved by the principal investigator were specifically approached to increase the likelihood of meeting the minimum hospital length of stay requirement of 48 h. Patients were excluded if PIVC was inserted with ultrasound guidance, alternate site or dressing used, voluntary withdrawal, or allergy to cyanoacrylate or formaldehyde. Written informed consent was obtained from all enrolled patients or their legally authorized representative.

Participants were randomized by 1:1 ratio to either the control group: SPD or the experimental group: SPD + CG. The research staff and study subjects were not blinded to the intervention. However, there was no visual difference in the dressing appearance of control and experimental arms. The same research staff performed daily catheter follow-ups to assess for functionality and complications.

A cohort of clinicians, including ED physicians and nurses, were trained on the proper application of the cyanoacrylate glue prior to subject enrollment. The Adhezion Biomedical clinical team provided a 30-min didactic including a hands-on session to practice the application on healthy volunteers. The principal investigator provided clinicians with guidelines to confirm functionality of the existing PIVC and safely remove and reapply the dressing.

Study procedure

Post enrollment, research staff confirmed functionality of the existing PIVC previously placed by ED staff. The assessment included observing for blood return into the tubing upon aspiration and/or unobstructed flush with a minimum of 1–2 ml of normal saline. If the patient was actively receiving an infusion, the drip was briefly halted to evaluate for functionality. Functionality was assessed with the existing index dressing in place. If PIVC was not functional, a new catheter was inserted in a new location, documented, and patient continued in the study. For the control group, the SPD was gently removed to minimize any potential dislodgments or skin injury. The site was evaluated for oozing or blood and as needed cleaned with sterile gauze. Once the site was completely dry, a new SPD was applied and reinforced with tape in a standard fashion. See Appendix 1 for images depicting SPD/CG application. For the experimental group, the existing securement was also gently removed. The site was evaluated for oozing or blood and as needed cleaned with sterile gauze. Once the site was completely dry, the CG was applied per directions in Appendix 2. A new SPD + CG was applied per the standard fashion. Once securement was complete, functionality was reassessed per protocol above for both control and experimental groups. The time of the new dressing application was noted as time zero. Catheter dwell time began at this point.

At the index visit, researchers documented additional data variables including demographics such as age, sex, INR, platelets, insertion site details, and hours from insertion to dressing change.

The catheter was reassessed by the research team daily as long as the patient was hospitalized up to 7 days or 168 h. At each follow up interval the researcher alongside the treating inpatient nurse noted the date/time of evaluation and assessed for any signs and symptoms of complications and functionality of the device. A catheter was considered functional if the PIVC flushed without resistance. If the catheter and adhesive were removed early due to catheter failure or complication, or for patient was discharged prior to 7 days a medical adhesive remover was applied as needed.

If the catheter was identified to have any signs or symptoms of complications during follow-up assessment the date and time of observation of the complication was documented in the data collection tool and the primary team was notified of the complication. If the catheter was removed prior to the follow-up assessment, then the PIVC removal time and the reason for removal was obtained through chart review and discussion with nursing. Notable complications and reasons for removal included: completion of therapy, infiltration, dislodgment, phlebitis, leaking, and occlusion. The department of epidemiology assessed for catheter associated bloodstream infection employing CDC criteria.[23] For all catheters removed due to a complication, re-insertion attempt data was tracked through the medical record in the nursing section for venous lines and need for reinsertion of the PIVC or escalation to an ultrasound-guided IV, midline, PICC, or CICC was noted. If the patient was discharged prior to the time of follow-up assessment, then the time of discharge was documented and the PIVC was presumed to be functional until time of discharge unless otherwise noted in the chart.

The medication administration record was queried for all medications given through each catheter with specific attention to toxic infusates. Vesicants/irritants that are generally given via central line or considered caustic to the vessel were noted in both groups and number of doses recorded. See Appendix 3 for full list of noncytotoxic vesicants.

Catheter costs were calculated using labor and material costs of the index insertion and subsequent rescue catheters when applicable. Overall cost estimates, pulled from the existing literature when possible, for short peripheral IV, short peripheral IV with CG, ultrasound-guided short or long peripheral IV, midline catheter, PICC, and CICC were $30, $36, $45, $149, $249, and $319 respectively.[24–27]

Outcome measures

The primary endpoint was short PIVC survival comparing the standard of care SPD and the experimental SPD + CG groups. Secondary endpoints included complications and cost differences between control and experimental groups.

Primary data analysis

We performed a sample size calculation to evaluate PIVC failure up to 7 days follow-up between the SPD group (control group) and the SPD combined with CG group (experimental group). On the basis of the existing literature,[5,8] we conservatively assumed that the IV failure rate of the standard dressing group was 25% or 36%. We expected that the experimental group would reduce PIVC failure by a minimum 10% for prompting a change in practice. At a noninferiority design, a difference of IV failure rate (experimental vs control groups) in a noninferiority margin of 2% was accepted to be not appreciably inferior in a Farrington & Manning likelihood score test of two proportions. When the actual IV failure rate of the experimental group was 15% (vs 25% in control group) or 24% (vs 36% in control group), a sample size of 308 patients (154 per group) with a dropout rate of 10% in both groups achieved a power of 80% ($\alpha = 0.05$).

The intention-to-treat analysis included all patients who were eligible and randomly assigned to receive SPD combined with CG or standard dressing alone without loss-of-completion. All patients that had an index functional PIVC and discharged with less than 2 days (48 h) hospital length of stay were excluded from the per protocol analysis.

Categorical data were shown as frequencies (percentages) and continuous data as mean (standard deviation, SD). Baseline characteristics of patients were summarized for each study group and compared by using a t-test and $\chi 2$ test (or equivalent Fisher's exact) for continuous and categorical variables, respectively.

For the primary endpoint, we calculated and compared the absolute risk difference of the index PIVC failure rates between the experimental group (SPD + CG) and the control group (SPD) using the noninferiority test and the noninferiority margin of 2% as design. To further explore the effect of SPD + CG, IV survival over time was also analyzed in the intention-to-treat and per protocol populations using the Kaplan-Meier (K-M) method to compare catheter survival up to 7 days. In the initial K-M analysis, we identified that there were eight (ranged from 1.4 to 2.1 days) and 10 (ranged from 1.5 to 2.1 days) cross time points between survival curves in intention-to-treat and per protocol populations, respectively. Hence, to accommodate the potential violation of the proportional hazards assumption, before and after a specified time point (i.e. 2 days), the partial log-rank test was used to evaluate the difference in catheter survival between groups. The restricted mean survival time (RMST) was applied to quantify the catheter survival duration (i.e. a summary of the whole survival curve up to a time horizon). A piecewise Cox regression model before and after a specified time point (i.e. 2 days) was further employed to assess hazard ratios (HRs) for IV failure, adjusting for the prespecified covariates by all authors based on clinical rationale (age, sex, body mass index, platelet count, IV insertion direction, IV insertion location, time on insertion to dressing change, irritants use, and vesicants use).

For the secondary endpoints, the IV-related complications were summarized using descriptive statistics. Cost analyses, including total catheter costs and costs of rescue devices associated with the IV failure, were reported as mean and median for SPD + CG and SPD groups and compared using non-parametric bootstrapping. Moreover, a two-part regression analysis was adopted to analyze the cost in relation to patients with positive costs of rescue catheters on the failure of the index IV insertion. Tests were conducted as follows: noninferiority test of two proportions on IV failure rates at one-sided $\alpha = 0.05$ level and other difference tests at two-sided $\alpha = 0.05$ level. All statistical analyses were performed with R-4.0.2 (R Foundation for Statistical Computing), Stata v15.1 (StataCorp), and SAS v9.4 (SAS Institute, Inc., Cary, NC).

Results

Between November 2019 and October 2020, 1766 emergency department patients were screened and 350 subjects were randomized to SPD (control) or SPD + CG (experimental) groups. Overall, one patient in the control arm and four patients in the experimental arm voluntarily withdrew from the study leaving 174 and 171 patients in SPD and SPD + CG groups, respectively, for the intention-to-treat analysis. As catheter survival was the primary endpoint, patients discharged prior to 48 h hospital length of stay with a functional catheter (62; 17.7%) were excluded leaving 283 patients in the per protocol analysis (Figure 1). Patient and IV-related characteristics were similar between both groups. The average age was 68.4 (SD 15.3) and most patients were male (55.9%). There was no difference between groups in laterality of catheter placement, specific site of IV placement, or time from IV insertion to dressing change (Table 1).

Results indicated that on average, the overall IV survival for patients randomly assigned to SPD + CG was similar to patients assigned to SPD group (Table 2). In the intention-to-treat population, catheter failure occurred in 55 (32.1%) of 171 patients in the SPD + CG group and in 66 (37.9%) of 174 patients in the SPD group (absolute risk difference −5.8%, 90% confidence interval [CI] −15.8% to 4.3%, $p = 0.065$), with the upper limit of CI for the risk difference of IV failure slightly above the 2% noninferiority margin. Importantly, in the per protocol population, catheter failure occurred in 55 (38.7%) of 142 patients in the SPD + CG group compared to the overall catheter failure in 66 (46.8%) of 141 patients in the SPD group (−8.1%, −17.8% to 1.6%, $p = 0.04$), with the upper limit of CI for the risk difference of IV failure well below the 2% noninferiority margin.

The Kaplan-Meier survival analysis showed that there was a benefit of the SPD + CG at greater than 2 days of hospitalization ($p = 0.04$). Prior to 48 h, there was no survival enhancement to either group ($p = 0.98$) (Figure 2). When the index IV was function >48 h (2 days) up to 7 days follow-up, on average, the IV survival duration (RMST) with SPD + CG was longer than that with SPD (5.97 vs 5.43 days, $p = 0.05$). Moreover, in a multivariable piecewise Cox regression, when the IV was functional greater than 48 h, the risk of IV failure in the SPD + CG was 43% less than the SPD group (adjusted hazard ratio [HR] 0.57, 95% CI 0.34 to 0.97; $p = 0.04$) (Table 2). At the 7 days follow-up cutoff, 15 and 24 IV catheters were functional and still active in the SPD and SPD + CG groups respectively. With regard to the benefit of SPD + CG in IV function, we found similar results in per-protocol analysis (Figure 2 and Table 2).

Complications were more frequent in the SPD group (65; 37.4%) compared to SPD + CG group (55; 32.2%). Infiltration was the most common complication in the SPD + CG group (26; 15.2%) and occurred more frequently compared to the SPD group (23; 13.2%). Leaking was the most common complication in the SPD group (31; 17.8%) and occurred more frequently compared to the SPD + CG group (24; 14%). No significant differences

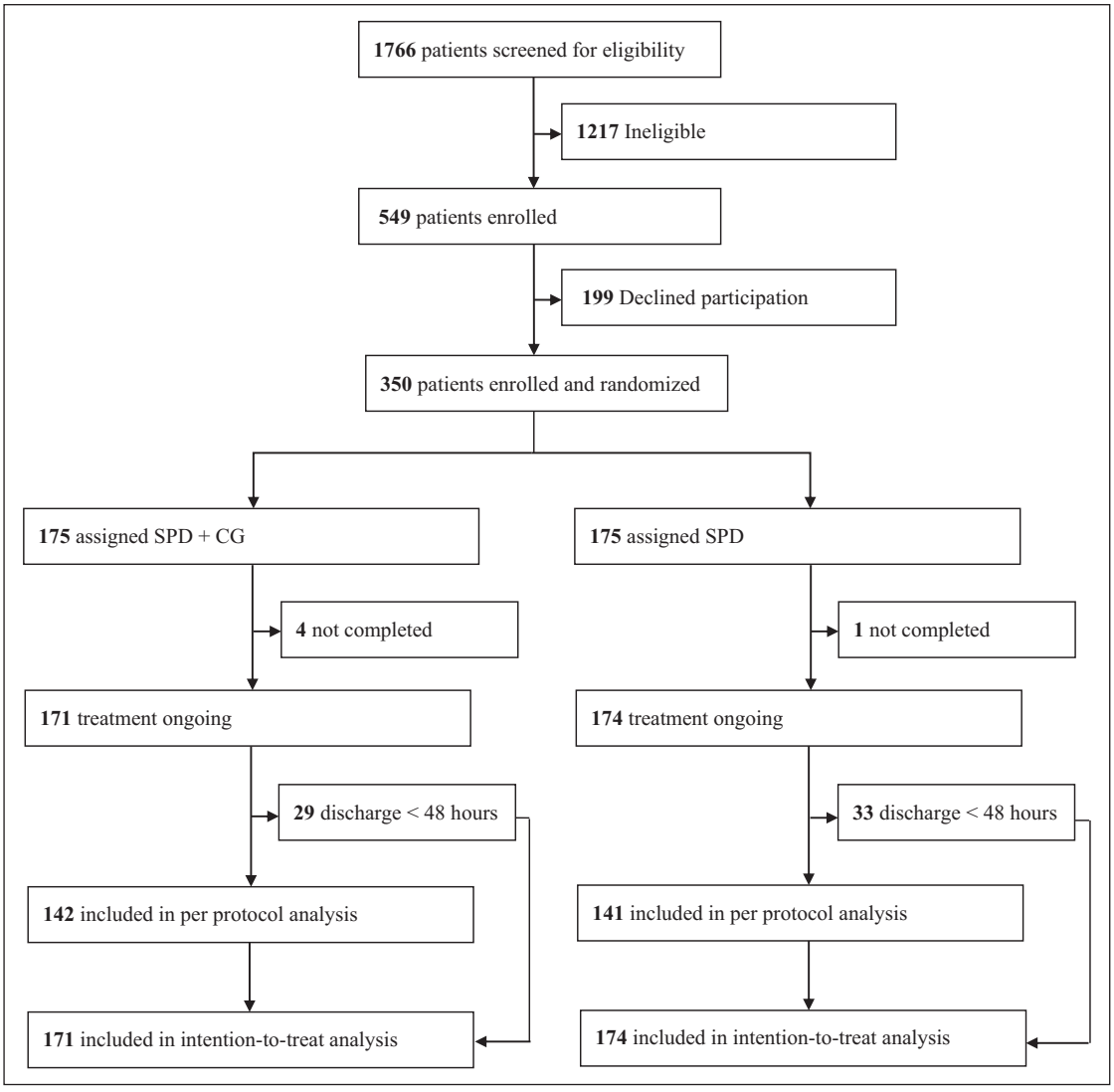

Figure 1. Trial profile of peripheral intravenous catheter securement with cyanoacrylate glue.
SPD + CG = standard semipermeable dressing and clear tape with cyanoacrylate glue. SPD = standard semipermeable dressing and clear tape.

were identified between SPD + CG and SPD groups (Table 3). No patients in either study group developed catheter associated bloodstream infection.

Costs were similar in the SPD and SPD + CG groups. When labor and material costs were considered for all index and rescue catheters, overall, there was no difference in the mean total cost per hospitalized patient ($53.6 [median $36] in SPD + CG vs $50.9 [median $30] in SPD; $p = 0.53$). In addition, when the cost of rescue devices for index PIVC failure was considered, there was no difference in mean (or median) rescue cost between two groups. However, when the effect of SPD + CG on IV failure and rescue cost was jointly assessed by the two-part model, the estimated marginal (or incremental) rescue cost at SPD + CG was lower than SPD by approximately $6.6 as the index IV was function >48 h ($p = 0.07$) (Table 4). Results also indicated that marginal effect of SPD + CG varied over the life course, for example, this difference was much greater for elderly patients.

Limitations

Our study had some limitations. It was conducted at a single site academic tertiary care center with a unique study population and findings may not be generalizable to all settings. The complications analysis was limited as the documentation in the electronic medical record was variable and at times incomplete. While research staff routinely had conversations about the IV site with nursing staff to improve compliance with documentation, the large number of nursing staff and limited access to off-shift personnel left a void in this category. The cost analysis was also limited as only labor and material costs of the index and rescue catheters were considered. Multiple PIV insertions and other

Table 1. Demographic and clinical characteristics.

Variables[§]	Study group		Overall ($n = 345$)
	SPD + CG ($n = 171$)	SPD ($n = 174$)	
Patient characteristics			
Age, years	68.8 (15.4)	68.0 (15.3)	68.4 (15.3)
Sex			
Male	98 (57.3%)	95 (54.6%)	193 (55.9%)
Female	73 (42.7%)	79 (45.4%)	152 (44.1%)
BMI, kg/m^2	29.0 (7.9)	28.5 (7.7)	28.7 (7.8)
Systolic blood pressure, mmHg	137.8 (29.0)	136.7 (24.7)	137.2 (26.9)
Diastolic blood pressure, mmHg	74.7 (18.2)	74.0 (17.2)	74.4 (17.7)
Heart rate, bpm	85.3 (21.7)	84.4 (22.8)	84.8 (22.2)
Temperature, °F	98.1 (0.9)	98.2 (1.1)	98.2 (1.0)
Blood oxygen saturation, %	96.9 (2.7)	97.0 (2.5)	97.0 (2.6)
Platelets count $\times 10^9/L$	234.6 (100.7)	238.4 (99.0)	236.5 (99.7)
$\leqslant 150$	30 (17.5)	23 (13.2)	53 (15.4)
>150	141 (82.5)	151 (86.8)	292 (84.6)
INR level			
<2	65 (38.0%)	75 (43.1%)	140 (40.6%)
2–3	9 (5.3%)	4 (2.3%)	13 (3.8%)
>3	5 (2.9%)	3 (1.7%)	8 (2.3%)
Unmeasured	92 (53.8%)	92 (52.9%)	184 (53.3%)
IV Characteristics			
Insertion direction			
Right	98 (57.3%)	90 (51.7%)	188 (54.5%)
Left	73 (42.7%)	84 (48.3%)	157 (45.5%)
Insertion location			
Antecubital Fossa, AC	124 (72.5%)	121 (69.5%)	245 (71.0%)
Forearm	31 (18.1%)	35 (20.1%)	66 (19.1%)
Hand	7 (4.1%)	10 (5.8%)	17 (4.9%)
Wrist	9 (5.3%)	8 (4.6%)	17 (4.9%)
Insertion to dressing change, hours	3.9 (1.9)	3.8 (1.9)	3.9 (1.9)
Infusates[¶]			
Irritants	31 (18.1%)	32 (18.4%)	63 (18.3%)
Vesicants	4 (2.3%)	8 (4.6%)	12 (3.5%)
Both	3 (1.7%)	3 (1.7%)	6 (1.7%)

SPD + CG: standard semipermeable dressing and clear tape with cyanoacrylate glue; SPD: standard semipermeable dressing and clear tape; IV: intravenous; BMI: body mass index.

[§]Data are presented as mean (SD) for continuous variables or No. (%) for categorical variables in the intention-to-treat population, $n = 345$. All p-values between groups were greater than 0.05.

[¶]Infusate was used within 7 days follow-up.

complications such as thrombophlebitis can be painful impacting patient satisfaction. Patient satisfaction may influence overall reimbursement and was not considered. Further, it is not uncommon for significant time delays to occur when a catheter fails prematurely. This delay may add to the overall hospital duration and is a quantifiable cost but was not considered in this cost analysis.

Discussion

In this randomized study, we found that cyanoacrylate glue applied in the ED improved short PIVC survival in patients with hospital duration greater 48 h up to 7 days. No benefit was found between the SPD and the SPD + CG less than or equal to 48 h. Multiple reasons may have contributed to the comparable failures up to 48 h including medication tolerance and hemodilution. If an irritating infusate was administered with poor hemodilution, the securement of the catheter may have been an inconsequential IV survival variable early in the treatment course.[28] Further, we postulated similar failure rates during the first 48 h of therapy were related to the adhesive component of the dressing. It was likely the standard semipermeable dressing and clear tape was most adherent soon after application and may

Table 2. Primary endpoint-related results.

	Analysis	Time	Study Group		*p*-Value
			SPD + CG	SPD	
Intention-to-treat	IV failure (event)‡, *n* (%)	Overall	55/171 (32.1%)	66/174 (37.9%)	0.065
	Restricted mean survival duration§, days	⩽2 days (48 h)	1.84	1.83	0.81
		>2 days (48 h)	5.97	5.43	0.05
	Hazard ratio (95% CI) on IV failure¶	⩽2 days (48 h)	1.05 (0.63 to 1.77)	1[reference]	0.85
		>2 days (48 h)	0.57 (0.34 to 0.97)	1[reference]	0.04
Per Protocol	IV failure (event) ‡, n (%)	Overall	55/142 (38.7%)	66/141 (46.8%)	0.04
	Restricted mean survival duration§, days	⩽2 days (48 h)	1.82	1.80	0.71
		>2 days (48 h)	5.97	5.43	0.05
	Hazard ratio (95% CI) on IV failure¶	⩽2 days (48 h)	1.02 (0.60 to 1.71)	1[reference]	0.95
		>2 days (48 h)	0.57 (0.34 to 0.97)	1[reference]	0.04

SPD + CG: standard semipermeable dressing and clear tape with cyanoacrylate glue; SPD: standard semipermeable dressing and clear tape; IV: intravenous; CI: confidence interval.
‡Absolute risk difference of IV failure between SPD + CG and SPD was compared based on one-sided noninferiority test of two proportions. The significance of the test was verified by the upper limit of the 90% confidence interval with 2% noninferiority margin.
§Restricted mean survival days of line function under the Kaplan–Meier curves, accounting for the non-proportional hazards, were calculated and the intervention effect was assessed by the difference between SPD + CG and SPD.
¶A piecewise Cox regression, accounting for the non-proportional hazards, was used and adjusted for age, sex, body mass index, platelet count, IV insertion direction, IV insertion location, time on insertion to dressing change, irritants use, and vesicants use.

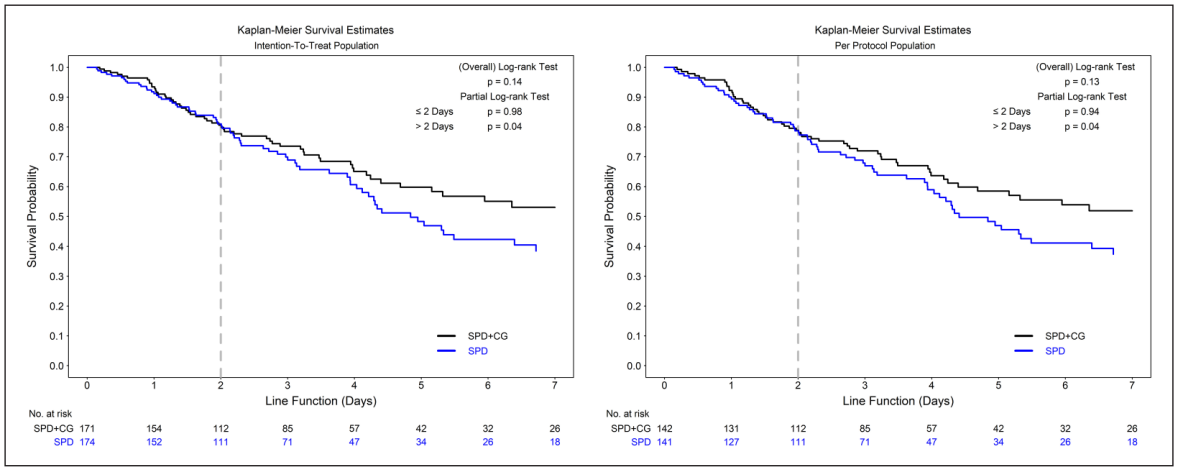

Figure 2. Kaplan-Meier Catheter Survival Estimates
SPD + CG = standard semipermeable dressing and clear tape with cyanoacrylate glue. SPD = standard semipermeable dressing and clear tape.

Table 3. Intravenous line-related complications.

Complications§	Study Group		Difference (95% CI)‡ (%)
	SPD + CG (*n* = 171) (%)	SPD (*n* = 174) (%)	
Infiltration	26 (15.2)	23 (13.2)	2.0% (−5.6 to 9.6)
Phlebitis	10 (5.9)	13 (7.5)	−1.6% (−7.3 to 4.0)
Dislodgment	3 (1.8)	8 (4.6)	−2.8% (−7.3 to 1.1)
Leaking	24 (14.0)	31 (17.8)	−3.8% (−11.7 to 4.2)
Occlusion	3 (1.8)	1 (0.6)	1.2% (−1.6 to 4.6)
Death	1 (0.6)	1 (0.6)	0.0% (−2.7 to 2.8)
Other¶	1 (0.6)	1 (0.6)	0.0% (−2.7 to 2.8)

SPD + CG: standard semipermeable dressing and clear tape with cyanoacrylate glue; SPD: standard semipermeable dressing and clear tape; CI: confidence interval.
§Data are presented as No. (%) in the intention-to-treat population, *n* = 345.
‡The exact 95% confidence intervals in the difference were shown.
¶It meant catheter damage.

Table 4. Intravenous line-related costs by study groups.

	Overall		*p*-Value	⩽ 2 days (48 h)		*p*-Value	> 2 days (48 h)		*p*-Value
	SPD + CG	SPD		SPD + CG	SPD		SPD + CG	SPD	
n	171	174		59	63		112	111	
Total costs[§]	$53.6 (38.4)	$50.9 (43.0)	0.53	$67.8 (55.4)	$60.1 (57.1)	0.49	$46.0 (22.0)	$45.7 (31.6)	0.52
	$36.0 (36.0, 66.0)	$30.0 (30.0, 60.0)	1.00	$36.0 (36.0, 81.0)	$30.0 (30.0, 60.0)	0.82	$36.0 (36.0, 36.0)	$30.0 (30.0, 60.0)	1.00
Cost associated with IV failure									
n	55	66		30	30		25	36	
Rescue device costs[§]	$54.6 (50.7)	$55.2 (54.8)	0.51	$62.6 (64.4)	$63.1 (69.3)	0.49	$45.0 (24.5)	$48.6 (38.8)	0.55
	$30.0 (30.0, 60.0)	$30.0 (30.0, 60.0)	0.69	$37.5 (30.0, 75.0)	$30.0 (30.0, 60.0)	0.53	$30.0 (30.0, 60.0)	$37.5 (30.0, 60.0)	0.67
Part 1: Effect on IV failure[¶]	−0.27	1[reference]	0.26	0.12	1[reference]	0.76	−0.64	1[reference]	0.05
Part 2:Effect on the cost of rescue devices[¶]	0.04	1[reference]	0.78	0.27	1[reference]	0.28	−0.10	1[reference]	0.61
Combine Part 1 and 2:Estimated marginal costs (US$)[¶]	−2.3 (−10.2 to 5.5)	–	0.56	10.0 (−9.2 to 29.2)	–	0.31	−6.6 (−13.9 to 0.6)	–	0.07
at age = 20	−1.4 (−5.8 to 2.9)	–	0.52	5.6 (−12.1 to 23.3)	–	0.54	−1.9 (−5.2 to 1.4)	–	0.26
age = 40	−1.9 (−7.3 to 3.5)	–	0.50	7.5 (−10.9 to 26.0)	–	0.42	−3.3 (−7.6 to 0.9)	–	0.13
age = 60	−2.3 (−9.2 to 4.6)	–	0.52	9.5 (−11.2 to 30.1)	–	0.37	−5.4 (−11.6 to 0.8)	–	0.09
age = 80	−2.5 (−11.3 to 6.3)	–	0.58	11.1 (−13.2 to 35.4)	–	0.37	−8.2 (−18.4 to 2.1)	–	0.12

SPD + CG: standard semipermeable dressing and clear tape with cyanoacrylate glue; SPD: standard semipermeable dressing and clear tape; IV: intravenous.

[§]Data are presented as mean US$ (SD) and median US$ (IQR; 25th percentile, 75th percentile) in the intention-to-treat population. With the highly skewed and heterogenous distribution of costs, nonparametric bootstrapping with 1000 replicates was used to assess the mean and median differences between SPD + CG and SPD.

[¶]A two-part regression model was used to fit the probability of IV failure with a logit model in the first part and a generalized linear model with the log link and gamma distribution for the second part, adjusted for patient characteristics including age, sex, body mass index, platelet count, IV insertion direction, IV insertion location, time on insertion to dressing change, irritants use, and vesicants use. Estimates of coefficients of regression in two parts were shown. Subsequently, the marginal or incremental effect of SPD + CG with the corresponding 95% confidence interval was estimated using the bootstrapping with 1000 replicates.

have weakened over the first 2 days with patient movement and accessing of the catheter site. CG could help enhance securement by increasing the bonding strength of the device to the skin independent of the dressing.

Efforts have been made to identify the best type of securement for the PIVCs. Unfortunately thus far, studies have not been successful in identifying any one superior modality.[13,15,29,30] Rickard et al.'s four-arm randomized controlled trial on inpatients is the largest published investigation on this topic that concluded no securement strategy, including cyanoacrylate glue, was superior to a low-cost SPD option.[13] On the contrary, our study provided evidence and support for CG in a subset of patients with longer anticipated hospital duration when the intervention was started in the ED. It is important to recognize that the results from the Rickard et al. inpatient trial in Australia cannot be applied to an ED setting in the United States as PIVC practice patterns are different across the globe and across hospital units.[9] For instance, IV insertion site and diameter of catheter were vastly different in our study populations. In our trial 71% of PIVCs were placed in the antecubital fossa and none were 22-gauge in diameter compared to 5% placed in the antecubital fossa and 70% 22-gauge catheters in the inpatient trial. These insertion-related differences are relevant and influence the development of PIVC complications and failure and it is possible a blanket uniform securement approach for all insertions may not be the best strategy. Only one other investigation assessed the impact of cyanoacrylate glue on short PIVC survival in the ED setting.[8] That investigation was limited as the primary outcome evaluated PIVC failure at 48 h. Bugden et al. found an absolute reduction in PIVC failure of 10% in the first 48 h. It is conceivable that our study populations may have been different as Bugden et al. had a much higher dislodgment rate of 10.6% compared to 3.2% in our respective cohorts. While we noted a decrease in dislodgments in the SPD + CG compared to SPD group, the overall rate of dislodgments in our cohort was on the lower end of what is reported in the literature.[5,13,14] This may be due to a limited number of cognitively impaired study participants, lack of pediatric enrollments and higher acuity of patients. Given the consenting challenges of patients with altered mental status, it was likely that this population was under-represented but remains at the highest risk for dislodgments.[31] As the CG application targeted securement, it was possible that the benefit in these vulnerable populations may have been greater.

Other more subtle benefits of enhanced securement may involve decreasing complications leading to premature failure.[16] Inadequate catheter securement may facilitate ongoing small-scale movements of the catheter tip against the vein wall leading to vein irritation and inflammation culminating in complications such as infiltration, phlebitis, occlusion, and infection.[14,15] As 71% of the catheters in our study were placed in the antecubital fossa in which patient arm bending was a more likely scenario, enhanced securement with CG provided a potential solution to mitigate these complications. In our study, however, no specific pattern emerged in terms of complications. The complications data was limited as there was heavy reliance on nursing assessment and documentation. While the research team assessed catheters daily, most catheter complications/failure were recognized by nursing staff on shift, not by research staff during assessment. No patients had a catheter associated blood stream infection so the impact of cyanoacrylate glue on infection was not adequately assessed.

Adding the cost of the cyanoacrylate glue to the index catheter did not increase the overall costs comparatively between groups when overall cost of all index and rescue catheters was considered for the hospitalization. Rescue devices were required in over one-third of patients and when advanced catheters were needed, the cost associated with vascular access care rose significantly. In general, the cumulative IV related cost of the SPD + CG group was less at any given time point compared to the SPD, but not statistically significant.

PIVC securement with cyanoacrylate was found to be a potentially better measure to enhance short PIVC survival in patients with greater than 48 h of hospitalization up to 7 days. Practitioners could consider this intervention for admitted patients, particularly those with a longer anticipated hospital length of stay and can be effectively performed in the ED setting. In addition to the IV survival benefit, the intervention was cost neutral.

Contributorship

AB designed the study, had full access to all data in the study, and takes responsibility for the integrity and accuracy of the data analysis. AB, DJ, and NWC contributed to patient recruitment, data collection, data analysis. NWC ed the statistical analysis. All authors contributed to the writing and editing of the manuscript. All authors contributed to data acquisition, data analysis, or data interpretation, and all reviewed and approved the final version of the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: AB received an educational grant for research to conduct this trial.

Ethical approval

This study was approved by the Institutional Review Board.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Adhezion Biomedical

Guarantor

Amit Bahl MD

Role of Funding Source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication. Adhezion Biomedical had access only to the final published work.

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Supplemental material

Supplemental material for this article is available online.

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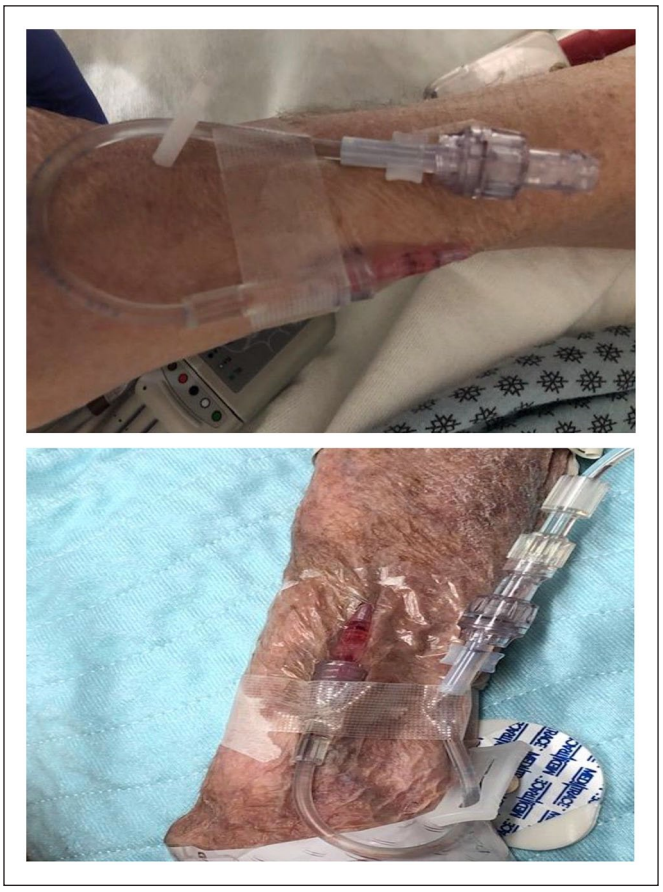
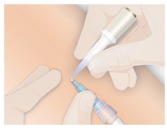


Appendix 1. Images depicting securement with standard semipermeable dressing and clear tape with or without cyanoacrylate glue.

Appendix 2. Cyanoacrylate glue application steps.

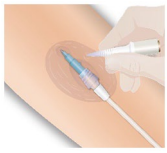
Point the tip towards the ceiling and away from the patient. Press the bottom of the applicator upward.

Invert the applicator and gently squeeze the ridges to initiate adhesive flow. Place 1-2 drops of adhesive at the catheter-skin junction.
Allow each drop of glue to "set-up" for a few seconds before adding the next drop.
Make sure the glue is surrounding the entire circumference of the catheter.

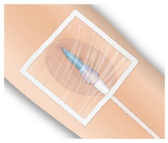


Place an additional 1-2 drops of adhesive under the catheter hub/extension set connection. Apply gentle pressure for 30 s to ensure securement between the catheter and the skin surface.

As desired, the remaining adhesive can be spread out beyond the area of the catheter to increase dressing adherence.



After application of SecurePortIV, a transparent film dressing should be applied per facility protocol.



Appendix 3. Non-cytotoxic vesicants.[19]

RED LIST	YELLOW LIST
Calcium chloride	Acyclovir
Calcium gluconate	Amiodarone
Contrast media—nonionic	Arginine
Dextrose concentration ⩾ 12.5%	Dextrose concentration ⩾ 10% to 12.5%
Dobutamine	Mannitol ⩾ 20%
Dopamine	Nafcillin
Epinephrine	Pentamidine
Norepinephrine	Pentobarbital sodium
Parenteral nutrition solutions exceeding 900 mOsm/L	Phenobarbital sodium
Phenylephrine	Potassium ⩾ 60 mEq/L
Phenytoin	Vancomycin hydrochloride
Promethazine	
Sodium bicarbonate	
Sodium chloride ⩾ 3%	
Vasopressin	