Reaching One Peripheral Intravenous Catheter (PIVC) Per Patient Visit with LEAN Multi-Modal Strategy: The PIV5Rights Bundle*

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Background

Peripheral intravenous catheter (PIVC) sales per year of 350 million exceed the number of people in the United States (US, 327 million). With 37 million US hospital patient admissions per year, these data indicate average usage of 10 PIVCs per patient admission, suggesting a very low insertion success rate and high failure associated with PIVCs. To improve the success with intravenous therapy and catheter insertions, investigation is needed to identify practices that, when performed together, result in higher success and longer dwell time to achieve one PIVC per patient per hospital visit.

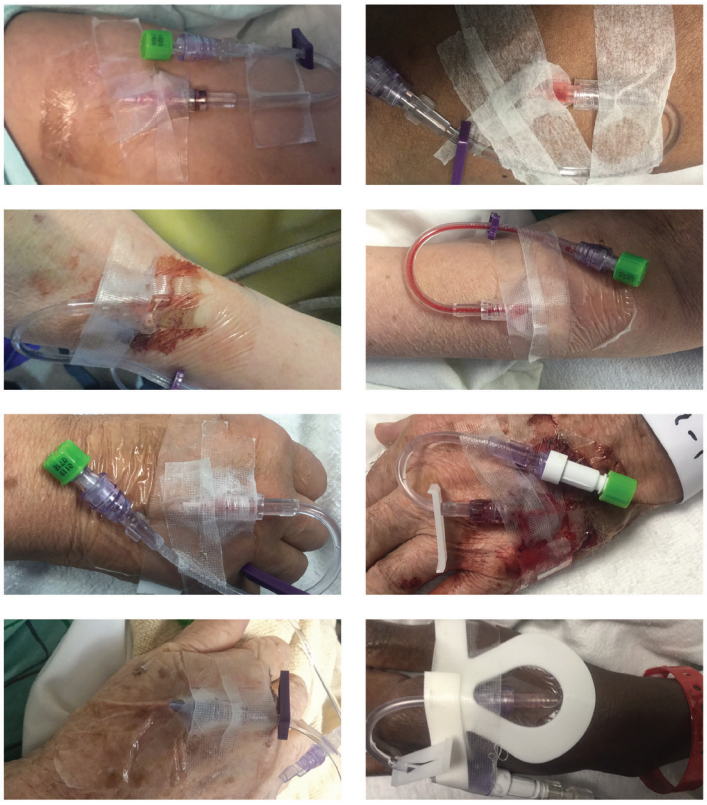
This study used the PIV5Rights™ Bundle, a five-step multi-modal best practice intervention strategy, to determine if the intervention outcomes and dwell time improved over current PIVC practices and could be used to achieve the Lean aspirational goal of one PIVC per patient per hospital visit.

P Proficiency
I Insertion
V Vein & Catheter
5 Supplies & Technology
R Review & Assessment

PIV5Rights Bundle

Figure 1

Current State: *Waste, Variability, Defects*



Methods

A prospective comparator multi-modal single-center clinical trial was conducted over 16 months to determine the impact of bundled practices including device insertions by vascular access specialty team (VAST) clinicians versus current practice. Lean thinking and Six Sigma methodology was performed in the planning stages to identify current practice, gaps, and supplies used. A five-step bundle of practices was created to compare current work (group 1) with a bundle of standardized work (group 2 PIV5Rights).

The five components of the bundle called the PIV5Rights are detailed in Table 1.

Table 1

1. Proficient, trained and educated clinician **Right Training**
2. Insertion and use of ultrasound for assessment, selection **Right Insertion**
3. Selection and use of the best vein and catheter **Right Vein and Catheter**
4. Supplies included; PIVC start kit, longer catheter, anti-reflux needleless connector, and antimicrobial dressing **Right Supplies and Technology**
5. Assessment performed by a proficient nurse and documented with photo in an iPad app **Right Review and Assessment**

The study group applied a LEAN healthcare standard work process with a Six Sigma design, measure, analyze, improve, control (DMAIC) approach that included vascular access specialty team (VAST) PIVC dwell time, complications and economic impact compared with current state general nursing practice. LEAN is a method taken from LEAN manufacturing that relies on a collaborative team effort to improve performance by systematically removing variation of practice while also pinpointing areas of waste leading to greater efficiency and cost reduction.

1. The first step of the PIV5Rights clearly **Defined** the goal of 1 PIVC per patient visit.

2. The second step **Measured** and determined catheter consumption at the hospital each year. Due to a lack of consistent or measurable PIVC usage in the Epic Systems Corporation (Epic, Verona, WI) electronic medical record (EMR), PIVC catheter in-patient consumption was collected from annualized supply chain purchasing records.

3. The third step **Analyzed** and compared the total of Hartford Hospital patient admissions.

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a. The number of in-patient PIVCs purchased annually was divided by the number of patient admissions which provided the total and average PIVC per patient admission. This number was further tied to the Hartford Hospital Average Length of Stay.

b. Analysis of the published evidence produced a PIVC insertion algorithm which included a 10-step PIVC insertion process creating Standard Work time interval.

c. Nursing labor costs were calculated based on Standard Work and average Registered Nurse (RN) salary for bedside versus VAST RN per 20-minute PIVC catheter insertion.

d. The calculation of PIVC supplies used with each insertion established a cost basis for group 1 of average usage supplies and group 2 with Standard Work supplies of IV Start Kit, skin disinfection, catheter, needleless connector, transparent dressing, change of tubing when applicable and ultrasound as needed. Ultrasound cost was not included.

e. The annual PIVC catheter consumption data multiplied by the cost per PIVC placement established the per PIVC catheter insertion economic impact to the hospital.

4. **The Improve step** involved the VAST implementing the PIV5Rights™ approach: (see Fig. 2 and Table 2)

a. Right Proficiency (competency of the inserter)

b. Right Insertion with the option of using ultrasound (VAST standardized method)

c. Right Vein and Catheter (selection, vein, and catheter-based on evidence)

d. Right Supplies and Technologies - IV Start Kit, Chlorhexidine Gluconate (CHG)/alcohol prep (Becton Dickinson, Chloraprep™), 22g 1.75" catheter (BBraun, Introcan™ Safety), anti-reflux valve needleless connector (Nexus, TKO™), chlorhexidine (CHX) antimicrobial bordered securement dressing (entrotech life sciences, PrevahexCHX™)

e. Daily assessment, every 12-24 hours, of the insertion site used a Cloud-based iPad app with a checklist and photo accountability of all sites

5. The **Control process with Standard Work** was established with a centralized VAST PIVC insertion for all patients.

Results

The study measured multi-modal (PIV5 Rights) best practice bundle with a VAST versus current state complication outcomes, dwell time (success rate), and cost associated with multiple PIVC restarts (Tables 2 and 3).

Table 2. Results with Complications

	Group 1 n=94	Group 2 n=113	Total Sample N=207	p Value
Success Rate				
Catheters with Completion of Treatment	14 (15%)	101 (89%)	115 (56%)	<0.001
Catheter Failure/Causes of Removal				
Location/Patient Complaint	27 (29%)	0	27 (13%)	<0.001
Site Symptomatic	15 (16%)	0	15 (7%)	<0.001
Other	38 (40%)	12 (11%)	50 (24%)	<0.001
Total Catheter Failure	80 (85%)	12 (11%)	92 (44%)	<0.001
Complications Resulting in Catheter Removal				
Accidental Dislodgment	1 (1%)	1 (1%)	2 (1%)	N/A
Catheter Occlusion	8 (9%)	0	8 (4%)	0.002
Infiltration	7 (8%)	4 (4%)	11 (5%)	0.212
Phlebitis	13 (14%)	5 (5%)	18 (9%)	0.017
Pain	9 (10%)	2 (2%)	11 (5%)	0.013

Table 3. Overall Outcomes

The Results		
Variable	**Group 1** (n=94)	**Group 2** (n=113)
Success Rate (therapy completed)	15%	89%
Dwell Time, Hours (mean ± SD, P<0.001)	29.6 ± 18.0	71.4 ± 58.8
Complication Rate (%, P<0.001)	40%	11%
Cost/Bed/Year (2018 USD)	$4,781	$1,405

Table 4. Comparison of Usage and Cost Analysis

	GROUP 1 CATHETERS				GROUP 2 CATHETERS			
33,486 ADMITS 75% of 44,648 admits have an IV catheter placed	CATHETER USAGE (Admits Only)		CATHETERS PER PT VISIT		CATHETER USAGE (Admits Only)		CATHETERS PER PT VISIT	
CATHETER USAGE	**148,200 Catheters**		**4.4** 148,200 ÷ 33,436		**36,835 Catheters** 89% Success Rate – 1 Catheter 33,486 * 1.1		**1.1**	
	Nurse Hours		FTE Equivalent		Nurse Hours		FTE Equivalent	
TIME TO PLACE IV	**49,400** 148,200 x 20 minutes ÷ 60		**23.75** 2,080 h/yr. per FTE		**12,278** 36,835 x 20 minutes ÷ 60		**5.9** 2,080 h/yr. per FTE	
	Labor	Supplies	Cost per IV	Total	Labor	Supplies	Cost per IV	Total
IV COSTS	**$16.17** RN @ $48.50/hr	**$11.80** Catheter, Tubing Connectors/ Caps, Kit	**$27.97** $16.17 ÷ $11.80	**$4,145,154** 148,200 x 27.97	**$18.68** IV-trained RN @ $56.01/hr	**$14.40** Adds better technology	**$33.08** $18.68 ÷ $14.40	**$1,218,502** 36,835 catheters x 33.08
PER BED				**$4,781** $4.1M/867 beds				**$1,405** $1.2M/867 beds

Analysis of the data showed that pre-study PIVC consumption was 4.4 catheters per patient hospital admission (n=148,200 catheters/year, see Table 4), reflecting waste within labor and supply costs for PIVC insertion and usage with cost per PIVC of $27.97. Group 2 PIV5Rights used a trained vascular access nursing team for insertion and management following a standardized protocol for a statistically significant 89% of PIVCs achieving the end of therapy with cost per PIVC of $33.08.

Despite the initial higher cost per PIVC in group 2, the saving was $3,376 per patient bed ($1,405 vs $4,781) versus group 1 (see Table 3). Group 1 PIVCs (see Fig. 1) reached the end of treatment in 15% of catheters, less than one in five. PIVC retrospective audits for current practice demonstrated more than 50% of catheters failed within the first 24 hours, while less than 11% of group 2 failed in the study period from November 2016 through February 2018 (see Fig. 2). This application of LEAN methodology with infusion therapy resulted in a projected $2.9 million annual savings with $3,376 per bed per year cost reduction with the house-wide application.

Figure 2

Future State: *Standard Work, EVB–Best Practice*

Clinical Implications

Many hospitals are reducing the size of vascular access teams without investigating their cost basis per bed. The cost associated with intravenous therapy can exceed $4 million per year as seen in this study reflecting an underutilized team. Hospitals without teams performing ultrasound-guided PIVC may have usage of 8 catheters per patient bed, double the usage and cost associated with the current state at this hospital. Administrators have the potential to achieve savings easily in the millions by applying the PIV5Rights Bundle.

Conclusions

Implementation of the PIV5Rights Bundle with dedicated VAST proved a successful model, both for patient outcome and financial savings. By centralizing ownership of vascular access within a team of proficient clinicians for insertion and management, the PIV5Rights Bundle Right Approach made for the Right Results in hospital infusion therapy with a win for patients, a win for the administration, and positive feedback for the VAST.

Limitations: Difficult to establish a conclusive causal relationship with multi-modal application and results are suggestive of change based on identical components in the bundle. Cost analyses of material management supply costs were collected retrospectively and prospectively, based on annual consumption and economic data calculations represented noted within figures.

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