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Surgeon, not technique, defines outcomes after central venous port insertion

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Abstract

Background: Although central venous access for port placement is common and relatively safe, complications and poor resource utilization occur. We hypothesized that despite the simplicity of port placement, surgeon and/or resident performance—rather than technique—is associated with clinical outcomes and operating room efficiency.

Materials and methods: Medical records of 1200 patients who underwent port placement between 2012 and 2015 at our institution were retrospectively reviewed. Insertion route (subclavian, internal jugular, cephalic cutdown), individual surgeon (A-G), surgeon volume, body mass index, patient age, and resident presence were evaluated to determine their association with operating room time, complications, and need for alternate insertion route.

Results: On univariate analysis, operating room times were significantly different among individual surgeons, with surgeons E and F having the longest operating room times (50 and 63 *versus* 31–40 min; $P < 0.01$) and switching to an alternate method more frequently (13.5% and 21.3%, *versus* 0%–10.3%, $P < 0.01$). On multivariate analyses, operating time was increased with elevated body mass index, resident presence, and switching to an alternate method. Individual surgeons had varied effects on operating time with two surgeons found to be the predominant

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drivers (OR 19 and 27; $P < 0.01$). With residents excluded, these two surgeons continued to increase operating times (OR 15 and 29; $P < 0.01$) and procedural complications (OR 3.2 and 5.9; $P < 0.05$).

Conclusions: Although port placement is ostensibly simple, individual surgeon performance is the primary driver of patient outcome and operative efficiency. In an era requiring optimized resource utilization and outcomes, these data demonstrate potential for enhanced programmatic organization and case distribution.

Keywords

Port; Efficiency; Surgeon; Venous access; Resource utilization; Resident presence

Introduction

Since its description by Niederhuber,¹ port placement for the purpose of central venous access has become a common surgical procedure performed by both general and specialty-trained surgeons. Despite the appearance of simplicity, a great deal of variation exists in regard to insertion method and complication rates, as the number of practitioners placing these implantable access devices has broadened substantially (including nonsurgeons).² In this era of focus on quality and resource utilization, seeking out the sources of variation in surgical care and outcomes is important as a step toward improving patient care. Identifying the best means of placing these devices is crucial for maintaining quality of life for individual patients.^{3,4}

The role of insertion method and technique on patient outcomes has been well studied. The three most widely used methods include ultrasound-guided percutaneous catheterization of the internal jugular vein, catheterization of the subclavian vein via a blind approach while using anatomic landmarks, and surgical cut-down technique for catheterization of the cephalic vein. Although clinical guidelines make no specific recommendations regarding insertion method,^{5,6} studies have shown conflicting results with regard to speed, success rates, and complication rates.^{2,7–12}

And while the influence of method and anatomical site of insertion have been well documented, the role of provider-specific factors has been unexplored, and differences in provider skill and/or training may account for observed variability in the operative outcomes. Furthermore, how these procedural variations impact operating room time and efficiency is unknown. We hypothesized that individual surgeon—with and without resident presence—is the strongest predictor of complication rate, operating room time, and operating room efficiency (i.e., need to switch to an alternate method of insertion) than is method of insertion.

Materials and methods

After approval by the University of Cincinnati's Institutional Review Board, the medical records of all patients ($n = 1378$) who underwent port placement for the purpose of central venous access between October 2012 and March 2015 at the University of Cincinnati

Medical Center and its affiliated hospitals were reviewed. All duplicate entries and those patients without a complete operative note recorded in the system were excluded ($n = 178$); the final cohort consisted of 1200 patients.

To identify differences due to insertion method, patients were first grouped according to subclavian, internal jugular, or cephalic cut-down approach. A second analysis was performed, stratifying the study cohort by individual surgeon, with and without resident presence. The seven highest volume surgeons over the 3-y period (labeled A-G, performing between 76 and 324 procedures) were individually compared, with the remaining surgeons pooled into a “low-volume surgeon” group and analyzed jointly. All data for this study were drawn from individual patient medical records and included patient characteristics, surgical technique, individual surgeon(s), resident presence, operative time, and complications occurring within 2 wk of the procedure. Complications included pneumothorax, hospital admission, need for replacement, central line infection, and malfunction of port.

Univariate analyses were performed using a Wilcoxon rank-sum test, with method of insertion as the class variable and the following three measures as outcome variables: complication, operating room time, and need to switch to an alternate method. Statistical significance was determined by a P value less than 0.05. Multivariate linear and logistic regression analyses were then performed to identify predictors of the three dependent variables to include complication (analyzed as a dichotomous variable for each patient), operating room time (analyzed as a continuous variable), and need to switch to an alternate method (analyzed as a dichotomous variable). Independent variables with a $P < 0.10$ on univariate analysis were used in multivariate analyses. Predictor variables included patient age, body mass index (BMI), complications of port placement, resident presence at the initial procedure, and individual surgeon. Subanalyses were performed to further evaluate the influence of resident presence on the aforementioned outcome measures. Because individual surgeon preference dictated a specific route of insertion, this variable was not included in multivariate analyses to minimize confounding.

Results

Patient- and procedure-specific characteristics according to insertion method are shown in Table 1. Ports placed via the cut-down approach had the longest operating room times and were more likely to require switching to an alternate method intraoperatively (all $P < 0.01$). Those placed via ultrasound-guided percutaneous catheterization of the internal jugular vein were fastest, least likely to require switching to an alternative method, and required fewer access attempts before cannulation (all $P < 0.01$). Those placed via the subclavian approach had the highest rate of pneumothorax ($P = 0.04$), were most likely to require multiple attempts prior to establishing access, and were more frequently performed with residents present ($P < 0.01$).

Patient- and procedure-specific characteristics according to individual surgeons are shown in Table 2. Surgeons differed significantly based upon patient age, BMI, total operating room time, need to switch to an alternate method, multiple access attempts, and whether a resident was present during the procedure. Of note, Surgeon E and F were found to have the longest

operating room times and the highest rates of switching to alternate methods. Surgeon A was found to have the shortest operating room time, the lowest rate of switching to an alternate method, and was the highest volume surgeon.

On multivariate analyses, individual surgeon factors were found to be the strongest predictors for all three endpoints (surgeon A was found to have the most favorable outcomes on univariate analysis and was therefore used as the reference for individual surgeon covariables). Six of the seven individual surgeons were found to be independent predictors of increased operating room times (Figure A). Most notably, surgeon E increased operating room time by 19 min, whereas surgeon F increased OR time by 27 min. When residents were excluded, three (compared with five from the original model) of the seven surgeons remained independent predictors for increased operating room time including surgeon D, who increased operating time by 8 min ($P = 0.03$), surgeon E increasing operating time by 15 min ($P < 0.01$) and surgeon F increasing operating time by 29 min ($P < 0.01$; Table 3). Low-volume surgeons were also found to be significant predictors of increased operating room time, albeit to a lesser degree increasing operating time by 6 min ($P < 0.01$). Additional predictors for increases in operating time were resident presence (6 min), need to switch to an alternate method intraoperatively (10 min), and the presence of a procedural complication (14 min; all $P < 0.01$; Figure A).

Furthermore, the rate of switching to an alternate method of insertion intraoperatively was also predicted by surgeon-specific factors. Again, surgeons E & F were found to be the greatest predictor of switching to an alternate method with surgeon E increasing the likelihood of switching by over 6-fold and surgeon F by over 12-fold. ($P < 0.01$) Low-volume surgeons also had increased rates of switching methods, albeit to a smaller degree. (OR 4.3; $P < 0.01$; Figure B). In the absence of resident participation, the only predictor of needing to switch to an alternate method was surgeon E (OR 3.82, $P = 0.01$; Table 3).

Procedural and overall complication rates were evaluated and similar themes were noted. Predictors for procedural complications remained surgeons E and F and low-volume surgeons (4.9 versus 10.4 versus 3.7; $P < 0.01$; Figure C). The same was seen for overall complication rates with surgeon E demonstrating a 5-fold increase and surgeon F demonstrating an 8-fold increase in overall complications as compared with surgeon A ($P < 0.01$). Low-volume surgeons had a 4-fold increase in overall complication rate ($P < 0.01$; Figure D). Finally, when examining both procedural complications and overall complications in the absence of resident participation, again the only significant predictors were individual surgeons including surgeon E (OR 3.2 and 2.7) and surgeon F (OR 5.9 and 5.1; Table 3). For all outcome measures, low-performing individual surgeons confer the greatest amount of risk despite resident involvement.

Discussion

To date, the most studied focus of port placement has been on the method of insertion, yet none have been identified as the gold standard.^{8,9} We have evaluated the outcomes following 1200 port placements at a tertiary care center and have found that individual surgeons were the strongest predictors of increased operating room time, likelihood of switching to an

alternative method, and procedural complications. Furthermore, for the surgeons who had consistently worse outcome measures, resident participation could not be blamed for their longer operating room times, need to switch to alternate methods or increased complication rates.

Bolstering our argument that individual surgeon performance is far more impactful than insertion method, our analysis demonstrated that insertion method accounted for a maximum difference of 15 min in operating room time, a 1.2% in pneumothorax rate, an 11.4% in likelihood of switching to an alternate method, and a 16% maximum difference in the need for multiple access attempts. These values were significantly lower than those noted when comparing the minimum and maximum values for individual surgeon metrics. For example, the maximum difference in operating room time between surgeons was 37 min, with a 1.9% difference in pneumothorax rate, a 21.3% difference in likelihood of switching to an alternate method, and a 19% difference in the need for multiple access attempts. Furthermore, multivariate analysis revealed individual surgeon factors to be the greatest predictors of all four outcomes measures in our study. In this particular analysis, two surgeons (E & F) were consistently the strongest predictors for increased operating room time, need to switch to an alternate method, procedural complication, and overall complication rates. Resident presence, patient BMI, and switching to an alternate method intraoperatively were also found to be predictive of increased operating room time; however, these were not significant for the other three outcome measures.

There is a growing body of research suggesting surgeon volume is an important predictor of outcomes following complex surgical procedures.^{13–17} Intuition correctly suggests that increased volume correlates to improved outcomes following complex surgical procedures, and it follows that simple procedures—such as port placement—do not require high case volumes to achieve excellent results. However, the volume effect in our study was inversely proportional to desired outcomes; the second highest volume surgeon in this group, placing over 160 ports during the 2-y study period, was found to be one of the strongest predictors for increased operating room time, need to switch to an alternate method, procedural complication, and overall complication rate. Alternatively, surgeon G—one of the lowest volume surgeons—placed only 87 ports throughout the study period, yet (1) averaged 1 min slower operative time than the fastest surgeon, (2) had the lowest rates for pneumothorax and need for multiple access attempts, and (3) switched methods very rarely relative to the other study surgeons. Furthermore, surgeon G was the only surgeon not found to be an independent predictor of any poor outcomes on multivariate analysis. These data would suggest that for a minor procedure such as port placement, surgeon-specific factors dominate the volume argument.

At most academic institutions, port placement remains a resident-level procedure, with varying amount of attending surgeon involvement in the component steps. While this reality introduces potential confounding into our models—certainly a variable impossible to control for in a comprehensive manner—we found that resident involvement had statistically significant effects on outcome measures; however, they were not the strongest predictors of outcome measures, supporting that which is already reported in the literature.^{18,19} Slight decreases in operating room times, need to switch to an alternate method, procedural

complications, and any complication were seen with the removal of resident involvement. However, the individual surgeons who were found to be the strongest predictors of poor performance measures in the original model remained as such when residents were removed. Again, we see that individual surgeon characteristics are the greatest predictors of poor performance in this analysis, and while resident involvement may exacerbate underperformance, they are not the cause for it.

While port placement remains a minor procedure with excellent success rates and no real risk of mortality, this analysis highlights the significant opportunity that exists to develop a programmatic change to maximize operating room efficiency, simultaneously minimizing patient risk and operating room time. Surgeon-specific factors were the strongest predictors for increased operating room time and complications suggesting that a quality improvement initiative focusing on providing the infrastructure and support for high-performing and efficient surgeons to provide these services to patients in need of permanent central access has the greatest potential to improve care. If the average operating room time for port placement, for example, was reduced by 25 min (we have demonstrated a 32-min maximum difference in operating room times between surgeons) in 1000 ports placed, a total of 416 h of operating room time would be saved. In addition to saved resources, patient waiting time and quality of care would likely improve. At the University of Cincinnati, we have implemented an efficiency improvement plan through which a structured referral system for port placement, dedicated operating room time in an outpatient setting, and protected time for surgeons to create a simple and seamless process for patients. Data are forthcoming, but through this initiative we aim to reduce scheduling waiting time, day of surgery turnaround time, and procedural complications, while increasing patient satisfaction.

Although we have comprehensive data on over 1000 patients from a single institution, there may be some unavoidable bias as a result of our retrospective methods. As stated in the methods, individual surgeons generally performed the same insertion method for all port placements. While possible that this confounds the distinction between surgeon-specific factors and those associated with insertion method, we have attempted to eliminate this bias by removing insertion method from the multivariate models. Furthermore, aiming to maintain anonymity, we did not include identifying factors of the individual surgeons including duration of practice, surgical specialty, overall complication rates, overall caseload etc. Thus, we are unable to detail granular procedural components that lead to low-performing outliers. Given the single institution nature of this study, it is possible that other health systems or practice patterns may not allow for generalizability of our results. Validation of our findings, from other institutions with potentially varied port placement practices, will be an important future direction. Finally, it must be acknowledged that data, such as these, may limit autonomy and scope of surgeon practices, and we must be careful how these data are interpreted and implemented by administrators and policy makers. At our home institution, we have implemented an efficiency improvement initiative that has allowed for dedicated outpatient operating room time and space to allow for a seamless process for port placement.

Conclusion

This analysis demonstrates that surgeon-specific factors dominate operative efficiency and outcomes after port placement. While resident presence may exacerbate poor performance, increased operating room time, need to switch to an alternate method, and complications persist for those surgeons who consistently underperform—even when residents were removed from the analysis. Furthermore, case volume does not appear to have an effect on outcomes following this relatively simple procedure, suggesting a need for individual practice improvement rather than referral to high-volume surgeons. With thoughtful, dedicated, system-level changes for common procedures—such as discussed here—efficiency and improved resource utilization can profoundly help both patients and providers.

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Figure –. Forest plot demonstrating predictors of increased operating room time (A), predictors of need to switch to an alternate method during port placement (B), predictors of procedural complication rate (C), and predictors of any complication following port placement (D).

Table 1 –
Patient- and procedure-specific characteristics of port placement according to insertion method.

Clinical variable	Subclavian; n (%/IQR)	Int. Jugular; n (%/IQR)	Cephalic; n (%/IQR)	P value
# Of Patients	402 (30%)	404 (30%)	394 (30%)	
Age	60.4 (51–67)	59.0 (49–67)	58.4 (49–67)	0.45
OR time (min)	37 (30–46)	31 (26–38)	46 (34–59)	<0.01
BMI	26.1 (22–30)	27.5 (23–33)	28.0 (24–32)	<0.01
Pneumothorax	5 (1.2%)	1 (0.3%)	0 (0.0%)	0.04
Alt. method	31 (7.7%)	11 (2.7%)	39 (9.9%)	<0.01
Kink	4 (1.0%)	4 (1.0%)	9 (2.3%)	0.21
Readmit	3 (0.8%)	3 (0.7%)	3 (0.8%)	1.00
Multiple attempts	83 (20.7%)	19 (4.7%)	39 (9.9%)	<0.01
Any LT complication	6 (1.5%)	8 (2.0%)	5 (1.3%)	0.71
Replaced	4 (1.0%)	4 (1.0%)	0 (0.0%)	0.15
Resident present	275 (68.4%)	220 (54.6%)	236 (59.9%)	<0.01

Alt = alternate; BMI=body mass index; IQR = interquartile range; LT = long-term; OR time = operating room time.

Table 2 –

Patient- and procedure-specific characteristics of port placement according to individual surgeon.

Clinical variable	Surg. A (n = 324)	Surg. B (n = 76)	Surg. C (n = 105)	Surg. D (n = 94)	Surg. E (n = 163)	Surg. F (n = 94)	Surg. G (n = 87)	Low vol.	P value
Age	58.5	59.7	65.7	63.1	59.1	56.2	57.9	57.5	<0.01
BMI	27.5	28.9	25.2	26.6	28.4	28.2	27.0	26.5	<0.01
OR time	31	40	33	40	50	63	32	37	<0.01
PTX	0.3%	0.0%	1.9%	1.1%	0.0%	0.0%	0.0%	0.8%	0.38
Alt. method	1.9%	6.6%	0.0%	2.1%	13.5%	21.3%	2.3%	10%	<0.01
Kink	0.9%	2.6%	0.0%	1.1%	3.1%	3.2%	0.0%	1.2%	0.21
Readmit	0.3%	1.3%	2.9%	0.0%	0.0%	1.1%	0.0%	1.2%	0.15
Multiple attempts	3.7%	7.9%	16.2%	20.2%	12.9%	21.3%	2.3%	17.7%	<0.01
LT comp.	1.2%	1.3%	3.8%	0.0%	1.2%	2.1%	0.0%	2.3%	0.35
Replaced	0.9%	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%	1.2%	0.37
Resident present	53.7%	89.5%	89.5%	74.5%	44.2%	74.5%	57.5%	52%	<0.01

Alt. method = alternate method; LT comp. = long-term complication; OR time = operating room time; PTX = pneumothorax; Surg = surgeon; Vol = volume.

Multivariate analyses determining predictors for increased operating room time, need to switch to an alternate method, and any procedural complications among ports placed without resident participation.

Table 3 –

Clinical variable	OR time (slope)	P value	Switch to alternate method (odds ratio)	P value	Procedural complication (odds ratio)	P value
Age	0.01	0.84	0.99	0.41	0.99	0.44
BMI	0.22	0.06	1.01	0.79	1.01	0.86
Alternate method	6.28	0.46	—	—	—	—
Procedural complication	21.19	<0.01	—	—	—	—
Surgeon						
A	1.00 (reference)		1.00 (reference)		1.00 (reference)	
B	2.80	0.61	1.55	0.79	1.31	0.87
C	0.03	0.99	1.04	0.98	0.87	0.93
D	7.99	0.03	0.74	0.84	0.61	0.75
E	15.04	<0.01	3.82	0.01	3.21	0.02
F	29.32	<0.01	3.40	0.13	5.91	<0.01
G	1.25	0.65	1.89	0.42	1.58	0.56
	$R^2 = 0.48$		$c = 0.71$		$c = 0.71$	

c = c-statistic; OR time = operating room time.