Variation in the Practice of Central Venous Catheter and Chest Tube Insertions among Surgery Residents

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Abstract

Objectives: Central venous catheter (CVC) and chest tube (CT) insertions are common bedside procedures frequently performed by surgery residents. Despite published guidelines, variability in the practice exists. We sought to characterize the surgery residents’ practice patterns surrounding these two bedside procedures. Materials and Methods: Over the last 1½ months of the academic year in 2012 and 2013, surgery residents across the US were surveyed online. Participants reported levels of agreement for 15 questions in a 5-point Likert scale format. Results: A total of 219 residents completed the survey. Majority of residents agreed that they received appropriate education and training. Over half of the respondents reported that they did not have attending staff physician’s supervision during the procedures. Junior residents felt less confident in performing CVC or CT insertions. Those younger than 29 years old and of female sex were also less confident in performing CT insertion. Although almost all residents reported using maximal sterile barrier precautions, 7% reported not securing their gowns and another 7% reported inadequate draping of patients. About ¾ reported no hand cleansing before the procedures. Those from community programs compared to university programs less frequently used antibiotics. Sixty-five percent of residents reported routine use of ultrasound for CVC insertion. Conclusion: Surgery residents do not strictly adhere to the guidelines for CVC and CT insertions, and there is substantial variation in the practice of the procedures, which may contribute to complications associated with these procedures. This survey opens new areas for in-service education, feedback, and practices for these procedures to reduce the risk of complications, especially the infectious one.

Keywords: Central venous catheter, chest tube, guidelines, maximal sterile barrier precautions

INTRODUCTION

Central venous catheter (CVC) and chest tube (CT) insertions are common bedside procedures in trauma and Intensive Care Unit and frequently performed by surgery residents. More than 150 million CVCs are inserted each year in the United States,[1] and there are more than 250,000 nosocomial catheter-related bloodstream infections (CRBSIs),[2] in addition to mechanical complications. In a meta-analysis of 2573 CRBSIs, the case-fatality rate was 14%, and 19% of these deaths were attributed to catheter-related infections.[3] CT insertion is a common procedure performed in emergency rooms and surgical departments for pneumothorax, hemothorax, and pleural effusion, among other indications. The infectious complication associated with CT insertion has been reported to be ranged from 1.1% to 4%.[4-6]

Efforts to decrease complications related to these two most commonly performed bedside procedures are imperative. Adherence to guidelines is important in reducing complications and healthcare costs. Recommended strategies to improve procedure outcomes include standardization of procedure training, establishment of minimum competency standards before unsupervised practice, and adherence of guidelines. Practice guidelines for the prevention of CVC insertion had been developed for healthcare personnel who insert intravascular catheters, with the most current one in 2011.[7] Guidelines for CT insertion were also developed in 2003 on behalf of the British Thoracic Society Pleural Disease Group.[8] CT insertion is also included in the Advanced Trauma Life Support (ATLS®) curriculum.[9] Unfortunately, no data are

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available thus far regarding the practice pattern of surgery residents in the placement of these commonly performed bedside procedures. We therefore conducted this survey to the general surgery residents in the US. We hypothesize that there is a variation in the practice of CVC and CT insertions among surgery residents. The primary aim of this survey was to determine how strict they are in mandating and adhering to the evidence-based guidelines in performing these two bedside procedures. The secondary aim of this study was to determine their self-reported confidence of performing these procedures as well as their attitude toward controversial area in CVC insertion.

**Materials and Methods**

After approval from the University at Buffalo Health Sciences Institutional Review Board, surgery residents across the US were surveyed online over the last ½ months of the academic year in 2012 and 2013. The survey request was disseminated via e-mail through the Association of Residency Coordinators in Surgery (ARCS) list serve. Some program coordinators e-mailed back to confirm that they distributed the survey information to their residents, while other coordinators did not respond but might have sent the survey along. Several steps were taken to maximize the response rate to this online survey as outlined in the literature by Dillman. The initial invitation e-mail included instructions detailing how to access the survey in the SurveyMonkey commercial website. Two reminder e-mails were sent to the nonresponders at varying intervals. In the 2013 survey, we asked that the residents who participated in the 2012 survey to refrain from retaking the same survey. There was no ACGME working hour policy change between 2012 and 2013. Participants reported levels of agreement in a 5-point Likert scale format. The survey was strictly confidential and did not include personal identification. It contained questions regarding demographics, education and in-service training, practice of maximal sterile barrier precautions (MSBPs), and others [Table 1]. The survey remained open to all surgery residents for a total of ½ months. Data were downloaded from the online secured database and analyzed.

Statistical analysis was performed using Minitab® 17 (Minitab Inc., State College PA). Descriptive statistics were used to characterize the overall study sample with respect to respondent demographics and resident information and were presented as median (interquartile range) and percentages. For ease of interpretation, survey responses to questions (on confidence and surgery training experiences) were reduced to the nominal level by dividing the responses into agree (strongly agree and agree) and disagree (neutral, disagree, and strongly disagree) categories. The Chi-square or the Fisher’s exact test was used to assess the demographic predictors of residents’ confidence of performing the procedures. Significance was defined as $P < 0.05$.

| Table 1: Surgical resident survey questions on the practice of central venous catheter and chest tube insertions |
|--------------------------------------------------|
| Demographics                                      |
| Gender                                           |
| Postgraduation year                              |
| Program location                                 |
| Type of program                                  |
| Procedure education and training                 |
| Supervision during CVC or CT insertions          |
| Number of CVC and CT insertions, respectively     |
| Confidence of performing CVC and CT insertions   |
| Practice of maximal sterile barrier precautions and aseptic technique |
| Cap, mask, sterile gown, sterile gloves and a sterile body drapes during the procedures |
| Exposure of my scrub due to inadequate gowning during the procedures |
| Exposure of patients’ gown, tracheostomy tube, cervical collar, or bed sheet during the procedures |
| Hands cleaning with alcohol-based rubs, gels or foams prior the procedures |
| CVC insertion site cleaned with a chlorhexidine solution instead of a betadine solution |
| Others                                           |
| Routinely 24 h prophylactic antibiotics after a CT insertion |
| US for CVC insertion                             |

CVC: Central venous catheter, CT: Chest tube, US: Ultrasound

**Results**

**Respondent demographics and resident information**

There were a total of 239 surgery residents (132 in 2012 and 107 in 2013) in the US who participated in the survey. Only one respondent from the military residency program in 2012 was excluded from the study. Among the participants, 219 residents responded (125 in 2012 and 94 in 2013) with a complete survey. A complete survey was defined as >90% of the questions answered. The demographic characteristics of 219 residents are shown in Table 2.

**Education, training, and competency**

The majority of the residents (97%) agreed that they have received appropriate instructions on all steps of CVC and CT insertions, including adherence to the MSBPs, before performing the procedures. However, when we were asked if there was a presence of an attending staff physician during the procedure, 57% of the respondents answered “No.” As shown in Table 3, postgraduate year (PGY)-1 residents reported a most frequent supervision by an attending staff physician, which is statistically significant when compared with PGY-2 residents ($P < 0.001$).

The association between level of PGY and number of these two bedside procedures performed was assessed by the ordinal logistic regression model. As shown in Table 4, this model revealed that level of PGYs was a predictor of experience in both CVC and CT insertions in terms of number of procedures performed [Table 4].
The residents were asked to report their self-confidence of performing these two procedures. The demographic predictors of residents’ confidence of performing CVC and CT insertions are shown in Table 5. There was no difference regarding the confidence of performing CVC based on age or gender. In contrast, in terms of CT insertion, residents younger than 29 years old ($P < 0.01$ vs. age group of 30–34 years old) and of female sex ($P < 0.05$ vs. male) reported a lower confidence level. We further grouped the residents according to their PGY levels. As shown in Table 5, PGY-1 residents were less confident of performing either CVC or CT insertion ($P > 0.001$ vs. PGY-2 for either procedure).

**Using maximal sterile barrier precautions and aseptic technique**

Residents' reported adherence to the use of the different components of the MSBP's varied substantially. As shown in Figure 1, the majority of residents surveyed (87%) reported that they always wear a sterile gown, sterile gloves, cap, mask, and use large sterile drape when performing CVC or CT insertion. However, when they were asked if they tie and secure the gown on the back to prevent drop of the gown from the neck and anterior chest, 16 respondents (7%) reported that they did not secure the gown. As depicted in Figure 2, the gown drops from the front so that part of their scrub top is exposed. Sixteen responders (7%) also reported that, during the procedures of CVC or CT insertions, they saw patients' gown, tracheostomy tube, cervical collar, bed sheet, or other nonsterile parts of the bed.

We surveyed the residents to see if they cleanse their hands with either alcohol-based rubs, gels, or foams before these two procedures. Sixty-four respondents (29%) reported that

### Table 2: Demographic characteristics of 219 survey respondents

| Variable                | Respondents, n (%) |
|-------------------------|--------------------|
| PGY level               |                    |
| 1                       | 45 (21)            |
| 2                       | 61 (28)            |
| 3                       | 39 (18)            |
| 4                       | 37 (17)            |
| 5                       | 37 (17)            |
| Male to female ratio    | 1.3:1              |
| Program locations       |                    |
| Northeast               | 135 (62)           |
| South                   | 25 (11)            |
| Midwest                 | 40 (18)            |
| West                    | 19 (9)             |
| Type of program         |                    |
| University              | 154 (70)           |
| Community               | 65 (30)            |

*Percentages are rounded-up and may total >100. PGY: Postgraduate year

### Table 3: Percent of respondents who reported of the absence of supervision while performing the procedures

| PGY | n (%) | P     |
|-----|-------|-------|
| 1   | 13 (29)| <0.001|
| 2   | 40 (66)| Reference |
| 3   | 29 (74)| 0.351 |
| 4   | 20 (54)| 0.258 |
| 5   | 22 (59)| 0.544 |

PGY: Postgraduate year

### Table 4: Postgraduation year as predictor of experience of central venous catheter and chest tube insertions using ordinal logistic regression model

|          | OR   | 95% CI       | P*  |
|----------|------|--------------|-----|
| CVC: CVC insertion | 0.18 | 0.11-0.28    | <0.001 |
| CT: CT insertion   | 0.19 | 0.14-0.26    | <0.001 |

CVC: Central venous catheter, CT: Chest tube, OR: Odds ratio, CI: Confidence interval, *P<0.05 indicates statistical significance

### Table 5: Respondents who were not confidence of performing central venous catheter and chest tube insertions

| Variable                | Total   | CVC | P*  | CT | P*  |
|-------------------------|---------|-----|-----|----|-----|
| Age                     |         |     |     |    |     |
| ≤29                     | 82      | 13 (16) | 0.20 | 16 (20) | <0.01 |
| 30-34                   | 113     | 11 (10) | Reference | 8 (7) | Reference |
| 35-39                   | 20      | 2 (10)  | 0.97 | 2 (10) | 0.66 |
| ≥40                     | 4       | 0     | NA  | 0  | NA  |
| Gender                  |         |     |     |    |     |
| Male                    | 124     | 2 (10)  | Reference | 9 (7) | Reference |
| Female                  | 95      | 14 (15) | <0.25 | 17 (18) | <0.05 |
| PGY level               |         |     |     |    |     |
| 1                       | 45      | 15 (33) | <0.001 | 18 (40) | <0.001 |
| 2                       | 61      | 4 (7)   | Reference | 1 (2) | Reference |
| 3                       | 40      | 1 (3)   | 0.65 | 3 (8) | 0.30 |
| 4                       | 37      | 3 (8)   | 1.00 | 3 (8) | 0.15 |
| 5                       | 37      | 3 (8)   | 1.00 | 2 (5) | 0.55 |
| Program type            |         |     |     |    |     |
| University              | 154     | 20 (13) | Reference | 16 (10) | Reference |
| Community               | 65      | 6 (9)   | 0.75 | 11 (17) | 0.19 |

*P values of $\chi^2$ or Fisher’s exact test comparing residents’ responses with particular demographic or programmatic characteristics to a particular reference in the same category. CT: Chest tube, CVC: Central venous catheter, PGY: Postgraduate year, NA: Not available
they did not often do so. In terms of preparing the skin before CVC insertion, 216 respondents (99%) reported that they used 0.5% chlorhexidine preparation with alcohol instead of tincture of iodine.

**Others (presumptive antibiotics after chest tube insertion and routine ultrasound use for central venous catheter insertion)**

Other important questions asked in this survey were the presumptive antibiotic use for CT insertion and routine ultrasound use for CVC insertion. Thirty-eight respondents (17%) reported the routine use of presumptive antibiotics following CT insertion [Figure 3]. As shown in Table 6, residents in community training programs less frequently used presumptive antibiotics after CT insertion as compared to those in university training programs (Fisher’s exact, $P < 0.005$). PGY-2 residents are less likely to use antibiotic for CT insertion when compared with PGY-1 residents ($\chi^2$, $P < 0.005$). In terms of the application of ultrasound for CVC placement, 65% of the residents reported routine use of ultrasound guidance for CVC placements. There is no difference in the ultrasound use between residents from university and community programs.

**Discussion**

The purpose of this study was to investigate whether surgery residents are applying evidence-based guidelines in performing these bedside procedures. Our study demonstrates a substantial variation in this practice among surgery residents in the US. To our best knowledge, we are the first to study the surgery residents’ practice pattern regarding these two procedures. Although the overall response rate was low, we believe that the data gathered are generally reflective of current practice of CVC and CT insertions among surgery residents in the US.

The cost of CRBSIs[7] and post-CT insertion empyema[12-14] is substantial, in terms of both morbidity and financial resources expended. To improve patient outcome and to reduce healthcare costs, there is considerable interest by healthcare providers, insurers, regulators, and patient advocates in reducing the incidence of these infections. The goal of an effective prevention program should be the elimination of CRBSIs after CVC insertion and empyema after CT insertion from all patient-care areas. To achieve this goal, preprocedural education and training are imperative. Previous studies have demonstrated the importance of education and training of healthcare professionals in the management of CVC and CT insertions.

Figure 2: Central venous catheter placement. Depicted in figure are breaches in sterile technique including maximal sterile barrier precaution, gown drop, and exposure of patient’s nonsterile subjects. Consents for photograph were obtained from the patient’s family and the resident

Figure 3: Percentage of residents responded to questions regarding use of ultrasound for central venous catheter insertion and antibiotic for chest tube insertion

| Table 6: Responses to questions regarding ultrasound use for central venous catheter insertion and application of 24 h antibiotic after chest tube insertion |
|-----------------|-----|-----|-----|-----|-----|-----|-----|
|                  | PGY level |       |       |       |       |       |
|                  | 1     | 2     | 3     | 4     | 5     |       |
| n                |       |       |       |       |       | 154  |
| CVC: US          |       |       |       |       |       | 65   |
| Yes (%)          | 30 (67)| 43 (70)| 21 (53)| 24 (65)| 25 (67)|       |
| No (%)           | 15 (33)| 18 (30)| 19 (47)| 13 (35)| 12 (33)|       |
| $\chi^2$        | Reference| 0.675 | 0.183 | 0.864 | 0.931 |       |
| CT: Antibiotic use |       |       |       |       |       |       |
| Yes (%)          | 13 (29)| 4 (7) | 5 (12) | 6 (23) | 10 (27) |       |
| No (%)           | 32 (71)| 57 (93)| 35 (88)| 31 (77)| 27 (73) |       |
| $\chi^2$        | Reference| 0.002 | 0.109 | 0.199 | 1.00  | 0.003 |

*P values of $\chi^2$ or Fisher’s exact test comparing residents’ responses with particular demographic or programmatic characteristics to a particular reference in the same category. CT: Chest tube, CVC: Central venous catheter, PGY: Postgraduate year, US: Ultrasound
personnel regarding the indications for intravascular catheter use, proper procedures for the insertion and maintenance of intravascular catheters, and appropriate infection control measures to prevent intravascular catheter-related infections.

Similarly, data from previous studies demonstrated that with adequate education and training on CT insertion, the risk of complications can be reduced. Although strong evidence of the relationship between physician’s education and training with outcomes, this recommendation is not well compliant among residents, as shown in the current study. Our study shows that roughly only half of the surgery residents surveyed reported that there was attending staff surgeon’s presence while performing the CVC or CT insertion. It is not clear how many surgery residency training programs in the United States implement these preprocedural education and training. However, this should be strongly advocated.

Confidence is a feeling of trust in one’s own abilities, qualities, and judgments. In our study, surgical interns are less comfortable performing CVC and CT insertions. We also reveal that younger age and female sex were negative predictors of self-confidence in performing CT insertions. It is easily understandable that junior residents, because of their PGY level and less experience with these procedures, had less self-confidence in performing these procedures. We do not know if a younger age necessarily indicates a junior level in the resident training program. However, younger surgery residents in our survey felt less confident about performing these procedures. Our data on female residents’ lack of self-confidence in performing these procedures are supported by other studies. Bucholz et al. conducted a national survey of 4136 US general surgery residents in 2008 and found that female residents were twice more likely than male residents to worry about their competency after general surgery training. Nomura et al. also reported lower confidence levels in female primary care medicine residents in terms of physical examination and procedural skills. On the other hand, self-reported feelings of confidence do not necessarily correlate well with objective measures of competence and skills, as shown by a previous study by one of our authors (JH).

MSBPs are defined as wearing a sterile gown, sterile gloves, and cap and using a full-body drape (similar to the drapes used in the operating room) during the bedside procedures. MSBPs are recommended for all invasive bedside procedures including CVC and CT insertions. Several observational studies have demonstrated that a bundle approach, including hand hygiene, MSBPs, cleaning the skin with 2% chlorhexidine, antibiotic-impregnated CVCs, and avoiding femoral insertion sites, resulted in decreasing CRBSIs. The study also confirmed that contamination during CT insertion is a major cause of development of pneumonia and empyema. It is recommended with category “IA” for the prevention of CRBSIs infection in the Healthcare Infection Control Practices Advisory Committee guideline published in 2002 and current guidelines. MSBP is also recommended for CT insertion by the British Thoracic Society Standards of Care Committee. In our study, only 87% of the residents reported that they always use MSBP and 7% of the residents reported that their gown drops during the procedures. It is a serious concern. Previous studies reported a 6-fold reduction in the incidence of septicemia when full-barrier technique is used, compared with the use of only sterile gloves and the small drape provided in the typical CVC kit. The importance of MSBP should be implemented in resident in-service education and training. The use of MSB should also be emphasized on the person assisting with the procedure. Compliance with MSBP could also be increased by ensuring that all residents involved in CVC and CT insertions must be appropriately educated and must be supervised by a certified/privileged practitioner (e.g., attending staff physician, fellow, and senior resident) until properly certified to perform the procedure independently.

Considerable debate continues as to whether presumptive antibiotics should be given following CT insertion. CT insertion is considered a “clean contaminated” procedure, especially when it is performed in the emergency department for trauma patients. CT insertion carries a potential complication of infections ranging from 1.1% to 4%..

Although the newer guidelines by the Eastern Association for the Surgery of Trauma did not recommend for or against presumptive antibiotics following CT insertion because of insufficient published evidence, a recent systemic literature review and meta-analysis concluded that infectious complications are less likely to develop if presumptive prophylactic antibiotic is administered following CT insertion after penetrating trauma. In our survey, only 17% of the surgery residents reported a routine use of presumptive antibiotics following CT insertion. Furthermore, residents from community programs are less likely to give antibiotics after CT insertion as compared with those from university programs. The reason for this discrepancy between community and university training programs is unknown. While the debate regarding presumptive use of antibiotics following CT insertion continues, residents’ practice of presumptive use of antibiotics will continue to be diversified.

Besides infectious complications related to CVC placement, other important complications associated with CVC insertion is the mechanical ones, including pneumothorax. CVC placement is an intuitively simple but technically challenging procedure. Previous studies have demonstrated that the use of ultrasound is an effective means of reducing the number of cannulation attempts and the rate of complications associated with CVC placement. In the 2011 practice guidelines for the prevention of intravascular catheter insertion, use of ultrasound guidance to place CVC (if this technology is available) is recommended. In our study, 65% of the residents reported routine use of ultrasound guidance for a CVC placement. In the era of universal availability of ultrasound in hospitals, it is not clear why the other 35% of surgery residents did not routinely use this technique. This could be due to the lack of in-service education and training on the ultrasound use or simply the preference of attending staff physicians. Regardless, the use of ultrasound-guided techniques in the CVC placement should be strongly encouraged.
While this study is unique in scope, it has several limitations. First, the survey was distributed through the ARCS list serve. We did not know exactly how many residents were actually invited for the survey. Therefore, the response rate was unknown but clearly low. Thus, the survey is subject to response bias and may not accurately reflect the current condition and opinions of all surgery residency programs throughout the United States. Second, the survey questions were in Likert scales, which may be subject to distortion from several causes. Although the residents were assured of strict confidentiality of the survey, respondents may avoid using extreme response categories (central tendency bias), agree with statements as presented (acquiescence bias), or just try to portray themselves in a more favorable light (social desirability bias).

**Conclusion**

Our study demonstrates that surgery residents do not strictly adhere to the evidence-based guidelines for CVC and CT insertions and considerable variation exists, which may contribute to complications associated with these procedures. This study opens new areas for interactive in-service education and training, feedback, and practices, as well as increased supervision, for these procedures in surgery residents to nurture self-confidence and reduce the risk of complications, especially the infectious one.

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**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

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