

Outcomes of Tube Thoracostomies Performed by Advanced Practice Providers vs Trauma Surgeons

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OUTCOMES OF TUBE THORACOSTOMIES PERFORMED BY ADVANCED PRACTICE PROVIDERS VS TRAUMA SURGEONS

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Background The role of advanced registered nurse practitioners and physician assistants in emergency departments, trauma centers, and critical care is becoming more widely accepted. These personnel, collectively known as advanced practice providers, expand physicians' capabilities and are being increasingly recruited to provide care and perform invasive procedures that were previously performed exclusively by physicians.

Objectives To determine whether the quality of tube thoracostomies performed by advanced practice providers is comparable to that performed by trauma surgeons and to ascertain whether the complication rates attributable to tube thoracostomies differ on the basis of who performed the procedure.

Methods Retrospective blinded reviews of patients' charts and radiographs were conducted to determine differences in quality indicators, complications, and outcomes of tube thoracostomies by practitioner type: trauma surgeons vs advanced practice providers.

Results Differences between practitioner type in insertion complications, complications requiring additional interventions, hospital length of stay, and morbidity were not significant. The only significant difference was a complication related to placement of the tube: when the tube extended caudad, toward the feet, from the insertion site. Interrater reliability ranged from good to very good.

Conclusions Use of advanced practice providers provides consistent and quality tube thoracostomies. Employment of these practitioners may be a safe and reasonable solution for staffing trauma centers. (*American Journal of Critical Care*. 2008;17:357-363)

Advanced registered nurse practitioners and physician assistants may increase access to health care in many settings. By expanding physicians' capabilities, these advanced practice providers (APPs) can compensate for shortages of physicians in underserved areas.¹ Initially concentrated in primary care,²⁻⁴ APPs are now commonly providing inpatient medical,⁵⁻⁸ surgical,^{9,10} and pediatric¹¹ care. Moreover, the care APPs provide is generally comparable to that provided by physicians.¹² The role of APPs in emergency departments,¹³ trauma centers,^{2,14-16} and critical care¹⁷ is becoming more widely accepted.

The restrictions implemented in 2003 on the number of hours surgical residents can work have affected many health care institutions,¹⁸ including, and perhaps disparately so, trauma centers. To fill the gaps created by these policy changes, APPs are being recruited to provide care in critical care settings and to perform invasive procedures that were previously performed exclusively by physicians.^{14,16} Research

supports the efficacy and safety of APPs' performance for placement of intracranial pressure monitors¹⁹ and insertion of arterial catheters.²⁰ However, little clinical research on the performance of tube thoracostomies by APPs is available.¹⁶

Tube thoracostomy is a technically advanced procedure requiring precision and skill. Incorrect tube placement can result in serious com-

plications, including pulmonary artery cannulation, empyema, unresolved pneumothorax, persistent effusion, tube malpositioning, and subcutaneous emphysema.^{12,21-24} These complications may contribute to patients' morbidity, mortality, and extended length of stay (LOS) in the hospital.

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The purpose of our study was to determine whether the quality of tube thoracostomies performed by APPs was comparable to that performed by surgeons and to ascertain whether the complication rates attributable to tube thoracostomies differ on the basis of which of these 2 practitioner types performed the procedure.

Methods

This retrospective, quasi-experimental, blinded chart review received approval from the institutional review board. The study sample consisted of all patients admitted to the trauma service at Wesley Medical Center, Wichita, Kansas, between June 1, 2003, and December 31, 2003, who required tube thoracostomy. Patients whose insertion of a thoracostomy tube involved medical students or residents were excluded. Data were gathered from the trauma registry, billing records, and patients' medical records.

Chest tubes were inserted in the trauma bay, the intensive care unit, or the operating room. Patients were sedated or had been given a general anesthetic. Sterile technique was maintained throughout. After administration of an antibiotic for prophylaxis, typically a first-generation cephalosporin (when possible²⁵) and a local anesthetic, the thoracostomy tube was inserted through an incision at or near the fifth intercostal space, near the midaxillary line. Blunt and sharp dissection were used as needed, and the pleural cavity was entered in a controlled fashion. After digital exploration to confirm that no pleural adhesions were present, a chest tube was inserted in a cephalad direction. The tube was sutured in place, covered with an occlusive dressing, and attached to a commercially available collection device at -20 cm of water suction. A chest radiograph was then obtained immediately.

Interpretation of chest radiographs by radiologists was used to determine the quality of tube thoracostomy placement. Patients' medical records were used to determine complications associated

Use of advanced practice providers is increasing in a variety of settings.

with the procedure. Each chart was assigned a random number to prevent reviewers from knowing whether a surgeon or an APP performed the tube thoracostomy. The chart was then reviewed for details and complications of the insertion procedure.

Demographic and clinical characteristics of the study population included sex, age, and Injury Severity Score. Guidelines offered by Deshpande et al²⁶ were used to evaluate appropriate positioning of chest tubes. Placement was deemed incorrect if the tube was positioned within the intrafissure or intrapulmonary space; the tip of the tube abutted into the mediastinum, heart, or apex; the tube was intra-abdominal or transdiaphragmatic; or the tube extended caudad (toward the feet) from the thoracostomy insertion site. Possible insertion-related complications included bleeding at the insertion site, reexpansion pulmonary edema, loss of pulse, and/or vasovagal phenomena. Outcome-related complications and relevant details included dislodgement of the thoracostomy tube, need for and timing of tube reinsertion, empyema, need for video-assisted thoracoscopic surgery or thoracotomy (along with timing and reason for such procedures), tube reinsertion less than 5 hours after scheduled removal, and increases in hospital LOS.

All chest radiographs obtained after insertion of thoracostomy tubes were reviewed by 3 different radiologists. Radiographs were evaluated for the following quality indicators: tube kinking; extrapleural position of the lateral drainage port; positioning of drainage port(s) within the fluid collection; abutment of the tube tip against mediastinal structures; placement within the lobar fissure, intra-abdominally, and/or transdiaphragmatically; and tube directed caudad from insertion site (a tube directed horizontally from the insertion site can result in intrafissure placement and therefore less optimal function of the chest tube because lung tissue surrounds the tube and occludes the drainage ports). Confirmation of quality indicators required the agreement of at least 2 of the 3 radiologists.

Statistical Analysis

Data were analyzed by using SPSS for Windows, versions 11.5 and 14.0.²⁷ The results are presented in means and standard deviations. The appropriateness of group comparison was evaluated by using χ^2 analysis and *t* tests. Interrater agreement was assessed by using intraclass correlation coefficient reliability and a 2-way mixed model, evaluating absolute agreement, and reporting the mean measures, coefficients, and confidence intervals.²⁸ Intraclass values were interpreted as follows: less than 0.20, poor; 0.21 to 0.40, fair; 0.41 to 0.60, moderate; 0.61 to 0.80, good;

and 0.81 to 1.00, very good.²⁹ The Fisher exact test was used to determine associations between complications and the type of practitioner who did the insertion. Hospital LOS was compared by using an independent samples *t* test.

Results

A total of 55 records were identified that documented tube thoracostomy performed during the 6-month study period. Of these, 4 records were excluded because of missing data; thus, 51 charts were included in the review. The study population (51 patients) was predominantly men (63%) and had a mean age of 41.8 years. A total of 5 APPs and 7 trauma surgeons performed the tube thoracostomies during the study period. Comparisons of patients' demographic and clinical characteristics (Table 1) revealed no statistical differences between the groups according to number of patients, number of tube thoracostomies, sex, age, Injury Severity Score, indications for tube thoracostomy, or mechanism of injury. The mean and median Injury Severity Scores were 22.3 (SD, 11.2) and 21.0, respectively. A total of 71 tube thoracostomies were performed for a variety of indications, including pneumothorax, hemothorax, hemopneumothorax, hemothorax, pleural effusion, and tension pneumothorax. Mechanisms of injury were motor vehicle collision, gunshot wound, stab wound, fall, animal-mediated injury, pedestrian injury, crushing injury, motor-cycle collision, and all-terrain vehicle collision.

Complication rates were similar between APPs and trauma surgeons.

Insertion Complications

No insertion complications (bleeding at the insertion site, reexpansion pulmonary edema, loss of pulse, or vasovagal phenomena), empyema, or tube dislodgements occurred. Video-assisted thoracoscopic surgery or thoracotomy was performed in 2 instances after tube insertions by trauma surgeons and in 1 instance after insertion by an APP; this difference was not significant ($P > .99$). A total of 3 tube thoracostomies required tube reinsertion less than 5 hours after scheduled tube removal: 1 performed by trauma surgeons and 2 performed by APPs ($P > .99$).

Placement Quality Indicators

Interrater reliability of quality indicators as assessed by 3 independent radiologists is given in Table 2. Agreement between at least 2 of 3 raters was required for the complication to be deemed conclusive.

Table 1
Demographics and clinical characteristics of the study population^a

Variable	Study population	Tube thoracostomy by practitioner type		P
		Surgeon	Advanced practice provider	
No. of patients	51	27 (53)	24 (47)	.67 ^b
No. of chest tubes inserted	71	33 (46)	38 (53)	.55 ^b
Men	32 (63)	16 (59)	16 (67)	.59 ^b
Age, mean (SD), y	41.8 (18.9)	41.7 (17.6)	41.9 (20.7)	.97 ^c
Injury Severity Score, mean (SD)	22.2 (11.2)	23.1 (13.6)	21.3 (8.0)	.58 ^c
Indication for thoracostomy				.28 ^b
Pneumothorax	21 (30)	8 (24)	13 (34)	
Hemopneumothorax	21 (30)	9 (27)	12 (32)	
Hemothorax	14 (20)	10 (30)	4 (11)	
Pleural effusion	8 (11)	4 (12)	4 (11)	
Tension pneumothorax	1 (1.4)	0 (0)	1 (2.6)	
No data	6 (8.5)	2 (6.1)	4 (11)	
Mechanism of injury				.16 ^b
Motor vehicle collision	25 (49)	12 (44)	13 (54)	
Gunshot wound	7 (14)	5 (19)	2 (8.3)	
Stab	5 (10)	4 (15)	1 (4.2)	
Fall	5 (10)	1 (3.7)	4 (17)	
Animal	3 (5.9)	2 (7.4)	1 (4.2)	
Pedestrian accident	2 (3.9)	2 (7.4)	0 (0)	
Crush	2 (3.9)	1 (3.7)	1 (4.2)	
Motorcycle collision	1 (2.0)	0 (0)	1 (4.2)	
All-terrain vehicle collision	1 (2.0)	0 (0)	1 (4.2)	

^a All values are number (%) unless indicated otherwise. Because of rounding, percentages do not all total 100.

^b Frequencies compared by using Pearson χ^2 .

^c Means compared by using independent sample *t* test.

Table 2
Interrater reliability (N = 71 insertions)

Quality indicator	Intraclass correlation coefficient ^a		P	Agreement by 3 radiologists
	Coefficient (CI)	Reliability ^b		No. of cases (%)
Tube kinking	0.873 (0.812-0.917)	Very good	<.001	64 (90)
Lateral drainage port extrapleural	0.787 (0.681-0.862)	Good	<.001	62 (87)
Tube extending caudad from insertion site	0.826 (0.742-0.886)	Good	<.001	63 (89)
Abutment to mediastinum	0.768 (0.655-0.848)	Good	<.001	48 (68)
Intrafissure placement	ND	ND	ND	70 (99)
Intra-abdominal/transdiaphragmatic placement	ND	ND	ND	69 (97)

Abbreviations: CI, confidence interval; ND, no data; reliability could not be assessed because at least one rater in pair(s) was constant.

^a 2-way mixed model; absolute agreement; average measures reported.

^b Reliability interpretation from Altman.²⁹

Interrater reliability was very good for the interpretation of tube kinking and good for lateral drainage port extrapleural, tubes directed caudad from the insertion site, and tube tip abutment against mediastinal structures. No cases of intrafissure or intra-abdominal/transdiaphragmatic tube insertions were interpreted by more than 1 rater. Rating agreement for these 2 complications was unanimous for 70 of 71 insertions for intrafissure placement and 69 of 71 insertions for intra-abdominal or transdiaphragmatic placement.

None of the patients in the study experienced bleeding at the insertion site, reexpansion of pulmonary edema, loss of pulse, or a vasovagal episode. Table 3 shows the quality indicator results for the total sample and for practitioner type. The only significant difference according to practitioner type ($P = .02$) was for tubes directed caudad from the insertion site. This complication occurred in 7 of 33 insertions (21%) made by surgeons and in 1 of 38 insertions (2.6%) made by APPs.

Table 3
Comparison of quality indicators between surgeons and advanced practice providers

Quality indicators	Study population (N = 71)	Tube thoracostomy by practitioner type		p ^a
		Surgeon (n = 33)	Advanced practice provider (n = 38)	
Tube kinking	9 (13)	5 (15)	4 (11)	.72
Lateral drainage port extrapleural	7 (10)	3 (9.1)	4 (11)	>.99
Tube extending caudad from insertion site	8 (11)	7 (21)	1 (2.6)	.02
Abutment to mediastinum	24 (34)	12 (36)	12 (32)	.80
Intrafissure placement	0	0	0	
Intra-abdominal/transdiaphragmatic placement	0	0	0	
Complications requiring additional interventions				
Dislocation of chest tube	0	0	0	
Empyema	0	0	0	
Video-assisted thoracoscopy/thoracotomy	4 (5.6)	3 (9.1)	1 (2.6)	.34
Reinsertion of chest tube <5 hours after removal	3 (4.2)	1 (3.0)	2 (5.3)	>.99

^a Fisher exact test used.

Complications Requiring Additional Interventions

A total of 4 of the 71 tube thoracostomies (5.6%) required video-assisted thoracoscopic surgery or thoracotomy: 3 of 33 insertions (9%) performed by trauma surgeons and 1 of 38 insertions (2.6%) performed by APPs. Among the 4 video-assisted thoracoscopic surgeries, 2 occurred within 48 hours of admission in patients with gunshot wounds, 1 was done to evaluate a diaphragmatic injury, and 1 was done to evaluate continued chest tube drainage in a patient whose chest tube had been inserted at an outlying facility. Reinsertion of the chest tube was required in 3 of the 71 tube thoracostomies (4.2%): 1 of the 33 insertions (3%) performed by trauma surgeons and 2 of the 38 insertions (5.3%) performed by APPs. The occurrence of these complications did not differ according to practitioner type.

Of note, the review of patients' charts indicated that all tube thoracostomy complications documented had favorable resolutions.

Outcome Quality Indicators

Data on 3 patients were excluded from analysis of hospital LOS because their LOS was greater than 2 SDs from the mean. One of these patients, who had been crushed and buried in a sand pit, required tube thoracostomy on the 12th hospital day. Another patient, who had been in a motor vehicle collision, was transferred from an outside facility and had bilateral tube thoracostomy when admitted to our facility. A new tube thoracostomy was performed on day 26 because of pneumothorax. The third patient, who had multiple gunshot wounds to the chest, head, and back, had left-sided tube thoracostomy on day 1 and right-sided tube thoracostomy on day 31; both thoracostomies were

performed to treat hemopneumothoraces. The mean LOS for the remaining 48 patients was 13.3 (SD, 7.4) days; 11.8 (SD, 6) days and 14.2 (SD, 9) days for surgeons and APPs, respectively. The mean hospital LOS did not differ significantly according to practitioner type ($t_{46} = -1.6$; $P = .11$).

No deaths occurred as a direct result of tube thoracostomy. Among the 51 patients in the study, 4 died of closed head injuries and 1 of a gunshot wound.

Discussion

Reported complication rates associated with tube thoracostomy are variable. Overall, the rate of complications requiring additional intervention in our study was 11% (12% for trauma surgeons and 8% for APPs). These results are consistent with those of other published reports. Etoch et al³⁰ reported an overall complication rate of 21% for tube thoracostomies at their level I trauma center; the rates were 6% for surgeons, 13% for emergency physicians, and 38% for referring physicians. In the study by Chan et al,²² the rates were 14% for physicians in the emergency department, 9% for physicians in the operating room, and 25% for physicians in the inpatient wards. Deneuille³¹ prospectively followed patients requiring tube thoracostomy and found a 25% overall complication rate for this procedure. Complication rates of tube thoracostomy performed by APPs have not been previously published.

Use of APPs may be a safe and reasonable solution for staffing trauma centers. Spisso et al¹⁵ found a decrease in trauma patients' LOS after the addition of nurse practitioners to the trauma service. Miller

All tube thoracostomy complications documented had favorable resolutions.

APPs offer a safe and reasonable solution for staffing trauma centers.

et al¹⁶ described the role of APPs in a level II trauma center, which included having APPs perform tube thoracostomy. Oswanski et al¹⁴ retrospectively reviewed their experience with APPs collaborating with residents on a trauma service and found no effect on patients' mortality and a decrease in patients' LOS. They proposed APPs as a staffing option in the operation of other level II trauma centers and, perhaps, level I centers.¹⁴ Furthermore, satisfaction of patients and clinicians, as well as cost-effectiveness, has been positively associated with use of APPs.^{8,32,33}

The APPs in our study were licensed to practice in the state of Kansas and had completed their education in accredited programs. APP training in tube thoracostomy is taught in Fundamental Critical Care

Support and Advanced Trauma Life Support courses by attending surgeons. After training, each APP is directly proctored in the completion of 10 tube thoracostomies. The American College of Chest Physicians guidelines²³ call for at least 10 placements of chest tubes to establish competency, and 5 placements per year are required for competency

maintenance. In contrast, Miller et al¹⁶ reported that only 5 placements were required. At Wesley Medical Center, APPs are considered credentialed after they have completed 10 placements of chest tubes. APPs who have attained privileges in tube thoracostomy, after proctoring and credentialing, are allowed to perform this procedure while indirectly supervised.

Limitations

In our study, tube thoracostomies performed by APPs were limited to those performed during direct or indirect oversight by the attending trauma surgeons, in accordance with training guidelines.³² As the supervising physician, the trauma surgeon retained responsibility for the procedures. Because certain patients or situations may present specific challenges for a novice in performing tube thoracostomy, variations in the level of surgeons' participation in the tube thoracostomies performed by APPs would be expected.

Lack of randomization among practitioner types could be considered a limitation; however, the non-significant differences between the 2 types in population demographic and clinical characteristics suggests that comparison of subgroups was appropriate. The study also was limited by the small number of patients who had tube thoracostomies during the study period; additional investigations therefore are necessary to validate our conclusions.

Interpretation of chest radiographs has subjective elements. Because the radiologists in the study were not provided with consensus training or allowed access to patients' records, we were reassured by the acceptable levels of interrater reliability. The clinical literature indicates that moderate, rather than high, levels of agreement in interpretation of chest radiographs may be common.³⁴⁻³⁹

Conclusion

Our evaluation of the complication rates associated with tube thoracostomy done by APPs and by trauma surgeons expands on earlier findings about the appropriateness of having nonphysicians care for patients.^{2,9,10,14,15,17} With increasing demand for trauma and emergency care,^{40,41} the challenges of an aging and expanding North American population that is threatening to outgrow its health care workforce,⁴² and the relatively recent restrictions on residents' work hours,⁴³ more health care centers are turning to educated and supervised APPs to participate in procedures once reserved for physicians. APPs may increase the availability of health care and offer safe and valuable alternatives to trauma center staffing.

Wesley Medical Center, which is an American College of Surgeons-verified, level I trauma center, maintained accreditation while using this model of trauma team structure and patient care. Our results support the conclusion that the quality of tube thoracostomies performed by APPs is neither statistically nor clinically inferior to that of tube thoracostomies performed by attending trauma surgeons. These findings add to the evidence that well-educated and supervised APPs may safely and competently enhance and expand the trauma/emergency center staffing model and thereby benefit such centers considerably, not only in this procedure but in the overall care of trauma patients.

FINANCIAL DISCLOSURES

None reported.

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