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ORIGINAL ARTICLE

Safety and Feasibility of Percutaneous Tracheostomy Performed by Neurointensivists

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Abstract

Introduction We evaluated the effects of a change from routine surgical tracheostomy (ST), performed primarily by ENT surgeons, to bedside percutaneous tracheostomy (PT) performed by neurointensivists.

Methods The first 67 PT procedures performed by neurointensivists were retrospectively reviewed, and compared with 68 consecutive ST procedures performed during the previous year. Demographics, severity of illness, procedural complications, incidence of ventilator-associated pneumonia (VAP), duration of mechanical ventilation (DMV), length of stay (LOS), and hospital charges were evaluated.

Results Age, race, gender, neurological diagnoses, comorbid illnesses, and Glasgow coma scale on admission and the day of tracheostomy were similar. Procedural complications occurred in 8% of PT patients and 9% of ST patients, including clinically significant bleeding, transient loss of the airway, ICP rise requiring treatment, or acute lung injury ($P = 0.3$). PT was performed earlier than ST (median [interquartile range] ventilator day 8 [4–11] vs. 12 [8–18], $P = 0.001$). Median DMV was shorter in the PT cohort (19 [10–27] vs. 24 [16–33] days, $P = 0.02$), as was median ICU LOS (15 [9–21] vs. 19 [12–27] days, $P = 0.01$). ICU charges (US dollars) were lower in the PT cohort (median $123,404 vs. $156,311, $P = 0.01$). Trends toward less VAP, shorter hospital LOS, and lower total hospital charges among patients receiving PT did not achieve significance.

Conclusions PT performed by neurointensivists was safe compared to ST. Timely PT by neurointensivists may offer significant advantages in terms of ventilator weaning, ICU LOS, and the cost of care.

Keywords Percutaneous tracheostomy · Ventilator-associated pneumonia · Ventilator days · Length of stay · Neurointensivist

Introduction

Percutaneous dilational tracheostomy has been compared extensively to surgical tracheostomy (ST), with a favorable profile characterized by fewer wound infections, lower rates of clinically significant bleeding, and significant cost savings [1–6]. Percutaneous tracheostomy (PT) is commonly performed by surgeons, anesthesiologists, and medical intensivists [7, 8]; guidelines for the training and credentialing of interventional pulmonologists published by the American College of Chest Physicians suggest that a minimum of 20 procedures are typically required to gain basic procedural competency [9]. PT performed by neurointensivists, a recognized subspecialty under the United Council of Neurological Subspecialties [10], has not been widely described.

There are several reasons why PT might be an appropriate skill for neurointensivists to develop. The frequency of tracheostomy is high among the population served by neurocritical care physicians, including a significant

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number of patients with ischemic stroke [11], intracerebral hemorrhage [12], subarachnoid hemorrhage [13], traumatic brain injury [14–16], hypoxic-ischemic encephalopathy, and status epilepticus. Neurointensivists may be more vigilant in recognizing and managing subtle dangers to brain injured patients that may occur during the procedure, such as hypoventilation, head-down positioning, hypoxia, hypotension, and elevated intracranial pressure (ICP) [13, 17–19]. Finally, tracheostomy decreases the work of breathing [20], and early tracheostomy is increasingly recognized as a potential method for reducing the duration of mechanical ventilation (DMV), the frequency of ventilator-associated pneumonia (VAP), intensive care unit length of stay (ICU LOS), and mortality [21, 22] among patients who require prolonged mechanical ventilation. Finally, neurointensivists are well poised to judge the optimal timing of tracheostomy in their patients, avoiding the delays of unnecessary consultation and surgical scheduling.

In the fall of 2007, we initiated a program of routine bedside PT as an alternative to open ST. Initially these procedures were performed by neurointensivists (N.B., K.L.) under the supervision of a pulmonary intensivist (D.B.S.), but later were performed by neurocritical care fellows under the supervision of neurointensivists. In this report, we compare our initial experience with PT to a consecutive series of ST procedures performed during the previous year by otolaryngology and cardiothoracic surgery residents under the supervision of surgical attendings.

Methods

Routine percutaneous dilational tracheostomy performed by neurointensivists was initiated in our 18-bed neuro-ICU in September 2007. All patients were determined to need long-term mechanical ventilation or airway protection by their attending physicians. Written informed consent was obtained for each procedure, and a surgical "time-out" was performed before each procedure. Patients received sedation with propofol or midazolam, intravenous analgesia with fentanyl, and topical analgesia with 1.5% lidocaine with 1:200,000 epinephrine. All patients were paralyzed for the procedure with vecuronium or *cis*atricurium. Percutaneous dilational tracheostomy was performed through a 1.5-cm transverse incision at the second of third cartilaginous interspace using a modification [23] of the procedure initially described by Ciaglia et al. [24], with the Cook Ciaglia Blue Rhino PT kit. Because of concern for hypoventilation and elevated ICP [13, 17–19] associated with bronchoscopy, capnography was routinely used to verify tracheal positioning of the tube [25], with bronchoscopy available for evaluation of the airway or tracheostomy placement, if necessary. All patients received assist control mode ventilation and FiO_2 1.0 throughout the procedure.

After receiving approval from the Columbia University Institutional Review Board, retrospective review of the charts and billing records of these PT patients, and sequential patients who received ST during the preceding year, was performed. Demographics, history, admission diagnoses, Glasgow Coma Scale score on admission and on the day of tracheostomy, complications of the procedure, ventilator settings, and modified Rankin score on hospital discharge were recorded. Complications were carefully reviewed, with major bleeding defined as that warranting bronchoscopy, causing airway obstruction, requiring blood transfusion, or causing new radiographic infiltrates and a durable worsening of oxygenation after the procedure. Loss of control of the airway during the procedure, even without harm, was considered an adverse event, as was an increase in ICP that warranted treatment with hyperventilation or osmotherapy. Patients were considered to have VAP if they received the clinical diagnosis more than 48 h after intubation, received antimicrobial therapy, and had a new radiographical infiltrate and two of three clinical criteria: purulent secretions, fever, and leukocytosis or leukopenia [26].

Cost data were estimated based on direct hospital charges billed to the patient, and as a function of ICU LOS, billed at $8227 per ICU day, the standard room charge in our unit. Modified Rankin score (mRs) [27] at discharge was determined from the physician discharge records, nursing and therapy notes, and social work records.

Non-normally distributed data were expressed as median values and compared with the Mann–Whitney *U*-test. *P*-values less than 0.05 were considered significant.

Results

Sixty-seven patients who underwent PT by neurointensivists between September 2007 and April 2008 were compared with 68 sequential patients during the preceding year that had a tracheostomy performed by surgeons. Of the 68 preceding tracheostomy procedures, 6 were percutaneous bedside tracheostomy performed by the cardiothoracic surgery service, and 62 were open ST performed by the ENT service. The demographic characteristics of these patients are described in Table 1.

Age, gender, race, past medical history, and GCS at both the time of hospital admission and the date of tracheostomy were similar between the cohorts. Admitting diagnoses were also statistically similar, with a mild excess of ischemic stroke in the PT cohort.

Major procedural complications included clinically significant bleeding, present in five (7%) ST patients and

Table 1 Baseline characteristics of tracheostomy patients

	Surgical[a] ($n = 68$)	Neurointensivist[b] ($n = 67$)	P
Age, years, mean (SD)	58 (18)	60 (18)	0.5
GCS score[c], median (IQR)	8 (6–14)	8 (5–11)	0.4
Women, n (%)	34 (51)	30 (45)	0.6
Race, n (%)		0.2	
Black	10 (17)	17 (25)	
White, non-Hispanic	28 (47)	24 (36)	
White, Hispanic	16 (27)	24 (36)	
Asian	6 (10)	2 (3)	
Diagnosis, n (%)			1.0
Intracerebral hemorrhage	19 (28)	17 (25)	
Ischemic stroke	8 (12)	13 (19)	
Subarachnoid hemorrhage	9 (13)	8 (12)	
Traumatic brain injury	6 (9)	4 (6)	
Neuromuscular disease	6 (9)	4 (6)	
Status epilepticus	6 (9)	8 (12)	
CNS tumor	4 (6)	4 (6)	
Cardiac arrest	4 (6)	4 (6)	
Other[d]	5 (8)	5 (8)	
Past medical history, n (%)			
COPD[e]	1 (2)	4 (6)	0.4
Coronary artery disease	8 (12)	7 (10)	1.0
Congestive heart failure	5 (8)	4 (6)	1.0
Hypertension	35 (52)	38 (57)	0.4
Diabetes mellitus	53 (21)	53 (21)	1.0

[a] Represents group of tracheostomies performed by surgical teams

[b] Represents group of tracheostomies performed by neurointensivist team

[c] Glasgow Coma Scale score

[d] Represents a mixed group of low frequency diagnoses including hepatic encephalopathy, encephalitis, central apnea syndrome, multiple sclerosis, botulism, extrapontine myelinolysis, lung cancer, movement disorders, and ADEM

[e] COPD Chronic Obstructive Pulmonary Disease

Table 2 Comparison of clinical characteristics and complications between surgical and non-ST groups

	Surgical	Neurointensivist	P-value
GCS score[a]	9 (6–10)	8 (5–10)	0.3
Ventilator day[b]	12 (8–18)	8 (4–11)	<0.001
Post-injury day[c]	16 (1–21)	9 (5–15)	<0.001
Complications			0.4
Bleeding[d]	5 (8)	2 (3)	
Lost airway	0 (0)	1 (2)	
Rise in ICP	0 (0)	1 (2)	
Infection	1 (2)	0 (0)	

[a] Glasgow Coma Scale score

[b] The median (IQR) number of days ventilated prior to tracheostomy

[c] Median (IQR) number of days after injury that tracheostomy was performed

[d] Defined as bleeding that required transfusion within 48 h of tracheostomy

two (3%) PT patients (Table 2). Both of the PT patients had oozing around the tracheostomy site that resolved with packing, and were treated with a transfusion of packed red blood cells within 72 h of the procedure. Three of the ST patients had serious bleeding into the airway. All of these patients required bronchoscopy; one had severe lung injury, hypoxemia, and massive bilateral infiltrates after the procedure; one had bleeding that ultimately stopped without intervention; and one experienced respiratory and cardiopulmonary arrest, with resultant hypoxic-ischemic encephalopathy (successfully treated with therapeutic hypothermia) as a result of airway obstruction from blood clots. One patient in the ST group developed a wound infection requiring intravenous antimicrobial therapy, one patient in the PT group suffered loss of the airway requiring the procedure to be suspended while the patient was reintubated, and one patient developed ICP crisis during PT with bronchoscopy, that resolved with hyperventilation and a bolus of 23.4% saline solution.

Percutaneous tracheostomy patients were ventilated for a shorter period of time at the time of tracheostomy as compared to ST patients (median ventilator day 8 [IQR: 4–11] vs. 12 [IQR: 8–18], $P < 0.001$). Patients in the PT group also underwent tracheostomy sooner after their injury than the ST patients (median post injury day 9 [IQR: 5–15] vs. 16 [IQR: 1–21], $P < 0.001$). PT patients also had shorter median days on a mechanical ventilator (19 [IQR: 10–27] days vs. 24 [IQR: 16–33] days, $P = 0.02$). Though there was an overall lower frequency of ventilator associated pneumoni (VAP), it did not reach statistical significance (69% vs. 79%, $P = 0.1$). Median ICU length of stay (LOS) and hospital LOS were both shorter in the PT cohort. This translated into lower median ICU charges in the PT group. The median discharge modified Rankin scores were identical in the two cohorts (Table 3).

Discussion

In our initial 8-month experience, percutaneous dilational tracheostomy performed at the bedside proved safe, convenient, and cost effective in the hands of neurointensivists. When compared to primarily ST the preceding year, patients received PT sooner, had shorter ICU LOS, shorter DMV, and lower ICU charges. Trends toward a lower incidence of VAP, shorter hospital LOS, and lower overall charges for hospital care were also present, but did not achieve statistical significance.

Table 3 Comparison of clinical outcomes and associated costs between tracheostomies performed by surgeons and neurointensivists

	Surgical[a]	Neurointensivist[b]	*P*-value
VAP	53 (79)	46 (69)	0.2
Ventilator days	24 (16–33)	19 (10–27)	0.02
ICU LOS	19 (12–27)	15 (9–21)	0.01
Hospital LOS	30 (19–42)	25 (17–35)	0.1
Cost of ICU stay	$156,311 ($98,722–$222,126)	$123,404 ($71,985–$174,822)	0.01
Cost of hospital stay	$339,332 ($213,917–$466,785)	$264,820 ($167,540–$403,270)	0.07
Discharge modified Rankin score	5 (4–5)	5 (4–5)	0.8

[a] Represents group of tracheostomies performed by surgical teams

[b] Represents group of tracheostomies performed by neurointensivist team. All values presented as either number (percentage) or median (interquartile range)

The most likely explanation for earlier PT than ST was the avoidance of real-world delays associated with the process of consultation and surgical scheduling. This translated into a median reduction in ICU LOS of 4 days, or viewed another way, the elimination of approximately 33 unnecessary ICU occupancy days per month accounted for by patients waiting for tracheostomy. Earlier tracheostomy also probably facilitated ventilator weaning, and was in turn related to shorter DMV and ICU LOS, and a trend toward less VAP [20, 22, 28]. Although the indications for tracheostomy are not uniformly agreed upon, there is a strong trend in critical care medicine toward performing tracheostomy earlier, when prolonged mechanical ventilation or need for airway protection are anticipated [29], and in the ICU using a percutaneous technique [1]. Our findings lend additional support to those concepts.

Our study was retrospective in nature, not randomized, and therefore subject to the potential biases of the research design. Recognizing that tracheostomy may have been performed on patients who were less sick in the PT cohort, we evaluated admission diagnoses and GCS on admission and on the day of tracheostomy, and found no difference. Nonetheless, some of the apparent benefits of PT could have been due to a subtly less-sick patient cohort. Almost all the tracheostomies in both cohorts were performed by trainees, at various experience levels, clouding a true comparison of the surgical and percutaneous techniques, and accounting for a rate of "major complications" that is in the upper range of those reported in most series [1, 2, 30–32]. However, all procedures in both groups were supervised by fully trained and credentialed physicians, reflecting the reality in teaching hospitals around the world. Finally, because procedural complications were recorded by physicians performing one arm of the comparators (the PT group), it is possible that their bias crept into the interpretation of complications, although the converse might also be true, that the neurointensivists performing PT were more closely observed, and the complications more rigorously recorded.

Our experience indicates that percutaneous dilational tracheostomy can be safely performed by neurointensivists, facilitating timely procedures and potentially shortening the DMV, reducing ICU LOS, and decreasing the overall cost of healthcare. Tracheostomy is an ancient [33] and important critical care skill, commonly employed in patients with severe brain injury, which helps develop expertise in airway management, and should be strongly considered as a standard part of neurocritical care training [10].

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