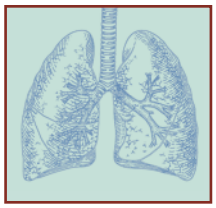

Comparison of Respiratory Infections Before and After Percutaneous Tracheostomy

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Background A tracheostomy is often performed when patients cannot be weaned from mechanical ventilation. Respiratory infections (ventilator-associated pneumonia and infection of the lower respiratory tract) complicate the course of hospitalization in patients receiving mechanical ventilation.
Objectives To evaluate respiratory infections before and after a percutaneous tracheostomy and to describe their outcomes.
Methods Medical records of adults who had percutaneous tracheostomy during a 1-year period at a tertiary care hospital in the southeastern United States were reviewed retrospectively.
Results Data for 322 patients were analyzed. Patients were predominately male (63.0%) and white (57.8%), with a mean age of 57.4 years. Ventilator-associated pneumonia or infection of the lower respiratory tract was identified in 90 patients (28.0%); the majority of infections were lower respiratory infections. Of all infections, 52% occurred before the tracheostomy, and 48% occurred after the procedure. Respiratory infections were associated with longer stays and higher costs, which were significantly higher in patients in whom the infection developed after the tracheostomy. Gram-negative organisms were responsible for the majority of infections.
Conclusions Data related to respiratory infections that occurred before a tracheostomy were similar to data related to infections that occurred after a tracheostomy. Most infections were classified as lower respiratory infection rather than pneumonia. Infection, before or after a tracheostomy, resulted in longer stays and higher costs for care. Interventions focused on preventing infection before and after tracheostomy are warranted. (*American Journal of Critical Care.* 2014;23:e80-e87)

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Patients who require mechanical ventilation are at high risk for respiratory infections, including ventilator-associated pneumonia (VAP) and lower respiratory tract infection (LRI). When mechanical ventilation is needed, most patients have an endotracheal tube inserted. Surgical or percutaneous tracheostomy is performed if a patient cannot be weaned from mechanical ventilation.

Many investigators have addressed VAP in intubated, critically ill patients, and the ventilator care bundle of interventions has been widely implemented to reduce VAP.[1,2] The ventilator care bundle emphasizes elevation of the head of the bed, regular antiseptic oral care, and prophylaxis for stress ulcers and venous thromboembolism.[3]

Little has been published about prevention of respiratory infections in intubated patients who later require a tracheostomy. In previous studies, researchers[4-6] focused on infections in patients, primarily children, with long-term tracheostomies for airway management or ventilation. Data on infections in adult patients with a new tracheostomy are needed to guide development of interventions to prevent respiratory infection.

Efforts to prevent respiratory infection have been focused on intubated patients, yet many critically ill patients undergo a tracheostomy and remain at risk for infection during transitions to lower levels of care. Little has been reported on the incidence of infection once a patient has a tracheostomy. Studies on the relationship between tracheostomy and development of infection have yielded inconclusive results. In some studies[7,8] tracheostomy was a risk factor for VAP. However, a tracheostomy is indicated for patients who undergo prolonged mechanical ventilation, and an increased incidence of VAP most likely is related to duration of ventilation and not the airway itself.[9] In contrast, in a case-control study,[10] risk for VAP was decreased after tracheostomy, and meta-analyses[11,12] have shown no relationship between time of tracheostomy and rates of VAP. Nursing interventions to prevent infection after a patient receives a tracheostomy may change because of changes in airway management practices, such as oral care, or a lack of emphasis on infection prevention once the patient transfers from the intensive care unit (ICU). Determining whether or not infections are a problem can assist in implementing interventions to prevent infection.

> The relationship between tracheostomy and development of infection is inconclusive.

Data on respiratory infections, both VAP and LRI, are limited. Therefore, the primary objective of this study was to evaluate respiratory infections in critically ill patients who required a tracheostomy after endotracheal intubation. The secondary objective was to compare outcomes and resource utilization between patients who did and did not have an infection. Findings may be useful to establish benchmarks for gauging the effectiveness of interventions to prevent respiratory infections in patients with a new tracheostomy.

Methods

A retrospective, descriptive, comparative design was used to conduct the study. The sample consisted of adults 18 years or older who underwent a tracheostomy between July 1, 2010, and June 30, 2011, at a tertiary care hospital in the southeastern United States, for airway management and/or prolonged mechanical ventilation. Patients were excluded if they were less than 18 years old, required emergent tracheostomy for primary airway management, or had a tracheostomy performed to treat head or neck cancer.

The appropriate institutional review boards approved the study with a waiver of informed consent. Patients were initially identified by medical record numbers. The data were deidentified and aggregated for analysis.

Potential patients were identified through the medical center's financial database by using procedure codes for tracheostomy. Demographic data,

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Table 1
Centers for Disease Control and Prevention/National Healthcare Safety Network surveillance definitions[a]

Pneumonia
Mechanical ventilation for at least 48 hours
Two or more serial chest radiographs with at least 1 of the following (1 radiograph is acceptable if the patient has no underlying pulmonary or cardiac disease): New or progressive infiltrate Consolidation Cavitation
At least 1 of the following: Body temperature >38°C (104°F) White blood cell count <4000 or >12 000/μL^3 Altered mental status not attributed to other cause in adults ≥70 years old
At least 2 of the following: New onset of purulent sputum, change in sputum character, or increased secretions/suctioning requirements New onset of worsening cough, or dyspnea, or tachypnea Rales or bronchial breath sounds Worsening gas exchange
At least 1 of the following: Blood culture positive for organism unrelated to another infection Culture of pleural fluid positive for a pathogen Culture of minimally contaminated lower respiratory tract secretions positive for a pathogen ≥5% of cells obtained by bronchoalveolar lavage contain intracellular bacteria Histopathological examination of lung tissue shows evidence of infection
Lower respiratory infection
At least 1 of the following: No clinical or radiographical evidence of pneumonia
At least 2 of the following with no other recognized cause Body temperature > 38°C (104°F) Cough New or increased sputum production, rhonchi, or wheezing
At least 1 of the following: Culture of respiratory specimen obtained by deep tracheal aspirate or bronchoscopy positive for infection Antigen test of respiratory secretions positive for pathogen Diagnostic single antibody titer (IgM) or 4-fold increase in paired sera (IgG) for pathogen

[a] Based on information from Horan et al.[13]

ICU and hospital disposition, and total costs (direct plus indirect costs) for care were extracted from administrative and financial databases. Infection-related data were obtained from the infection control database. VAP and LRI were identified by infection preventionists on the basis of the criteria of the National Healthcare Safety Network[13] in effect at the time of the data entry (Table 1). For analysis, both VAP and LRI were classified as infection because the number of VAP cases was small, and patients with either type of infection received similar pharmacological treatment. Data were extracted into a spreadsheet and exported to IBM SPSS version 20 for statistical analysis. Data were screened for meeting assumptions of statistical tests: χ^2 analysis and analysis of variance. Post hoc analyses were done by using either the least significant difference test (equal variance) or the Tamhane T2 multiple comparison test (unequal variance). A priori, $P = .05$ was considered significant.

Results

Patient Characteristics

During the period studied, 418 patients admitted to the critical care units underwent a tracheostomy, and 323 of these met initial inclusion criteria. One patient was excluded from data analysis because time to infection was identified as an extreme outlier. The final sample size was 322 patients. All patients who met the study criteria had a percutaneous tracheostomy procedure.

Demographic data are summarized in Table 2. The majority of patients were male (63.0%) and white (57.8%). Nearly half (48.8%) had a primary discharge diagnosis of trauma or burn injury. The

Table 2
Comparison of patient characteristics: no infection, infection before tracheostomy, and infection after tracheostomy[a]

Variable	Entire sample (N = 322)	No infection (n = 232)	Infection before (n = 47)	Infection after (n = 43)	*P*
Sex, No. (%) of patients					.20
Male	203 (63)	153 (66)	25 (53)	25 (58)	
Female	119 (37)	79 (34)	22 (47)	18 (42)	
Race/ethnicity,[b] No. (%) of patients					.05
White	186 (58)	140 (60)	23 (49)	23 (54)	
Black	78 (24)	44 (19)	18 (38)	16 (37)	
Hispanic	45 (14)	37 (16)	5 (11)	3 (7)	
Other	13 (4)	12 (5)	1 (2)	1 (2)	
Primary discharge diagnosis, No. (%) of patients					.01
Trauma or burn injury	157 (49)	125 (54)	16 (34)	16 (37)	
Medical or surgical condition	165 (51)	107 (46)	31 (66)	27 (63)	
Age, mean (SD), y	57.4 (18.7)	56.4 (18.8)	60.2 (18.80)	60.3 (17.9)	.25
APACHE II score, mean (SD)	23.8 (6.8)	23.2 (6.9)	24.2 (5.7)	26.4 (6.8)	.02[c]
Days from intubation to tracheostomy, mean (SD)	9.1 (5.6)	8.5 (5.3)	10.9 (6.7)	10.2 (5.2)	.01[d]

Abbreviation: APACHE, Acute Physiology and Chronic Health Evaluation.
[a] Because of rounding, not all percentages total 100.
[b] Hispanic ethnicity included in "race" category in database; therefore, we were unable to describe race and ethnicity as separate variables.
[c] Significant difference between those with no infection and those who acquired infection after tracheostomy.
[d] Significant difference between those with no infection and those who acquired infection before tracheostomy.

mean age of patients was 57.4 (SD, 18.7) years. Mean time from intubation to tracheostomy was 9.1 (SD, 5.6) days. Patient acuity was high; the mean score on the Acute Physiology and Chronic Health Evaluation II was 23.8 (SD, 6.8).

VAP or LRI was identified in 90 patients (28.0%); the majority of infections (n = 81; 90%) were classified as LRI. Timing of infection was nearly equal; 52% (n = 47) of infections occurred before tracheostomy and 48% (n = 43) after the procedure ($\chi^2 = 0.2$; $df = 1$, $P = .67$). Before the tracheostomy, VAP developed in 2.2% (n = 7) of the patients and LRI in 12.4% (n = 40). After the tracheostomy, VAP was identified in 0.6% (n = 2) of the patients and LRI in 12.7% (n = 41).

The overall (before and after) respiratory infection rate (combined VAP and LRI) was 13.6 per 1000 ventilator days. The VAP rate was 1.4 per 1000 ventilator days, and the LRI rate was 12.2 per 1000 ventilator days. The majority of respiratory infections (86%) were acquired in the intensive care unit. Differences in frequency between patients in whom VAP developed before tracheostomy and those in whom it developed after the procedure were not significant ($\chi^2 = 0.2$; $df = 2$; $P = .24$).

Organisms

Table 3 shows the frequency of organisms that caused the respiratory infection. In 66% of patients, a single organism was identified; 34% had infections caused by 2 or more organisms. The most frequently occurring organisms were *Pseudomonas* (28%) and *Candida* (21%). The frequency of *Pseudomonas* infections was significantly higher ($\chi^2 = 8.1$; $df = 1$; $P = .004$) in patients who acquired respiratory infection after the tracheostomy (42%) than in those who acquired

Table 3
Causative organisms of respiratory infection

Organism	No. (%) of patients[a]			*P*
	Overall infections (n = 90)	Infection before (n = 47)	Infection after (n = 43)	
Pseudomonas	25 (28)	7 (15)	18 (42)	.004
Candida	19 (21)	7 (15)	12 (28)	.13
Staphylococcus aureus	15 (17)	9 (19)	6 (14)	.51
Enterobacter	12 (13)	8 (17)	4 (9)	.28
Klebsiella	11 (12)	7 (15)	4 (9)	.42
Stenotrophomonas	9 (10)	6 (13)	3 (7)	.36
Methicillin-resistant *Staphylococcus aureus*	7 (8)	5 (11)	2 (5)	.29
Escherichia	6 (7)	3 (6)	3 (7)	.91
Acinetobacter	5 (6)	2 (4)	3 (7)	.57
Serratia	4 (4)	2 (4)	2 (5)	.93
Gram-negative (any)	63 (70)	31 (66)	32 (74)	.38

[a] Several persons had more than 1 organism identified; therefore, the percentages exceed 100%.

Table 4
Outcomes for patients with no infection, infection before tracheostomy, and infection after tracheostomy

Variable	Entire sample (N = 322)	No infection (n = 232)	Infection before (n = 47)	Infection after (n = 43)	*P*
ICU LOS, mean (SD), d	16.8 (11.8)	14.9 (9.2)	20.1 (12.1)	23.7 (18.7)	<.001[a]
Hospital LOS, mean (SD), d	32.8 (21.2)	29.9 (20.1)	37.0 (17.9)	43.6 (25.4)	<.001[a]
Ventilator days, mean (SD)	20.6 (15.2)	18.7 (14.0)	22.5 (13.5)	28.5 (19.8)	<.001[b]
Days from tracheostomy to transfer from ICU, mean (SD)	7.8 (9.2)	6.5 (7.3)	9.1 (8.5)	13.3 (15.4)	<.001[b]
Days from tracheostomy to hospital discharge/death, mean (SD)	20.4 (17.8)	18.7 (17.4)	20.4 (12.7)	29.6 (21.9)	.001[b]
Actual costs per case: fixed plus variable costs, mean (SD), $1000	116 (77)	107 (72)	125 (65)	153 (101)	.001[b]
Posthospital disposition, No. (%) of patients					.09
Long-term acute care hospital	104 (32)	73 (32)	16 (34)	15 (35)	
Skilled nursing facility	45 (14)	31 (13)	5 (10)	9 (21)	
Rehabilitation center	62 (19)	44 (19)	11 (23)	7 (16)	
Another hospital	39 (12)	30 (13)	2 (4)	7 (16)	
Home	23 (7)	22 (10)	1 (2)	0 (0)	
Hospice or death	49 (15)	32 (14)	12 (26)	5 (12)	

Abbreviations: ICU, intensive care unit; LOS, length of stay.
[a] All groups significantly different from one another.
[b] Significant difference between patients without infection and patients with infection after tracheostomy.

infection before the procedure (15%). No differences in frequencies for other organisms and timing of infection were noted (all $P > .05$). Gram-negative organisms were the leading cause of all infections before and after the tracheostomy and were identified in 70% of patients: 66% before and 74% after ($P = .38$).

Outcome Data

Patients with VAP did not differ significantly from patients with LRI in ICU and hospital lengths of stay, duration of mechanical ventilation, days from tracheostomy to transfer or discharge, or costs per case (independent sample Mann-Whitney test; $P > .05$ for all). Therefore, data were aggregated for analysis of outcomes.

Outcome data are shown in Table 4. Patients in whom a respiratory infection developed had significantly longer ICU and hospital lengths of stay than did patients without infection. Differences were significant ($P < .001$) for both of these variables among patients with no infection, patients with infection before tracheostomy, and patients with infection after the tracheostomy. Compared with patients who had no infection, the mean ICU length of stay was 5.2 days longer for those who had a respiratory infection before the tracheostomy, and 8.8 days longer for those who had infection after the tracheostomy. Differences in hospital length of stay were similar: an additional 6.9 days for patients with infection before the tracheostomy, and 13.7 days in those with infection after the procedure. Patients in whom the infection developed after the tracheostomy were treated with mechanical ventilation 9.8 days longer than were patients without infection ($P < .001$); no differences were noted between patients in whom infection developed before versus after tracheostomy. The time from tracheostomy to transfer or discharge from the ICU was more than twice as long ($P < .001$) for patients who had infection after tracheostomy (13.3 days) than for patients who had no infection (6.5 days); no differences were noted between patients who had infection before and patients who had infection after the procedure. Time to discharge was also significantly longer (10.9 days) for patients who had infection after tracheostomy ($P = .001$) than for patients who had no infection during their ICU stay. Prolonged duration of mechanical ventilation and hospitalization resulted in higher total (fixed plus variable) costs for care. Compared with patients who did not have infection, costs for care were significantly higher (an additional $46 000) for patients in whom infection developed after the tracheostomy ($P = .001$).

No significant differences in hospital discharge disposition were identified; however, compared with the other patients, more patients who had infection after tracheostomy were transferred to a skilled nursing facility or another inpatient facility. Only 23 patients (7.1%) were discharged home; all but 1 of these were infection-free. Patients in whom

infection developed before tracheostomy had the highest mortality rate, but this subset also had the highest severity of illness according to the Acute Physiology and Chronic Evaluation II (mean score, 26.43). Patients discharged to rehabilitation centers or home had the lowest severity of illness (mean score, 20). Scores were highest in patients who were discharged to long-term acute care hospitals or a skilled nursing facility or who died.

Discussion

The demographic characteristics of the sample are similar to those in many recent reports[14-16] of studies done in the United States and Australia. Age, sex, and ethnicity were similar among the 3 groups in our study (no infection, infection before tracheostomy, and infection after tracheostomy). Severity of illness was significantly higher in patients who acquired infection after the procedure. Severity of illness has been associated with prolonged weaning, longer duration of mechanical ventilation, and need for a tracheostomy.[17] Timing of tracheostomy after intubation was significantly longer in patients who had an infection before the tracheostomy. The infection most likely impaired weaning from mechanical ventilation, necessitating prolonged ventilatory support and causing difficulty in weaning.[18] Patients with medical-surgical conditions had a higher incidence of infection in general than did patients with trauma. This finding most likely is due to the older age and multiple comorbid conditions of the first group.[19]

Respiratory infections occurred in 28.0% of patients. As in national trends, the VAP rate was low (1.4 per 1000 ventilator days).[20] However, the rate of LRI (not publicly reported and comparative data are limited) was much higher at 12.2 per 1000 ventilator days. Outcomes for patients with VAP and patients with LRI were similar. These findings support recent recommendations for surveillance of ventilator-associated events (VAEs).[21,22] Complete data for estimation of VAEs were not available from the data we retrieved; however, most likely most of these cases would have been identified as VAEs on the basis of the new algorithm.[23]

We found no differences in frequency of infections that developed before or after the tracheostomy, although the number of cases of VAP documented after the tracheostomy (n = 2) was lower than the number documented before the procedure (n = 7). This finding was not significant because of the small sample size; however, this reduction in VAP is supported by Nseir et al,[10] who found that tracheostomy reduced the odds of VAP developing in a case control study.

Staphylococcus aureus was the most frequently occurring causative organism in patients who had infection before the tracheostomy. *Pseudomonas aeruginosa* was most commonly detected in infections that developed after the tracheostomy. Bacteriological findings, including the high prevalence of gram-negative organisms, are similar to those of other studies[24-28] in which researchers compared causative organisms of early- and late-onset VAP in patients with a tracheostomy. More than 20% of patients had an infection with *Candida* species and received treatment. *Candida* was detected more often in patients in whom infection developed after the tracheostomy (28%) than in patients who had infection before tracheostomy (15%). Many of these patients received antibiotics for treatment of injury and illness, and these drugs are the most likely reason for the high number of respiratory infections with *Candida* species. Note that surveillance criteria for the new VAE outcome exclude *Candida* species.[20]

The majority of infections were acquired in the ICU, where the ventilator bundle was routinely implemented. Because of the retrospective nature of the study and the limited data set, we were unable to assess compliance with the ventilator bundle. However, the head of the bed is routinely elevated at 30° or patients are in the reverse Trendelenburg position. Among the 322 patients in our sample, 321 (99.7%) received prophylaxis for venous thromboembolism. The median number of oral care interventions, including brushing the teeth and swabbing the mouth, was 8 per day in the 3 days immediately before tracheostomy. During the 3 days after tracheostomy, the median number of interventions was 4 to 5. Because infection, primarily LRI, occurred despite implementation of the ventilator bundle, additional interventions may be needed to prevent infection, especially after a tracheostomy. Important nursing interventions after a tracheostomy include ensuring that strategies to prevent aspiration are implemented, oral care is provided, and tracheostomy care is completed. Evidence-based practices for oral care interventions after a tracheostomy are also needed; we found a decrease in the median number of interventions documented per day.

> *Staphylococcus aureus* infection was the most frequent before the tracheostomy, *Pseudomonas aeruginosa* after.

Respiratory infection was associated with a longer ICU length of stay, hospital length of stay, duration of mechanical ventilation, and additional costs for care. Notably, for these outcome measures, we found no differences between patients with LRI and patients

with VAP. This finding also supports surveillance for VAEs rather than for VAP. By focusing solely on VAP, nurses can miss out on preventing other respiratory infections that have similar outcomes. Costs associated with development of pulmonary infections in our study were similar to those reported by researchers[29-32] who evaluated the costs of VAP in patients as a whole treated with mechanical ventilation and reported up to $40 000 in attributable costs.

Discharge disposition did not differ significantly among the 3 groups; however, we noted several trends. Of the 23 patients (7.1%) who were discharged home, 22 (96%) did not have an infection. The percentage of patients discharged home (7.1%) was lower than that reported in other studies,[33,34] a finding that may be attributed to a higher severity of illness in our sample. Compared with patients who had infection after tracheostomy, the percentage of patients discharged to a rehabilitation facility was higher for patients who had no infection or who had infection before the tracheostomy. This finding may also be associated with the lower severity of illness scores among the second 2 groups of patients. Patients who had an infection after the tracheostomy had a higher frequency of discharge to a skilled nursing facility or another hospital. Because these patients had longer hospital stays and higher severity of illness, this finding was not surprising. Discharge to a skilled nursing facility for patients with a tracheostomy is associated with a high rate of mortality after 1 year[33]; therefore, preventing infection before and after tracheostomy is critical.

A focus solely on ventilator-associated pneumonia, may miss other preventable respiratory infections.

Our study had several limitations. It was retrospective and depended on the availability of complete data from the medical records. Findings are limited to patients who had a percutaneous procedure at a tertiary care center. Infection was identified by infection preventionists per guidelines[13] of the National Healthcare Safety Network; findings were not independently validated by our research team. We primarily examined the association between respiratory infection and tracheostomy rather than prediction of infection or cause and effect. Factors other than infection, such as severity of illness and comorbid conditions, might have contributed to our findings. Gathering data related to risk factors for infection may have yielded additional valuable data. A prospective study would yield additional data on patients in whom an infection developed.

Research on care and management of patients with a tracheostomy is extremely limited, and has been focused on characteristics of patients, method of procedure, and when the tracheostomy should be performed. Evidence-based interventions for patients who require a new tracheostomy are needed; most studies have been focused on patients with a long-term tracheostomy, primarily children. Other studies[35-37] have been primarily quality improvement investigations. A future study on risk factors for infection after tracheostomy may help identify additional or different nursing interventions that should be included in a tracheostomy bundle.[37] Identifying patients in whom more infections develop, such as older patients with a medical diagnosis, may be indicated. Additionally, strategies for reducing colonization with gram-negative bacteria, especially *Pseudomonas*, are needed.

Evaluating the incidence of VAEs in patients, both before and after tracheostomy, will help establish benchmarks that can be used to determine the effectiveness of interventions to reduce respiratory infections and other complications of mechanical ventilation. Because the majority of infections in our study were attributed to the ICU stay, interventions need to be developed and tested for the periods before, during, and after tracheostomy. Tracking implementation of the ventilator bundle after tracheostomy is important to determine if the components continue to be implemented after extubation. The ventilator bundle may need to be different for patients who have had a tracheostomy.[37]

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