Research Article

An audit of characteristics and outcomes in adult intensive care patients following tracheostomy

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Abstract

Background: Tracheostomies are commonly performed on critically ill patients requiring prolonged mechanical ventilation. The purpose of this study was to review our experience with surgical and percutaneous tracheostomies and identify factors affecting outcome. **Materials and Methods:** Patients who underwent tracheostomy between January 1999 and June 2008 were identified on the basis of Diagnostic Related Group coding and the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification procedural code. The primary endpoint was in-hospital mortality. Contingency tables were generated for clinical variables and a chi-squared test was used to determine significance. **Results:** One hundred and sixty-eight patients underwent tracheostomy between January 1999 and 30 June 2008. In-hospital mortality was 22.6%. The probability of death was found to be independent of timing of tracheostomy, technique used (percutaneous vs. surgical), number of failed extubations and obesity. On univariate analysis, the null hypothesis of independence was rejected for age on admission (P = 0.014), diagnosis of sepsis (P = 0.0008) or cardiac arrest (P = 0.0016), Acute Physiology and Chronic Health Evaluation II score (P = 0.0319) and the Australasian Outcomes Research Tool for Intensive Care calculated risk of death (P = 0.0432). **Conclusion:** Although a number of patient factors are associated with worse outcome, tracheostomy appears to be a relatively safe technique in the Intensive Care Unit population.

Keywords: Intensive care, mechanical ventilation, tracheostomy

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Introduction

Tracheostomy is a commonly performed procedure to facilitate prolonged ventilator-based respiratory support in patients with respiratory failure, and may be carried out in up to 10% of all Intensive Care Unit (ICU) admissions.[1] Tracheostomy provides several potential advantages over prolonged endotracheal intubation, including improved respiratory mechanics with less dead space ventilation, decreased length of ICU or hospital stay and improved pulmonary toilet and comfort.[2-8] Recent studies have also demonstrated that tracheostomy results in fewer oral–labial ulcerations, lower incidence of pulmonary infections and lower sedative requirements.[7,8] Furthermore, newer techniques such as percutaneous dilatation tracheostomy (PDT) have been shown to be cost-effective and safe, offering clinicians an effective alternative to surgical tracheostomy (ST).

Despite the continuous advancement in techniques including the use of bronchoscopy and ultrasound guidance, complications following tracheostomy are not uncommon.[3] These include infection, bleeding, obstruction from posterior membranous trachea and infraglottic stenosis (1.6–10%, including asymptomatic, bronchoscopic or computed tomography [CT]-proven stenosis).[9-12] Tracheoarterial fistula is a rare (<1%) complication, but can lead to massive hemoptysis and death.[13] Bronchoscopy, as an adjunct for tracheostomy, is also not without drawbacks, including compromised ventilation causing hypoventilation, carbon dioxide

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retention, increased cost and time.[14,15] It is therefore necessary to ensure that the procedure is only performed in the appropriate setting.

Unfortunately, controversy continues to exist regarding a number factors related to tracheostomy in the ICU population, including indications, timing and procedure (PDT vs. ST).[16-21] The issue is further complicated by the difficulty in predicting the need for prolonged ventilation, which is an indication for tracheostomy.[22] Therefore, the purpose of this study is to review the role of tracheostomy in a regional medical/surgical ICU with a view to understanding factors affecting patient selection and outcome.

Materials and Methods

Data was extracted through Transition II database (Queensland Health Administrative database). The study period was from 1 January 1999 to 30 June 2008. Sample selection was based on tracheostomy Diagnostic Related Group (DRG code A06Z) and the procedural code for tracheostomy in International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM code 41883-00). Data was stored as a Microsoft Excel® file. Data in the sample were manually verified by chart review. Acute Physiology and Chronic Health Evaluation II score (APACHE II) was obtained from the Australasian Outcomes Research Tool for Intensive Care (AORTIC) database kept by the ICU (calculated on admission to ICU). The calculated risk of death scores was also retrieved from the AORTIC database (represents a multivariate additive linear regression model). Statistical analysis was performed using SAS Version 9.13.

The following data were obtained from the administrative database: admission and discharge date and discharge status. The following were obtained from each patient's medical chart: admission source, primary and secondary diagnoses, number of failed extubations, timing of tracheostomy, type of tracheostomy (surgical or percutaneous), obesity (body mass index >30 kg/m^2 or weight >92 kg). Presence of infection was determined from the primary and secondary diagnoses. Sepsis was considered to be present if the term was recorded in a clinical entry in the medical record prior to tracheostomy date.

Ethics approval for this study was obtained from the Human Research Ethics Committee (EC00167); reference 2008/049.

Results

The Logan Hospital is a general peri-urban hospital with 350 acute medical beds. The ICU is a mixed medical/surgical unit, although approximately 80% of the cases are medical. The number of ventilated cases has increased from 35 in 1999 to 279 in 2008 [Table 1].

One hundred and eighty-one records were identified from the Transition II database. Thirteen patients were excluded (seven did not have a tracheostomy performed; one had tracheostomy performed in another hospital; two charts were missing; one chart was incomplete; one underwent change of tracheostomy tube only; one patient entry was duplicated). Forty-one data errors in the revised sample were corrected during verification (e.g., ICU admission date, tracheostomy date, etc.). Thirty-eight patients died in-hospital of the final sample size of 168 patients (22.6%).

Overall, 90 patients were male and 78 female. Twenty-four male (27%) and 14 female patients died (18%), but this difference was not statistically significant ($P = 0.2$). Age on admission ranged from 22 to 87 years (mean

Table 1: Details of tracheostomy patients based on primary diagnosis

Primary diagnosis	Number	Deaths	Mortality (%)	Nr male	Mean age (years)	Mean ICU day tracheostomy	Mean LOS after tracheostomy	Mean AORTIC risk of death	Mean APACHE II score
Intraabdominal	36	10	27.8	21	57	9	43	0.31	22
Respiratory – infective	29	5	17.2	18	62	10	24	0.52	25
Exacerbation of COPD	26	5	19.2	9	65	9	27	0.43	22
Respiratory – noninfective, non-COPD	18	3	16.7	6	55	10	22	0.42	24
Central nervous system	16	4	25	8	54	7	17	0.45	23
Infection – soft tissue	13	5	38.5	9	55	13	33	0.54	25
Chest trauma	10	0	0	8	49	8	22	0.20	18
Cardiac arrest	7	5	71.4	5	64	10	10	0.62	29
Self-harm	5	0	0	3	55	7	14	0.15	23
Other	8	1	12.5	3	54	9	44	0.43	26
Total	168	38	22.6	90	58.9	10	28.4	0.45	23

COPD = Chronic obstructive airways disease, ICU = Intensive care unit, LOS = Length of stay, APACHE II = Acute physiology and chronic health evaluation II

58.9 years, median 60 years). Mortality (in-hospital) in patients aged over 65 years was 38% (23/61) and 14% for those aged 22–65 years ($P = 0.0004$). Median day of discharge following tracheostomy was 21.5 (mean 28.4; range 0–164). Hospital length of stay (LOS) ranged from 4 to 171 days (mean 38.7 days, median 32 days); this variable was related to the probability of death on univariate analysis ($P = 0.0117$).

One hundred and forty-seven patients were not extubated prior to tracheostomy (87.5%), while 12.5% patients failed one or more extubation attempts (one failure in 20, two failures in 1). Mortality was 24% in the never-extubated group and 10% in those who failed an attempt at extubation ($P = 0.1$). Tracheostomy was performed on inpatient Day 10 (mean 10.6; median 10; range 0–43), which was also Day 10 in ICU (mean 10; median 10; range 0–31). The timing of tracheostomy was not predictive of death ($P = 0.6$). The majority of tracheostomies were surgical (90 surgical and 78 percutaneous). In-hospital mortality was 20% versus 26% respectively ($P = 0.4$).

Mortality in patients suffering a cardiac arrest was highest (71%), followed by soft tissue infection (39%), intraabdominal disease (28%; pancreatitis, anastomotic leak, perforated viscus, trauma) and central nervous system disease (25%). Mortality in descending order of frequency was seen in exacerbation of chronic obstructive airways disease (19%), respiratory infection (17%), noninfective nonchronic obstructive airways disease (COPD) respiratory disease (17%) and miscellaneous conditions (13%). No patient with isolated blunt chest trauma or self-harm (poisoning or hanging) died. Seventy-five patients with a respiratory indication for tracheostomy had a mortality of 15% (aspiration, asthma, exacerbation COPD, pneumonia, pulmonary edema, pneumonitis, isolated blunt chest trauma). Ninety-three patients with a nonrespiratory primary diagnosis had a mortality of 29% (respiratory vs. nonrespiratory, $P = 0.02$).

Sepsis was diagnosed in 55 (mortality 38.2%) and absent in 113 (mortality 14.5%; $P = 0.0008$). Sixty patients (35.7%) were not treated for an infection (mortality 14%) while 108 patients were treated for an infection at any site (mortality 24%; $P = 0.9$). However, 21 of the 55 patients with infection and sepsis died (38%), while only three of 53 patients with infection but no sepsis died (6%), and this difference is highly statistically significant ($P = 0.0003$). Nine of 14 (64%) patients over the age of 65 years with an APACHE II score greater than 22 and a diagnosis of sepsis or cardiac arrest died (just under half did so within 6 days of tracheostomy). The 38 obese patients had a mortality of 18%, while the 77% who were nonobese (or had no weight recorded) had a mortality of 24% ($P = 0.5$). A summary of the results is provided in Table 2.

From the analysis of the chi-squared contingency table tests for each variable (data not shown), a logistic regression was performed. The logistic regression was statistically significant and explains approximately 24% of the variation in the survival outcome. All of the variables except age, APACHE II score and the AORTIC risk of death variables are statistically significant at a 5% level of error. Age on admission just marginally exceeds the 5% level of error ($P = 0.05$). A partial regression of the relationship between APACHE II score and AORTIC risk of death revealed them to be strongly collinear ($R^2 = 0.6$ and $P < 0.0001$). The logistic regression was thus reestimated with the AORTIC risk of death variable omitted, producing the results contained in Table 3.

Discussion

The purpose of our study was to review the role of tracheostomy in a regional ICU with the view to understanding factors affecting patient selection and outcome. We therefore reviewed all tracheostomies performed on ICU patients in our institution over the past 9 years. The overall mortality rate in our patients with tracheostomy compares favorably with our orotracheal ventilated patients (29.1%; 295/1012). Mortality rates

Table 2: Details of ventilated patients based on primary diagnosis (without tracheostomy)

Primary diagnosis	Number	Deaths	Mortality (%)	Nr male	Mean age (years)	Mean ICU LOS
Intraabdominal	205	43	21.0	110	61	10
Respiratory – infective	102	23	22.5	55	52	11
Exacerbation of COPD	133	39	23.9	65	62	6
Respiratory – noninfective, non-COPD	168	24	14.3	89	32	5
Central nervous system	162	16	9.9	105	38	3
Infection – soft tissue	41	23	56.1	57	59	9
Chest trauma	17	0	0.0	10	44	10
Cardiac arrest	29	29	100.0	16	60	1
Self-harm	180	0	0.0	86	38	2
Other	659	132	20.0	378	42	3
Total	1696	329	19.4	971	45.4	4.8

COPD = Chronic obstructive airways disease, ICU = Intensive care unit, LOS = Length of stay, APACHE II = Acute physiology and chronic health evaluation II

Table 3: Final logistic regression

Logistic regression point estimates	Intercept	Age on admission	Sepsis	Infection	LOS	APACHE II score	Cardiac arrest
Estimate	-3.729	0.033	1.276	-1.582	-0.024	0.041	2.315
Standard error	1.222	0.016	0.508	0.727	0.011	0.026	0.941
Pr $>\chi^2$	0.002	0.040	0.012	0.030	0.031	0.111	0.014
R-square[43]	0.2321						
Max-rescaled R-square[43]	0.3528						
Model significance test	χ^2 test statistic	Degrees of freedom	Pr $>\chi^2$				
Likelihood ratio	44.104	6	<0.0001				
Score	39.859	6	<0.0001				
Wald	28.973	6	<0.0001				

LOS = Length of stay, APACHE II = Acute physiology and chronic health evaluation II, AORTIC = Australasian outcomes research tool for intensive care,

Table 4: Studies of tracheostomy outcome

Study first author and year	Total number of patients	Number of patients with tracheostomy	Mortality for all patients %	Mortality for patients with tracheostomy %	Length of ICU stay for all patients (days)	Length of ICU stay for patients with tracheostomy (days)	APACHE II score	SAPS score
Present study	1894	168	15.5*	22.6*	3.9	38.6 ± 28	18.9 (all) 24 ± 9 (tracheostomy)	-
Kollef, 1999[25]	521	51	25.1*	13.7*	2.8 ± 10.1	30.9 ± 18.1	17.8 ± 7.2 (all) 19.2 ± 6.1 (tracheostomy)	-
Arabi, 2004[2]	-	29 (early) 107 (late)	-	17 (early) 14 (late)	-	-	20 ± 1 (early) 19 ± 1 (late)	-
Blot, 2007[23]	123	61	17.5	27	-	-	-	50 (both groups)
Combes, 2007[24]	506	166	45	37	15 ± 14	41 ± 27	-	53 ± 17 (all) 53 ± 16 (tracheostomy)
Scales, 2008[29]	25,902	3758 (early) 7169 (late)	-	35 (early) (90 days)	-	-	-	-
Kornblith, 2011[26]	-	1000	-	12	-	29 ± 0.6	-	-
Trouillet, 2011[30]	3484	109 (early) 107 (late)	-	17 ± 16 (early) 23 ± 21 (late)	-	24 ± 21 (early) 26 ± 22 (late)	-	47 ± 12 (early) 46 ± 11 (late)
Delaney, 2006[16] (metaanalysis)	1212	451 (PDT) 463 (ST)	37	35 (PDT) 39 (ST)	-	-	-	-

ICU = Intensive care unit, PDT = Percutaneous dilatation tracheostomy, ST = Surgical tracheostomy

from other published tracheostomy series can be seen in Table 4.[2,16,18,23-30]

The timing of elective tracheostomy in ICU patients remains controversial and is based on the opinions of attending medical staff and policies of individual units. We found the timing of tracheostomy not predictive of death. Our median time to tracheostomy was 10 days post admission to ICU (with a wide range of 0–31 days). Prior studies have produced conflicting results and are complicated by the lack of consensus of what denotes early or late.[2,18,23,27,31,32] Griffiths *et al*. identified five randomized controlled studies (406 patients) with adequate study design in a recent metaanalysis.[18] No differences in mortality or morbidity were identified, but early tracheostomy was associated with shorter ventilation and ICU LOS. Interpretation of this data is hindered by the small number of patients in each trial, heterogeneity of the populations and variability in study design, with "early" ranging from 0 to 7 days. The Tracman trial will hopefully clarify whether early tracheostomy provides a survival advantage.[33] The investigators intend to randomize patients into an early (1–4 days) and late (>10 days) group. The primary outcome is 30-day mortality. Although completed, data from this study has not been published. Until then, an individual approach to patients is likely to continue.

As might be expected, we found older (age >65 years) and sicker patients (APACHE II > 23) to have a higher mortality than younger, less-sick patients. Although our numbers were relatively small, patients with failed extubations faired as well as those without prior extubation attempts, contrary to the seminal paper by Seymour *et al*. demonstrating an increased risk of death in patients who failed extubation.[34] Overall, patients with nonrespiratory-related disorders faired worse than those with a primary respiratory cause for prolonged ventilation. If the primary diagnosis was sepsis, the mortality was more than double that of nonseptic patients. Many patients admitted to our ICU are severely obese and present in cor-pulmonalae. There is a general belief that these patients fare worse than the nonobese patients who undergo tracheostomy, as has been reported in several studies.[35-38] However, a recent metaanalysis failed to find an increased mortality.[39] Our data confirms that there is no increase in mortality in obese patients who require tracheostomy.

While the proportion of tracheostomies being performed percutaneously by intensivists has slowly increased in our ICU over a 9-year period (43% of the first 84 patients and 50% of the subsequent 84 patients), a significant proportion are still performed by surgeons. We failed to find a difference in mortality between ST and PDT. There are numerous studies and several metaanalyses supporting this finding.[16,40-42] However, two of the latest metaanalyses noted minor discrepancies: Delaney *et al*. (an intensivist) found no difference in mortality but suggested a decreased incidence of wound infection in patients undergoing PDT.[16] On the other hand, Oliver *et al*. (a surgeon) found an increase in minor complications in the PDT group compared with bedside ST, and suggested that more care is required in identifying patients for PDT.[28] Notwithstanding the bias introduced by the different author's speciality, there is little to support one technique over the other. Certainly, PDT is quicker and more convenient than ST performed in the operating theater, but bedside ST remains a reasonable alternative. PDT may be limited by a variety of factors, including patient anatomy and coagulopathy, leading, in some instances, to the more difficult cases being performed by surgeons. Ultimately, the decision of which technique to use will depend on patient factors and the skill mix in the hospital.

This study is confined by the limitations of all retrospective, observational studies, namely, difficulty in removing confounders and recall errors. A confounder, in a strict sense, can never be excluded without a systematic double-blinded randomised study. Recall errors were, in the majority, contributed by documentation, including a lack of documentation of the reason for performing tracheostomy. In many instances, the decision to perform a tracheostomy is arbitrary, based on intensivists expectations of LOS and likelihood of weaning to extubation.

Further limitations of the present study include the following. The study was performed in a general medical/surgical ICU and may not represent more specialized population groups such as trauma, neurosurgical or cardiothoracic. Secondly, deaths resulting from withdrawal of therapy were not documented and may adversely affect mortality results. Thirdly, a long-term follow-up of complications was not undertaken and therefore cannot be included in the analysis.

Conclusion

In our population cohort, we found that patients with the principle diagnosis of sepsis or who experienced cardiac arrest prior to admission had a significantly worse outcome. Older and sicker patients also had a higher mortality rate. However, approach and timing of tracheostomy, body habitus and source of admission did not affect outcome. Our experience has led us to favor PDT over ST for many reasons, including low complication rates, convenience and the ability to perform the procedure in ICU. Patients who are poor candidates for PDT, usually determined by perceived anatomical difficultly (e.g., short neck, with increased adipose tissue) are taken to the operating theater for an ST. Ultimately, an individualised risk and benefit approach in planning for a tracheostomy may be more appropriate than a routine arbitrarily chosen length of ICU stay.

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