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Predictors of short-term mortality in patients undergoing percutaneous dilatational tracheostomy[☆]

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Abstract

Purpose—The purpose of the study was to identify the predictors of short-term mortality in patients undergoing percutaneous dilatational tracheostomy (PDT).

Materials and Methods—Retrospective analysis of data pertaining to adult patients who underwent PDT between July 2005 and June 2008 in an urban, academic, tertiary care medical center was done. Clinical and demographic data were analyzed for 483 patients undergoing PDT via multivariate logistic regression.

Results—Mortality data were examined at in-hospital, 14, 30, and 180 days postprocedure. Overall mortality rates were 11% at 14 days, 19% at 30 days, and 40% at 180 days. In-hospital mortality was 30%.

Conclusions—Patients undergoing PDT have significant short-term mortality with 11% dying within 14 days and an in-hospital mortality rate of 30%. We identified an index diagnosis of ventilator-associated pneumonia and trauma to be associated with a higher survival rate, whereas older age, oncological diagnosis, cardiogenic shock, and ventricular-assist devices were associated with higher mortality. There is significant heterogeneity in both underlying diagnosis and patient outcomes, and these factors should be considered when deciding to perform this procedure and discussed with patients/family members to provide a realistic expectation of potential prognosis.

Keywords

Tracheostomy; Mortality; Critically ill; Intensive care

1. Introduction

Patients undergoing prolonged mechanical ventilation have high short- and long-term mortalities, have significant morbidity, and consume a disproportionately high share of health care resources. The annual incidence of tracheostomy has increased by almost 200% in the recent years, outpacing the rapid increase in patients undergoing mechanical ventilation by 3-fold [1]. Percutaneous dilatational tracheostomy (PDT) is being performed more frequently than the open surgical technique in the intensive care units (ICUs) for long-term ventilator-dependent patients. There are active ongoing debates about performing early vs

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late tracheostomy for long-term ventilator-dependent patients. Although the issue of timing of tracheostomy is receiving significant attention [2-4], few studies have focused on the difficult question of whether an individual patient should undergo tracheostomy at all [5,6].

Before performing PDT, it is crucial for physicians, patients, and their surrogates to assess prognosis and goals of care. The multifactorial decision-making process of whether to perform PDT is related to the treatment of the primary medical problem, perceived quality and quantity of life, and other end-of-life decision-making issues, such as the ability to communicate with family members [7]. Predictors of short-term mortality, such as age, sex, underlying diagnosis, or severity of illness, have not been investigated adequately in patients undergoing tracheostomy. Identifying the predictors of short-term mortality will facilitate informed decisions for physicians, patients, and their surrogates. The purpose of our study was to identify the predictors of short-term mortality in patients undergoing PDT.

2. Materials and methods

The Johns Hopkins Hospital Percutaneous Tracheostomy Program (PTP) consists of a multidisciplinary team of interventional pulmonologists, surgeons, anesthesiologists, nurse practitioners, nurses, respiratory therapists, and speech-language pathologists. All translaryngeally intubated ICU patients are screened daily from the time of intubation by the PTP. The decision to perform a tracheostomy is made by the ICU team. Once the decision is made, a bedside bronchoscopic video-assisted PDT is performed within 48 hours, along with careful follow-up for complications or of any additional airway needs [8].

All operators used the same technique described by Ciaglia using the Cook Blue Rhino kit (Cook Critical Care, Bloomington, IL). After inducing general anesthesia, the patient's neck is extended over a shoulder roll. A 1- to 2-cm vertical incision is made. An introducer needle is introduced between the second and third tracheal rings, and a guidewire is inserted through the needle. The needle is removed, and a 14F catheter dilator is used to create a tract. The Blue Rhino dilator is used to dilate the tissues, and finally a tracheostomy tube is placed. Placement is confirmed using real-time bronchoscopic visualization, and the tube is secured either with sutures or staples.

The PTP serves 8 ICUs (medical, cardiac, cardiothoracic surgery, neurologic, 2 surgical, and 2 oncological) with approximately 102 ICU beds in a large urban teaching hospital. The PTP performed an average of 160 tracheostomies per year over the last 5 years with continued incremental growth. Data on patients who underwent PDT are gathered prospectively on all patients. The Johns Hopkins Medicine Institutional Review Board Committee JHM-IRB X provided approval for this study protocol (approval no.—NA_00023447).

Investigators reviewed the electronic medical records (EMRs) of 483 patients using a predesigned data collection form with variables chosen a priori for clinical significance and data availability. Clinical information including demographics, ICU type, and diagnoses at the time of tracheostomy was retrieved from the EMR, discharge summaries, PDT procedure notes, and the percutaneous tracheostomy database. Diagnoses were not limited to the primary diagnosis but included all documented diagnoses at the time of tracheostomy. Mortality data were gathered from the EMR and the social security death index. The primary outcomes were survival at 14, 30, and 180 days posttracheostomy and at the time discharge from the large urban teaching hospital.

Once the data were deidentified, statistical analysis was performed using STATA 11.0 (StataCorp, College Station, TX, USA). Statistical significance was predetermined in reference to $P < .05$. Comparisons of continuous data were made using the Student t test, and comparisons of categorical data were performed using χ^2 tests. Variables with $P < .20$ were

considered for multivariate logistic regression after correlation coefficients were calculated. Variables with a correlation coefficient of greater than 0.4 required the elimination of 1 of the 2 related variables before further analysis. Decisions on elimination generally favored the removal of broad diagnosis categories, and more specific clinical variables were chosen for multivariate logistic regression. Backward stepwise logistic regression was then performed for each time point (14, 30, and 180 days and time of discharge). Odds ratios (ORs) and 95% confidence intervals (CIs) are reported to describe the risk for mortality. In a subset of patients for whom data were available, mortality was adjusted for severity of illness using the sequential organ failure assessment scores.

3. Results

A total of 483 patients underwent PDT from July 2005 to June 2008. Two hundred seventy patients (56%) were women, and the mean age was 57 years, ranging from 18 to 90 years. Our patients were from neurosciences critical care unit (27%), surgical ICUs (26%), cardiothoracic surgical ICU (23%), medical ICU (16%), coronary care unit (5%), and oncology ICUs (3%) (Table 1). The overall in-hospital mortality rate was 30%. At 14, 30, and 180 days posttracheostomy, mortality rates were 11%, 19%, and 40%, respectively. Mortality at discharge significantly varied by ICU location ($P = .0001$).

3.1. Characteristics with increased survival

Upon univariate and multivariate analysis (Tables 2 and 3), female sex was significantly associated with survival at 14 days (OR, 0.51; 95% CI, 0.28-0.95), 180 days (OR, 0.56; 95% CI, 0.37-0.85), and at the time of discharge (OR, 0.62; 95% CI, 0.40-0.96) in multivariate analysis. A diagnosis of acute stroke also predicted survival at 14 days (OR, 0.23; 95% CI, 0.07-0.78), 30 days (OR, 0.44; 95% CI, 0.21-0.94), and at the time of hospital discharge (OR, 0.42; 95% CI, 0.22-0.79). In addition, a diagnosis of ventilator-acquired pneumonia (VAP) predicted survival at 30 days (OR, 0.27; 95% CI, 0.09-0.79) and at the time of hospital discharge (OR, 0.43; 95% CI, 0.20-0.91). Moreover, being a trauma patient predicted survival at 30 days (OR, 0.09; 95% CI, 0.01-0.71), 180 days (OR, 0.28; 95% CI, 0.11-0.71), and at hospital discharge (OR, 0.10; 95% CI, 0.02-0.41).

When the model was adjusted for severity of illness in a subset of patients ($n = 465$), only VAP and trauma predicted increased survival (Table 4). Ventilator-acquired pneumonia predicted survival at 30 days posttracheostomy (OR, 0.28; 95% CI, 0.09-0.83) and at the time of hospital discharge (OR, 0.37; 95% CI, 0.16-0.84). Trauma was found to predict survival at 180 days (OR, 0.35; 95% CI, 0.14-0.91) posttracheostomy and at the time of hospital discharge (OR, 0.13; 95% CI, 0.03-0.59).

3.2. Characteristics with decreased survival

Older age was noted to be a statistically significant predictor of increased mortality at all time intervals. An oncological diagnosis predicted a higher risk for mortality within 30 days (OR, 2.00; 95% CI, 1.06-3.75) and within 180 days of tracheostomy (OR, 2.78; 95% CI, 1.51-5.10). Patients with an index diagnosis of cardiogenic shock at the time of tracheostomy had a higher risk for mortality within 180 days of tracheostomy (OR, 4.74; 95% CI, 1.99-11.33) and at the time of discharge from the hospital (OR, 2.74; 95% CI, 1.21-6.19). Placement of a ventricular-assist device (VAD) predicted a higher risk for mortality at 30 days (OR, 3.43; 95% CI, 1.36-8.61) and at the time of hospital discharge (OR, 4.03; 95% CI, 1.43-11.37). A diagnosis of acute renal failure at the time of tracheostomy suggested increased risk for mortality at 180 days alone (OR, 1.53; 95% CI, 1.02-2.32).

When the model was adjusted for severity of illness in a subset of patients ($n = 465$), the predictors, older age and oncological diagnosis, did not vary (Table 4). However, VAD predicted decreased survival only at the time of hospital discharge (OR, 3.54; 95% CI, 1.12-11.15), cardiogenic shock predicted decreased survival only at 180 days (OR, 3.21; 95% CI, 1.25-8.24), and acute renal failure was not found to be a predictor of decreased survival.

4. Discussion

Short-term mortality in mechanically ventilated patients undergoing PDT is remarkably high, with 30% of patients not surviving to hospital discharge. Patients had significantly higher odds of mortality for older age, oncological diagnosis, cardiogenic shock, and VAD placement. Patients with a diagnosis of VAP or trauma admission had significantly lower odds of mortality. Identifying these predictors of short-term mortality should facilitate informed decisions for physicians, patients, and their surrogates regarding PDT placement.

Accurately predicting survival in critically ill patients undergoing PDT remains challenging, and many physicians find it stressful and difficult relaying prognostic information in these areas of uncertainty. Further complicating this, patients', their surrogates' and physicians' expectations of survival and recovery of functional status can be quite discordant from reality, especially in patients requiring prolonged mechanical ventilation [9]. Reliable and accurate predictors of mortality and functional recovery would be invaluable in providing reasonable expectations of outcomes and establishing appropriate levels of care [10]. Despite the uncertainties, the time of discussion regarding tracheostomy placement provides an opportunity to reassess prognoses both for survival and recovery of functional status.

There is a relative paucity of literature on factors that predict short-term mortality after tracheostomy. Gerber et al [6] studied 60 patients looking specifically at prognostic factors at the time of tracheostomy. Comparable literature generally examined characteristics present at the time of intubation or a specific duration of mechanical ventilation such as 2, 14, or 21 days to define prolonged mechanical ventilation [2,11-13].

Our findings are consistent with large multicenter trials supporting increased mortality for older patients admitted to ICUs [13,14], smaller multivariate analyses of those undergoing any mechanical ventilation [15,16], and, most specifically, those undergoing more prolonged mechanical ventilation [2,11,17,18]. Two recent studies found that age older than either 50 or 65 years predicted increased mortality after adjusting for severity of illness [2,11]. We found a similar increase in mortality in patients who were older than 65 years. Physiologic age, and not just chronologic age, is clearly important. Ely et al [19] showed that patients older than 75 years did no worse than the younger elderly 65 to 75 years old. Regardless, older patients do likely have less physiologic reserve, but one should not use age alone to determine PDT candidacy.

Our findings for patients with oncological diagnoses were similar, with a significant increase in mortality at 30 and 180 days posttracheostomy. Acute respiratory failure in patients with cancer is traditionally associated with high in-hospital mortality rates, measured as high as 62% to 83% [20]. Although these numbers are quite high, improved outcomes for patients with cancer requiring mechanical ventilation have been recently reported and is likely because of advances in hematology/oncology and critical care medicine [20-22]. We included patients with both hematologic and solid tumor malignancies undergoing prolonged mechanical ventilation.

A common theme throughout our analysis were the poor outcomes in patients with advanced heart failure. Most impressively, multivariate analysis showed that the strongest predictor of

mortality at time of hospital discharge was in patients with a diagnosis of cardiogenic shock or who had placement of a VAD. Likewise, placement of a VAD was also associated with an increased mortality at 30 days and cardiogenic shock at 180 days. When adjusted for severity of illness, VAD was associated with increased mortality only at the time of hospital discharge and cardiogenic shock at 180 days. The CI for VAD and cardiogenic shock is relatively wide. This is most likely due to a smaller sample size (VAD, n = 23, and cardiogenic shock, n = 33). Nevertheless, our findings of decreased survival with VAD and cardiogenic shock are supported by other studies showing that prolonged hemodynamic compromise, cardiac dysfunction, and vasopressor requirements are associated with increased mortality in the cardiac surgery and general ICU populations [2,12,23-26].

Our findings likely represent the significant short-term mortality of terminal and irreversible disease processes similar to those with profound cardiac dysfunction. Despite the risk for mortality, reasonable goals of performing PDT include increasing patient comfort, facilitating weaning, and decreasing sedation requirements. In addition, the increased ability to communicate with a tracheostomy tube compared with a translaryngeal endotracheal tube may significantly improve quality of life in the last days of life, which is yet to be studied.

The survival benefit observed in our patients with an acute stroke was similar to the general PDT population[13,27,28]. Rabinstein et al [28] recently showed that many deaths in this group of patients are attributable to an increase in early mortality typically before the time that tracheostomy is even considered, selecting out the most neurologic devastated or acutely ill patients. They found that acute stroke patients who underwent tracheostomy had an inhospital mortality of 13% and a 1-year mortality of 30%, which is very similar to our findings (16% in-hospital and 31% at 1 year). Once the initial insult is survived, barring iatrogenic complications, safe disposition, and efforts aimed at improving functional recovery become paramount and are often achieved.

Ventilator-associated pneumonia has traditionally been associated with high mortality. In contrast, we found that VAP predicted survival at 30 days and at the time of hospital discharge. This may be because patients with VAP who are offered tracheostomy are maybe showing signs of clinical improvement, as opposed to those with VAP who either have early mortality or show signs of clinical deterioration and are not offered tracheostomy. Clearly, this should be investigated in future studies.

Patients carrying a trauma diagnosis showed the greatest survival benefit at most end points. Ours is the first study to separate these patients from the general surgical population at the time of tracheostomy and the first to show such benefit. This survival benefit is clearly not due to the PDT itself but rather the characteristics of the cohort undergoing tracheostomy. This study highlights the significantly better possible outcomes when often healthier and younger patients are faced with a short-term traumatic event. In addition, it emphasizes that trauma is a short-term disease in which a large proportion of injured patients die early, with relatively few late deaths after injury.

Finally, we also noted that the ICU location was associated with the risk of mortality. This is likely not due to the location itself but rather the underlying pathology for which these patients were admitted to those different ICUs. For example, patients with oncological diseases were treated in oncological ICUs, whereas patients with VAD in cardiothoracic surgical ICU.

The major strengths of this study are its large patient size and heterogeneity. Our study is the largest of its kind to examine predictors of short-term mortality in patients undergoing tracheostomy. Given our large sample size, we were able to examine a heterogeneous

population of patients including medical, surgical, trauma, and oncological and perform multivariate logistic regression analysis with the realization of statistical significance.

Certain limitations must be taken into account when interpreting our results. First, our study is from a single tertiary referral center with specialized ICUs, often caring for patients at the extremes of illness severity who have failed traditional measures and have access to resources not available at other institutions. Although a goal of our PTP is a more evidence-based, standardized approach to the tracheostomy process, decisions regarding who should undergo tracheostomy as well as the timing of the procedure are dependent on multiple factors including the patient, their surrogate decision makers, and members of different medical teams from a wide variety of specialties. This may introduce variability between providers as well as selection biases. Finally, although we examined mortality as a primary end point, the benefits of tracheostomy such as increased patient comfort, reduced sedation, ability to communicate with family, and decreased ICU length of stay should also be considered. Further efforts to measure these patient-centered outcomes even in those with increased mortality are being examined in a similar formal manner.

5. Conclusions

In conclusion, 11% of patients died within 14 days; 19%, within 30 days; and 40%, within 180 days of the PDT procedure. In-hospital mortality for all patients after PDT was 30%. Mortality was significantly lower for younger patients and those with VAP or trauma. Patients who were older, those with oncological diagnosis, cardiogenic shock, or a VAD had significantly higher odds of death. Significant heterogeneity exists in the clinical characteristics and outcomes for patients undergoing PDT. Elderly patients with irreversible disease and comorbidities have a poor outcome compared with younger patients with reversible disease. Identifying important predictors of short-term mortality may benefit patients and physicians by providing guidance regarding prognosis, expectations, and appropriate goals of care in mechanically ventilated patients who may be candidates for PDT.

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Table 1

Individual characteristics of study patients who lived and died to hospital discharge

Individual characteristics	All patients N = 483	Survivors at discharge n = 339	Nonsurvivors at discharge n = 144	P
Age in y, mean (range)	57 (18-90)	55.07	61.27	.0001 ^a
Sex, n (%)				
Male	270 (55.90)	181	89	.0885 ^b
Female	213 (44.10)	158	55	
Organ system diagnosis, n (%)				
Cardiac	182 (37.68)	106	76	<.0001 ^c
Pulmonary	196 (40.58)	141	55	.4866 ^c
Infectious disease	193 (39.96)	129	64	.1896 ^c
Gastrointestinal	111 (22.98)	71	40	.1025 ^c
Renal	274 (56.73)	175	99	.0005 ^c
Neurologic	195 (40.37)	176	28	<.0001 ^c
Oncological	57 (11.80)	34	23	.0641 ^c
Trauma	54 (11.18)	52	2	<.0001 ^c
ICU location, n (%)				
Neuroscience	131 (27.12)	113	18	.0001 ^d
Surgical	127 (26.29)	93	34	
Cardiothoracic surgical	109 (22.57)	54	55	
Medical	77 (15.94)	58	19	
Coronary care unit	25 (5.18)	17	8	
Oncology units	57 (2.90)	34	23	

^a Difference in the mean age between those alive vs dead.

^b Mortality difference at discharge by sex.

^c Mortality difference at discharge between the indexed diagnoses and all other diagnoses.

d Mortality difference at discharge by ICU location.

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Table 2

Univariate analysis of mortality after tracheostomy

14 d	Mortality ORs (95% CI), N = 483			Crude in-hospital mortality
	30 d	180 d	At hospital discharge	
Univariate analysis				
Age (per y)	1.03 (1.01-1.05)	1.03 (1.01-1.05)	1.04 (1.03-1.05)	1.03 (1.01-1.04)
Female	0.62 (0.32-1.14)	0.79 (0.48-1.27)	0.71 (0.49-1.05)	0.71 (0.47-1.07)
Organ system diagnosis				
Cardiac diagnosis (n = 182)	2.46 (1.35-4.53)	2.10 (1.29-3.39)	2.49 (1.67-3.71)	2.44 (1.61-3.74)
Cardiogenic shock (n = 33)	2.20 (0.76-5.56)	2.56 (1.10-5.71)	5.20 (2.20-13.59)	5.38 (2.40-12.62)
Valve surgery (n = 48)	1.91 (0.76-4.32)	1.83 (0.86-3.69)	2.06 (1.08-3.97)	2.39 (1.24-4.56)
VAD placed (n = 23)	2.23 (0.62-6.57)	3.44 (1.30-8.80)	2.42 (0.95-6.47)	5.93 (2.23-17.38)
Pulmonary diagnosis (n = 196)	0.60 (0.31-1.13)	0.84 (0.51-1.37)	1.05 (0.71-1.54)	0.89 (0.57-1.32)
Ventilator-associated pneumonia (n = 56)	0.26 (0.03-1.02)	0.29 (0.07-0.82)	0.74 (0.39-1.37)	0.48 (0.21-0.99)
Acute respiratory distress syndrome (n = 30)	0 (0-0.91)	0.13 (0-0.83)	0.43 (0.15-1.07)	0.57 (0.19-1.48)
Infectious disease diagnosis (n = 193)	1.24 (0.68-2.26)	1.08 (0.66-1.75)	1.26 (0.86-1.86)	1.3 (0.86-1.97)
Human immunodeficiency virus (n = 22)	0.35 (0.01-2.28)	0.40 (0.04-1.70)	0.22 (0.04-0.78)	0.36 (0.07-1.25)
Gastrointestinal diagnosis (n = 111)	1.01 (0.48-2.02)	1.03 (0.57-1.79)	1.30 (0.83-2.03)	1.45 (0.90-2.32)
Renal diagnosis (n = 276)	1.43 (0.78-2.70)	1.36 (0.84-2.24)	1.97 (1.33-2.93)	2.06 (1.34-3.19)
Acute renal failure (n = 257)	1.41 (0.77-2.63)	1.24 (0.77-2.01)	1.68 (1.14-2.47)	1.72 (1.13-2.61)
Neurology diagnosis (n = 195)	0.41 (0.20-0.80)	0.44 (0.25-0.74)	0.42 (0.28-0.63)	0.25 (0.15-0.40)
Stroke (n = 88)	0.23 (0.04-0.73)	0.42 (0.18-0.88)	0.60 (0.35-1.01)	0.39 (0.19-0.72)
Oncology diagnosis (n = 57)	2.63 (1.20-5.45)	2.34 (1.20-4.42)	2.46 (1.35-4.53)	1.71 (0.92-3.12)
Trauma admission (n = 54)	0.13 (0.00-0.78)	0.07 (0.00-0.41)	0.16 (0.06-0.39)	0.08 (0.01-0.30)

NA indicates not applicable.

Table 3

Multivariable analysis of mortality after tracheostomy

	Mortality ORs (95% CI), n = 483			
	Within 14 d	Within 30 d	Within 180 d	Before hospital discharge
Age (per y)	1.03 (1.00-1.05)	1.03 (1.01-1.04)	1.04 (1.03-1.05)	1.02 (1.01-1.04)
Sex (female)	0.51 (0.28-0.95)	0.67 (0.41-1.10)	0.56 (0.37-0.85)	0.62 (0.40-0.96)
Ventilator-associated pneumonia	0.25 (0.06-1.09)	0.27 (0.09-0.79)	<i>a</i>	0.43 (0.20-0.91)
Cardiogenic shock	<i>a</i>	<i>a</i>	4.74 (1.99-11.33)	2.74 (1.21-6.19)
VAD	<i>a</i>	3.43 (1.36-8.61)	<i>a</i>	4.03 (1.43-11.37)
Acute stroke	0.23 (0.07-0.78)	0.44 (0.21-0.94)	<i>a</i>	0.42 (0.22-0.79)
Oncological diagnosis	2.04 (0.99-4.21)	2.00 (1.06-3.75)	2.78 (1.51-5.10)	<i>a</i>
Trauma admission	0.15 (0.02-1.19)	0.09 (0.01-0.71)	0.28 (0.11-0.71)	0.10 (0.02-0.41)
Acute renal failure	<i>a</i>	<i>a</i>	1.53 (1.02-2.32)	<i>a</i>

^aVariables were eliminated in the multivariate modeling because of lack of significance for each time points.

Table 4

Multivariable analysis of mortality after tracheostomy adjusting for severity of illness

	Mortality ORs (95% CI), n = 465			
	Within 14 d	Within 30 d	Within 180 d	Before hospital discharge
Age (per y)	1.03 (1.01-1.06)	1.03 (1.00-1.04)	1.05 (1.03-1.06)	1.03 (1.00-1.04)
Sex (female)	0.50 (0.27-0.93)	0.99 (0.57-1.70)	0.76 (0.49-1.19)	0.84 (0.51-1.36)
Ventilator-associated pneumonia	0.26 (0.06-1.10)	0.28 (0.09-0.83)	<i>a</i>	0.37 (0.16-0.84)
Cardiogenic shock	<i>a</i>	<i>a</i>	3.21 (1.25-8.24)	1.72 (0.71-4.13)
VAD	<i>a</i>	2.17 (0.76-6.21)	<i>a</i>	3.54 (1.12-11.15)
Acute stroke	0.47 (0.13-1.67)	0.77 (0.34-1.72)	<i>a</i>	0.70 (0.35-1.38)
Oncological diagnosis	3.69 (1.6-8.47)	2.86 (1.41-5.8)	3.25 (1.67-6.34)	<i>a</i>
Trauma admission	0.41 (0.05-3.31)	0.16 (0.021-1.24)	0.35 (0.14-0.91)	0.13 (0.03-0.59)
Acute renal failure	<i>a</i>	<i>a</i>	0.86 (0.53-1.37)	<i>a</i>

^aVariables were eliminated in the multivariate modeling because of lack of significance for each time.