Comparison of 2 Models for Managing Tracheotomized Patients in a Subacute Medical Intensive Care Unit

Leslie A Hoffman RN PhD, Thomas H Miller RN PhD, Thomas G Zullo PhD, and Michael P Donahoe MD

OBJECTIVE: To compare 2 models for managing patients admitted to a subacute medical intensive care unit (MICU) who required prolonged mechanical ventilation (≥ 7 d). METHODS: The subjects were 192 consecutive patients (mean ± SD age 61.5 ± 16.1 y, 52% male, 86% white) managed during alternating 7-month blocks of time by an attending physician in collaboration with an acute care nurse practitioner (ACNP) (*n* = 98 patients) or by an attending physician in collaboration with critical care/pulmonary fellows (*n* = 94 patients). The total observation time was 28 months (14 mo per team). RESULTS: At unit entry, there were no significant differences in age, sex, race, comorbidity, Acute Physiology and Chronic Health Evaluation III score, or time of tracheostomy between the patients managed by the 2 teams. Patients managed by the ACNP team were more likely to have required mechanical ventilation due to an acute pulmonary problem (p = 0.005). At subacute MICU discharge, the groups were not significantly different in regard to subacute MICU length of stay, days on mechanical ventilation, or discharge weaning status (p > 0.05). The number of readmissions to the MICU was similar for the ACNP team (*n* = 7) and fellows team (*n* = 8), as were readmissions to the subacute MICU ≤ 72 h after discharge (ACNP = 2, fellows = 1). Each team had 2 deaths without treatment limitation. CONCLUSION: As hypothesized, management of patients who required prolonged mechanical ventilation with tracheostomy had equivalent outcomes with the ACNP team or the fellows team. *Key words: prolonged mechanical ventilation, tracheostomy, acute care nurse practitioner, medical intensive care unit, critical care, weaning*. [Respir Care 2006; 51(11):1230–1236.

Introduction

Mechanical ventilation is a common treatment in patients admitted to intensive care units (ICUs). Approximately one third of all ICU admissions require mechanical ventilation.[1] There are substantial costs associated with mechanical ventilation. In a geographically diverse sample of 51,000 patients admitted to ICUs in the United States, mean costs were $31,574 ± 42,570 for patients who required mechanical ventilation, versus $12,931 ± 20,569 for those who did not.[1]

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Although most mechanically ventilated patients remain in the ICU for ≤ 4 d,[2,3] approximately 10% require prolonged mechanical ventilation and receive tracheostomy,[4,5] which is an outcome commonly associated with substantially longer ICU and hospital stay.[4,5] There are indications that the number of patients who have a tracheotomy following ICU admission is increasing.[6,7] Cox et al[6] reported that the incidence of tracheostomy for prolonged mechanical ventilation increased by nearly 200% over the decade 1993 to 2002. At the same time, the increase in the incidence of respiratory failure was nearly 3-fold less. In this analysis of all hospital discharges in one state, patients

Leslie A Hoffman RN PhD, Thomas H Miller RN PhD, and Thomas G Zullo PhD are affiliated with the University of Pittsburgh School of Nursing, Pittsburgh, Pennsylvania. Michael P Donahoe MD is affiliated with the Division of Pulmonary, Allergy, and Critical Care Medicine, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania.

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Correspondence: Leslie A Hoffman RN PhD, University of Pittsburgh School of Nursing, 336 Victoria Building, 3500 Victoria Street, Pittsburgh PA 15261. E-mail: lhof@pitt.edu.

with tracheostomies accounted for 22% of all mechanical ventilation patient charges but represented only 7% of all patients who required mechanical ventilation.[6] These findings are concerning because they suggest an increase in the number of patients who require extensive resources at a time when Medicare payments cover approximately 80% of ICU costs.[8]

Concurrent with this change, the need for critical care services is increasing. During the next 30 years, the number of individuals participating in Medicare in the United States is predicted to increase by 50%.[9] These older beneficiaries currently account for more than half of all ICU days.[10] Consequently, demand for critical care services is also predicted to increase.[8,10] Using population-based age and gender-specific projections, Needham et al[7] estimated that the number of ICU patients who require mechanical ventilation will increase by 31% from 2000 to 2026, largely due to aging of the population. Other trends also influence this increase. Technological advances allow patients at higher risk for complications to be candidates for life-saving treatment. Because such patients need frequent monitoring, they are likely to be admitted to a critical care unit.[11] In addition, new accreditation standards in the United States limit the hours that house staff can provide patient care.[12] Therefore, many academic centers have found it necessary to reduce trainee hours and shift this responsibility to faculty or other care providers.

Substantial evidence supports the conclusion that patient outcomes are better when management of ICU patients is provided or supervised by intensivists.[13,14] Among patients admitted to an ICU, there are typically a minority who are in a more stable phase of their illness. With the exception of the need for prolonged mechanical ventilation, management of these patients often closely resembles that of patients with chronic illness. Consequently, they have been termed the "chronically critically ill."[15] With the increased demand for critical care services, decreased hours for house staff, and increased costs of health care, attention must be given to organizational aspects of ICU care that promote more efficient use of resources, while maintaining the quality of care.[16] Accordingly, we compared 2 approaches for managing "long-stay" ICU patients within the setting of a subacute medical ICU (subacute MICU).

The purpose of this study was to compare outcomes in a consecutive sample of patients admitted to a subacute MICU who required prolonged mechanical ventilation ($\geq$ 7 d) with tracheostomy when medical management was provided by either (1) an attending physician in collaboration with a unit-based acute care nurse practitioner (ACNP) or (2) an attending physician and critical care/pulmonary fellows who rotated coverage. Our central hypothesis was that patient outcomes would be equivalent between the 2 teams.

Methods

Study Site and Patient Selection

The research was performed at the University of Pittsburgh Medical Center. The data were collected as part of a prospective examination of outcomes of patients admitted to a subacute MICU.[17] The focus of this report is management of a subset of those patients (n = 192) who required prolonged mechanical ventilation ($\geq$ 7 d) with tracheostomy. The study protocol was reviewed and approved by the institutional review board.

During the study interval, responsibility for management of these patients was rotated every 7 months (total of 14 mo per team). Patients who remained in unit at the end of one of the 7-month rotations and were managed by both teams were not included in the analysis. Both providers were responsible for assessment, diagnosis, and writing all orders for care, including weaning and extubation. Both providers were responsible for admitting new patients and for discharge decisions. During rounds, the attending physician reviewed the care plan and suggested revisions, if indicated. The attending physician was also available, as needed, for consultation throughout the day. Both providers worked an 8–10-hour day (Monday to Friday) during daylight hours. Off-tour coverage was provided by residents and weekend coverage by the attending physician. The ACNP and the critical care/pulmonary fellows received an equivalent intensity of attending-physician oversight in the opinion of attending physicians participating in the study. However, the type, frequency, and outcome of this oversight were not measured as part of the study.

The nurse practitioner was a certified graduate of an ACNP program employed by the university-affiliated medical practice plan of the service administratively responsible for the unit.

The ACNP program, in existence since 1994, has been previously described.[18] Only one ACNP was employed, because this was judged sufficient for the caseload and assigned work hours. The fellows, who were board certified in internal medicine, were pulmonary/critical care fellows who rotated through the unit at 2-week (critical care fellows [n = 14]) or 4-week intervals (pulmonary fellows [n = 8]) during their fellowships. The fellows were also responsible for one night call per week, one night weekend call per month, and one 2-hour out-patient clinic per week.

Data Collection

Data were obtained from an electronic medical records database (Medical Archival System, Pittsburgh, Pennsylvania), the computerized bedside charting system (EMTEK, Phoenix, Arizona), and printed medical records, by research team members not involved in patient care.

Table 1. Characteristics of the Study Sample*

	ACNP Team (n = 98)	Fellows Team (n = 94)	p
Age (mean ± SD y)	61.9 ± 15.7	61.2 ± 16.6	0.762
Male (n and %)	50 (51.0)	50 (53.2)	0.763
White (n and %)	83 (85.6)	81 (87.1)	0.612
Charlson Comorbodity Score (mean ± SD)	6.5 ± 3.7	5.8 ± 3.8	0.166
Primary reason for ventilator dependence (n and %)			
Acute pulmonary	55 (56.1)	46 (48.9)	0.005
Chronic pulmonary	23 (23.5)	25 (26.6)	
Neurologic	10 (10.2)	18 (19.1)	
Postoperative	1 (1.0)	5 (5.3)	
Other/multiple problems	9 (9.2)	0 (0)	
Time of tracheostomy (n and %)			
Prior to hospital admission	25 (25.5)	18 (19.1)	0.515
Acute MICU	44 (44.9)	43 (45.7)	
Subacute MICU	29 (29.6)	33 (35.1)	
Mortality (n and %)			
Without treatment limitation	2 (2.0)	2 (2.0)	1.0†
With treatment limitation	0	1 (1.0)	

*Study sample n = 192 patients
†By Fisher's exact test
ACNP = acute care nurse practitioner

Main Outcome Measures

ICU length of stay was recorded for the number of days in the MICU prior to transfer, and days in the subacute MICU. Days on mechanical ventilation were recorded for the same intervals. Readmissions were recorded for patients who required transfer back to the MICU and patients readmitted to any ICU ≤ 72 hours after discharge from the subacute MICU. Weaning status was recorded at discharge from this unit.

Demographic and medical condition data included Charlson comorbidity score, which was calculated in the standard manner, using data available from the medical record.[19] Acute Physiology and Chronic Health Evaluation (APACHE III) scores were calculated in the standard manner at 3 time points: day 1 of ICU admission, first 24 hours of subacute MICU admission, and last 24 hours in the subacute MICU.[20] The primary reason for mechanical ventilation was coded using 5 categories: acute pulmonary (eg, acute respiratory distress syndrome, pneumonia); chronic pulmonary (eg, chronic obstructive pulmonary disease, idiopathic pulmonary fibrosis); neurologic (eg, quadriplegia, stroke); postoperative (eg, coronary artery bypass graft, lobectomy, other surgery); and other (eg, malignancy, gastrointestinal bleeding). In addition, deaths with and without treatment limitation were recorded.

Statistical Analysis

Baseline demographic and medical profile data were compared using the chi-square and t tests, as appropriate. Differences between patients managed by the ACNP team or fellows team for length of stay and days of mechanical ventilation were compared using multivariate analysis of variance. Disposition was analyzed with the chi-square test. Mortality and readmission data were analyzed using Fisher's test for differences between uncorrelated proportions. Calculations were made with statistics software (SPSS 13.0, SPSS, Chicago, Illinois).

Results

The sample consisted of 192 patients (mean ± SD age 61.5 ± 16.1 y) who had been mechanically ventilated for 23.9 ± 13.9 d (median 22.0 d). At entry to the unit, there were no significant differences in age, sex, race, Charlson comorbidity score, or timing of tracheostomy between the patients managed by the 2 teams (Table 1). APACHE III scores decreased significantly over time ($p \le 0.001$) in both groups (Fig. 1). The primary reason for prolonged mechanical ventilation differed between the groups ($p = 0.005$). The patients managed by the ACNP team were more likely to have an acute pulmonary problem. Four patients died without treatment limitation (ACNP 2, fellows 2). One death occurred with treatment limitation.

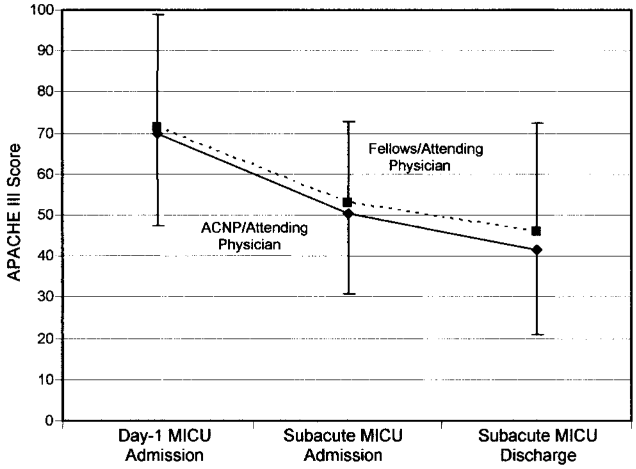

Fig. 1. Changes in APACHE III scores. There was no statistically significant difference in mean ± SD Acute Physiology and Chronic Health Evaluation (APACHE III) scores between the groups (fellows plus attending physician [squares and dashed line] versus acute care nurse practitioner (ACNP) plus attending physician]diamonds and solid line]) ($p = 0.312$). APACHE III scores decreased significantly ($p \leq 0.001$), and the change was similar in the 2 groups ($p = 0.683$).

Among patients discharged from the unit, there were no significant multivariate ($p = 0.455$) or univariate differences between the 2 teams in ICU length of stay before ($p = 0.215$) or after transfer to the subacute MICU ($p = 0.753$) (Table 2). Also, there were no significant multivariate ($p = 0.613$) or univariate differences in days of mechanical ventilation before ($p = 0.475$) or after transfer to the subacute MICU ($p = 0.545$). Fifteen patients required readmission to the MICU (ACNP 7, fellows 8). Three patients required readmission to an ICU ≤ 72 hours of after discharge; 2 were managed by the ACNP team and one by the fellows team. There were no significant differences in the proportion of patients weaned at discharge ($p = 0.582$) or disposition ($p = 0.449$).

Discussion

To our knowledge, this is the first study to prospectively compare outcomes of patients who required prolonged mechanical ventilation with tracheostomy when medical management was provided by a team consisting of an attending physician in collaboration with a unit-based ACNP or critical care/pulmonary fellows who rotated coverage. The hypothesis that outcomes would not differ between patients who were managed by the 2 teams was supported by the findings of no significant difference in length of stay, days on mechanical ventilation in the subacute MICU, readmission within ≤ 72 hours of ICU discharge, weaning status, or mortality.

The findings of this study raise several interesting points. The equivalent outcomes we observed may have resulted from the greater continuity provided by the ACNP versus the rotating coverage necessitated by training demands on the fellows. Alternatively, our findings may have been a consequence of the attending physician's ability to expertly direct care, regardless of changes in the composition of the clinical care team. It is also possible that our findings reflect the proficiency of a highly experienced ACNP who had greater familiarity with the unit and patient care demands. Regardless, our findings support the ability of an ACNP to provide safe, effective care in this environment, which is important in view of the projected increasing number of critically ill patients and an insufficient number of intensivists to provide the required care.

Available evidence from prior studies suggests that with appropriate training and supervision, ACNPs can provide safe, cost-effective care.[21–25] In those studies the ACNP most commonly managed a selected group of patients as a member of a clinical care team. Rudy and colleagues[22] examined characteristics of patients managed by ACNPs, physician assistants, and residents in 2 academic medical centers. Compared to ACNPs and physician assistants, the residents managed a larger case-load of patients and these patients were older and had higher APACHE III scores. In the nurse practitioner/attending collaborative service described by McMullen and colleagues,[24] the admitting medical resident or attending physician assigned patients with multiple comorbidities or patients judged good teaching cases to the team managed by house staff. Howie and Erickson[26] described an ACNP team that managed patients from the general medical population who had a lower probability of acute cardiac decompensation or need for treatment in the ICU. The ACNP team did not provide care for patients who were transferred to the ICU, but did provide care when the patients were transferred back to a general clinical unit.

Fewer studies have examined ACNP practice in the ICU. Russell and colleagues[27] compared outcomes in patients admitted to a neuroscience ICU or acute care neurosurgery unit who were managed by an ACNP team with historical controls managed by house staff. Patients managed by the ACNP team had a shorter ICU stay ($p < 0.001$), a shorter time to mobilization ($p < 0.05$), and lower rates of skin breakdown and urinary tract infection ($p < 0.05$). The number of patients who required mechanical ventilation was not provided. Burns and colleagues[28] reported a significant decrease in ICU stay, days of mechanical ventilation, and mortality when advanced-practice nurses provided consultation regarding readiness to wean from mechanical ventilation and weaning protocols, but did not assume responsibility for the daily medical management.

In the present study we examined 2 approaches for providing medical management for chronically critically ill ICU patients, designated by the need for prolonged mechanical ventilation (≥ 7 d) and tracheostomy. We se-

Table 2. Outcomes of Patients Who Survived to Unit Discharge*

	ACNP Team (n = 98)	Fellows Team (n = 94)	p
ICU stay (mean ± SD d)			
Prior to transfer to subacute MICU	13.2 ± 11.5	11.2 ± 10.6	0.215
Subacute MICU	14.6 ± 9.7	15.0 ± 11.4	0.753
Duration of mechanical ventilation (mean ± SD d)			
Prior to transfer to subacute MICU	11.9 ± 10.9	10.8 ± 10.6	0.475
Subacute MICU	13.0 ± 9.8	12.1 ± 10.4	0.545
Weaned prior to discharge (n and %)			
Yes	42 (42.9)	44 (46.8)	0.582
No	56 (57.1)	50 (53.2)	
Readmitted (n and %)			
To acute-care MICU	7 (7.1)	8 (8.5)	1.0†
To any ICU ≤ 72 h after discharge	2 (2.0)	1 (1.0)	
Disposition (n and %)‡			
General unit/home	38 (42.7)	33 (38.8)	
Long-term care/rehabilitation hospital	49 (55.1)	45 (54.2)	0.449
Skilled nursing facility	2 (2.2)	5 (6.0)	

*Study sample n = 192 patients
†By Fisher's exact test
‡Excludes patients who died or were transferred back to high acuity MICU
ACNP = acute care nurse practitioner

lected this subgroup because they have unique care needs that are not well fitted to continually rotating coverage. Patients managed by both teams were similar in demographic and medical condition variables. ICU length of stay prior to and following subacute MICU admission compared closely, as did days on mechanical ventilation.

Managing patients on prolonged mechanical ventilation requires being able to identify when the patient can be safely weaned from mechanical ventilation, discharged from the ICU, or requires readmission to the ICU. Judged by study outcomes, the teams performed similarly in making these judgments. A recent review that analyzed pooled data from multiple studies of ICU outcomes reported a mean ICU readmission rate of 7% (range 4–10%).[29] Both teams had fewer readmissions to the ICU within ≤ 72 hours of discharge than this mean percentage (ACNP 2%, fellows 1%).

Because admission criteria for subacute ICUs vary, we compared the severity of illness of our sample with that reported in other studies. The mean ± SD APACHE III scores for patients managed by the ACNP team and fellows team at entry to the subacute MICU were 50.5 ± 19.5 and 52.8 ± 20.1, respectively. From a study of patients admitted to 38 medical, surgical, neurologic, or mixed medical/surgical ICUs over a 4-year period, Sirio and colleagues[30] reported a mean APACHE III score of 46.9 ± 27.6 on day 1 of ICU admission. Two additional studies that enrolled samples from single centers reported nearly identical scores.[31,32] In intermediate care units, Junker and colleagues[33] reported a lower mean APACHE III score (28.9 ± 15.5) on Day 1 of admission from a study of over 8,000 patients admitted to 32 hospitals. Therefore, the severity of illness of patients managed by the ACNP and fellows was high, and comparable to Day 1 of ICU admission scores in other studies.

The presence of an intensivist significantly improves outcomes in regard to ICU and hospital mortality and length of stay.[14] In addition, evidence suggests that having responsibility for managing fewer patients can translate into better outcomes. Dara and Afessa[16] compared demographics, ICU and hospital length of stay, and ICU and hospital mortality when the intensivist-to-ICU-bed ratio was 1:7.5, 1:9.5, 1:12, and 1:15. There was no difference in severity of illness among the 2,492 patients admitted during the 4 time periods. After adjusting for factors known to affect ICU length of stay, mean ICU length of stay was significantly longer ($p < 0.001$) when the intensivist-to-ICU bed ratio was 1:15, compared to the period when the ratio was 1:7.5. There were no differences in ICU or hospital mortality, which suggests that the intensivist-to-ICU-bed ratio did not influence survival. However, shorter stay can translate into substantial cost savings.[34] Krishnan and colleagues[34] reported a similar benefit from a study that compared protocol-based weaning to weaning managed at physician direction. In contrast to prior studies,[5,35] the authors did not document any improvement in weaning success with use of a nursing/respiratory-therapy-driven protocol for discontinuing mechanical ventilation, despite high compliance with the protocol—a finding they attributed to physician availability. Compared with approximately 9.5 physician-hours/bed/day in their study, physician staffing was less in prior randomized trials that reported advantages with protocol-based weaning (eg, 3.5–4.7 physician-hours/bed/day).[5,35]

ICUs typically include patients whose severity of illness ranges from highly unstable and rapidly changing to a more stable phase of critical illness. It has been estimated that an intensivist is presented each day with as many as 1,000 pieces of information per patient,[36] and the greater the number of patients managed or supervised, the more intermittent the contact.[37] The ability to focus on fewer patients has a number of advantages, including the ability to attend to patient problems in a more timely manner, greater family and patient satisfaction, better end-of-life care, and more time for teaching and attention to unit management.[16,38–40] The complexity of today's health care delivery system and current scheduling often results in care providers working shifts of a few days a week, rotating off service, or having system-wide responsibilities that make it difficult to remember changes in the management plan over time.[41] As a unit-based clinician, the ACNP can be a resource regarding the plan of care, as developed over the length of the patient's ICU stay, and potentially improve care coordination for patients and their families.

Limitations

There are several limitations to the present study. First, the study was conducted in a university-affiliated medical center. The ACNP practiced in collaboration with attending physicians who were board-certified in critical care, supportive of this nurse practitioner's advanced practice role, and always available for consultation. Other settings might not provide the same level of support.

Second, because of the caseload and assigned hours, only one ACNP was employed, so the study evaluated the practice of only one ACNP. Though not optimal, other studies have used a single-practitioner model to compare the impact of a neurointensivist[42] and outcomes from 2 types of surgical procedures.[43]

Finally, the present study evaluated management of a subset of patients admitted to the subacute MICU. Outcomes might have been different if the patients were more recently admitted with a greater severity of illness.

Conclusions

This study was designed to compare outcomes in patients who required prolonged mechanical ventilation and tracheostomy when medical management was provided by an attending physician in collaboration with either a unit-based ACNP or critical care/pulmonary fellows who rotated coverage. The hypothesis predicting similar outcomes was supported by findings of no significant difference in length of stay, weaning status, days on mechanical ventilation, readmission to the ICU within $\leq$ 72 hours of discharge, disposition, or mortality. The findings of this study support that, with appropriate training and supervision, an attending physician/ACNP team can competently assume responsibility for the medical management of a case-load of patients who require prolonged mechanical ventilation and tracheostomy and are admitted to a subacute ICU.

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