Performance Improvement

Improving Care for the Ventilated Patient

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Mechanical ventilation is common in the intensive care unit (ICU). Patients on mechanical ventilation are at an increased risk of death and complications such as gastrointestinal bleeding[1] and ventilator-associated pneumonia[2] (VAP) and consequently are expensive to care for. Efforts to decrease the morbidity and mortality and improve the quality and safety of care that we provide are paramount.

Selective interventions or processes of care decrease morbidity, mortality, and costs of care for patients receiving mechanical ventilation.[3–6] In 2002, as part of an ICU quality improvement (QI) project with the VHA (Irving, TX) and the Institute for Healthcare Improvement (Boston), we developed measures of the quality of ICU care.[7] Four of these measures were selected for pilot testing by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) initial core set of quality measures.[8] The four JCAHO-selected therapies that were associated with improved outcomes in patients receiving mechanical ventilation included the use of semirecumbent positioning to prevent VAP,[3] daily interruption of sedative-drug infusions,[4] peptic ulcer disease (PUD) prophylaxis,[5] and deep venous thrombosis (DVT) prophylaxis.[6] *

In spite of the evidence, a gap exists between best evidence and current practice.[9] We found that performance

* After a public-comment period and initial testing for face validity and feasibility of data collection in May–June 2003, one of the eight candidate core measures—daily interruption of sedative-drug infusions—was dropped, and peptic ulcer disease (PUD) prophylaxis was renamed *stress* ulcer disease (SUD) prophylaxis.

Article-at-a-Glance

Context: Despite evidence that the use of specific interventions can decrease morbidity and mortality for patients receiving mechanical ventilation, a gap exists between best evidence and practice. A prospective cohort study was conducted in a surgical intensive care unit (ICU) that included all patients who were mechanically ventilated. The study was designed to ensure that for 90% of ventilator days, patients receive processes associated with improved outcomes, including semirecumbent positioning, daily interruption of sedative-drug infusions, peptic ulcer disease prophylaxis, and deep venous thrombosis prophylaxis.

Intervention: The improvement model included three interventions: (1) administering a questionnaire to identify barriers to compliance with the four care processes,(2) implementing an educational intervention, and (3) implementing a checklist to be completed daily during ICU rounds to ask providers whether patients were receiving these therapies.

Results: Overall, 80% of nurses did not know there was evidence to support at least one of the four therapies. During the study period (March 4–April 29, 2002), the percentage of ventilator days on which patients received all four care processes increased from 30% to 96% ($p < .001$).

Discussion: Evidence-based therapies for mechanically ventilated patients can reduce morbidity, mortality, and costs of care.

for each of these process measures varied widely in our ICU, and although our performance on some measures was good, on only 30% of ventilator days did patients receive all four processes. We grouped these four processes into a single quality measure called the ventilator bundle. A *bundle* is a set of process of care measures that relate to common disease and that together provide a more robust picture of quality than any single measure. The project was designed to ensure that for 90% of ventilator days, patients received all four care processes in the ventilator bundle. To accomplish this aim, we used a QI model that can be broadly applied to patients who require mechanical ventilation.

Table 1. Specifications for Process Measures

Quality Indicator	Definition
Prevention of ventilator-associated pneumonia	The percent of ventilator days on which the head of bed is elevated ≥ 30 degrees
Appropriate sedation	The percent of ventilator days on which (1) sedation was held for at least 12 hours or until patient could follow commands OR (2) if patient follows commands without a need to hold sedation
Appropriate peptic ulcer disease prophylaxis	The percent of ventilator days on which the patient received peptic ulcer disease prophylaxis
Appropriate deep venous thrombosis prophylaxis	The percent of ventilator days on which the patient received deep venous thrombosis prophylaxis

Methods

Study Design

In winter 2002 we designed a prospective cohort study in a surgical ICU at a tertiary care hospital, The Johns Hopkins Hospital. Our ICU has a 20-bed capacity, and 14 of the beds are used. There are approximately 1,750 admissions per year, and approximately 30% of patients require mechanical ventilation during their ICU stays. The patient's surgeon remains the attending of record, and all patients in our ICU are comanaged by an intensivist-led multidisciplinary team that includes ICU attending physicians [S.M.B., P.L., T.D., P.J.P.] and fellows, anesthesia and surgery residents, nurse practitioners [S.M.], nurses [D.P., K.E., A.F.], and a pharmacist (Pharm.D.). That is, the ICU can be described as a mandatory consult model where intensivists lead clinical decision making. This patient care model did not change during the study period. The nurse-patient staffing ratio in the ICU—1:1 or 1:2 (24/7)—did not change during the study period. The ICU principally but not exclusively provides care for patients undergoing oncologic-related surgery. The Johns Hopkins Medicine institutional review board approved the study with a waiver of informed consent.

Measures for Improvement

The primary outcome variable was the percentage of ventilator days per week when patients received all four care processes: semirecumbent positioning, daily interruption of sedative-drug infusions, PUD prophylaxis, and DVT prophylaxis. To reduce bias in data collection, explicit definitions were created for each of the process measures (Table 1, above), and standardized data collection tools were developed and pilot tested. We were not prescriptive in terms of the specific therapies used for PUD or DVT prophylaxis because the literature suggests that multiple therapies are effective.[5,6] In addition, it is difficult for providers to reach consensus on the single best form of PUD or DVT prophylaxis. We measured the percentage of ventilator days on which a patient received any form of prophylaxis, as documented in the electronic patient medication record. Semirecumbent positioning was measured using the bedside goniometer.

To ensure the validity and reliability of data collection, a physician [S.M.B.] and an acute care nurse practitioner [S.M.] independently pilot tested the data collection forms for one week. The kappa (percentage agreement beyond chance) was 0.9 for appropriate sedation and 1.0 for each of the other process measures. One of the investigators [S.M.B. or S.M.] then collected data daily for all patients who were mechanically ventilated with an endotracheal tube or tracheotomy during morning rounds (7 A.M.–10 A.M.) from March 4 through April 29, 2002.

Improvement Model

To gain visibility and credibility for this project, we created an interdisciplinary team to lead this QI effort. The improvement model consisted of the following three interventions:

1. Administering a questionnaire to identify barriers to compliance with the four care processes
2. Implementing an educational intervention to increase awareness of the evidence
3. Implementing a checklist to be completed daily during ICU rounds to ask providers whether patients were receiving these therapies

We based these interventions on the idea of independent redundancies (engaging independent providers to help ensure that we perform these processes) and the team care concept that we have developed in our ICU.

We also increased awareness of our current performance within the ICU by adding this topic to the agenda of previously established monthly performance improvement meetings and nursing educational meetings and discussing our performance during daily rounds. In addition, nursing developed a billboard within the ICU to highlight the project and post the performance for the entire staff to see.

Intervention 1. Administering a Questionnaire to Identify Barriers to Compliance with the Four Care Processes (Time Line: March 4–10, 2002)

To identify the barriers to compliance for these four care processes, we used the framework provided by Cabana et al.,[10] who grouped barriers to the use of best practice into three categories: awareness, agreement and ability. We focused on nursing awareness of the evidence, hypothesizing that nurses were not aware of the evidence to support the use of these processes. To test our hypothesis, we developed a mail questionnaire and distributed it to the full-time nursing staff (n = 30; Appendix 1, page 202) The questionnaire included 10 questions designed to determine if nursing staff was aware of the evidence supporting these therapies. Response categories were categorical (Yes, No, Don't know) or short answer. We measured the percentage of nurses who completed the questionnaire and the percentage who answered that they were aware of the evidence supporting these therapies.

Intervention 2. Implementing an Educational Intervention to Increase Awareness of the Evidence (Time Line: March 11–31, 2002)

The results of the questionnaire suggested that many nurses were not aware of the evidence for these four care processes for reducing morbidity and mortality. On the basis of these results, we hypothesized that we would increase the use of these therapies by increasing awareness of this evidence. To test our hypothesis, we developed and distributed an educational sheet to the ICU nursing staff (Appendix 2, page 203) The educational sheet provided a summary of the evidence to support each of the four care processes. An ICU attending [S.M.B.] and the nursing educators provided in-services to educate nursing staff. All full-time nurses were required to attend one of the seven in-services. During each of the 20–30 minute in-services, the ICU attending reviewed the evidence to support each of the four care processes for patients requiring mechanical ventilation and provided an opportunity for the nurses to ask questions. During the in-services, we evaluated whether nursing agreed that the processes of care were important and whether there were external barriers to providing these therapies to their patients, such as absence of a physician order. We also provided instruction to the ICU residents and fellows during daily lectures to ensure that they were aware of the evidence to support these therapies.

Intervention 3. Implementing a Checklist into Daily Rounds to Ask Providers Whether Patients Were Receiving These Therapies (Time Line: Introduced March 18, 2002)

Through discussions with nursing staff during the in-services, we determined that agreement with the evidence was not a barrier to use of the processes. Rather, we identified that a barrier to improved compliance was that physicians might not remember to write an order for these therapies when mechanical ventilation was required. We hypothesized that by using a standardized form to remind physicians during rounds in the ICU, we would improve compliance. To test our hypothesis, we developed a standardized checklist, the Daily Goals form, to ask whether physicians wrote orders for semi-recumbent positioning, daily interruption of sedative-drug infusions, PUD prophylaxis, and DVT prophylaxis (Appendix 3, page 204). The checklist was also used to explicitly outline the patient's plan of care for the day.

We pilot tested the checklist for one week in the ICU and interviewed 6 physicians and 14 ICU nursing staff regarding the clarity of the form, the burden of data

collection, the usefulness of the form, and the need for modification. On the basis of this feedback, we modified the form and provided in-services to the ICU physicians, fellows, and residents about the use of the checklist. The checklist was completed on all patients by the ICU resident or nurse practitioner during rounds, signed by the fellow or attending physician, and handed to the patient's nurse before moving on to the next patient. For two weeks, we audited the percentage of patients for whom the checklist was completed. We also interviewed 10 providers who had completed the checklist to evaluate the providers' perceptions of the form and the burden and average time to complete the form.

Analysis and Interpretation

We used a Fisher's exact test to compare the percentage of ventilator days when patients received all four care processes before and after the interventions. To estimate the potential clinical and economic savings as a result of our improved compliance with each of the four care processes, we calculated the difference between our pre- and postintervention compliance and used published estimates of the efficacy for those therapies.[11]

For clinical outcomes, we used the number needed to treat (NNT) which is 1/ARR (the absolute risk reduction, or the difference in outcomes between the two groups) and is interpreted as how many patients must be treated with the experimental intervention versus the control intervention to prevent one outcome. We used estimates of the NNT from published literature that included only ICU patients because the baseline event rate affects the NNT. We used an NNT of 4 for the prevention of clinically suspected VAP,[3] 47 for appropriate PUD prophylaxis,[5] and 6 for appropriate DVT prophylaxis.[6] Because estimates of attributable mortality vary among studies, we used mean values (ranges) from published studies. For the attributable mortality associated with VAP, we used 24% (range, 0–8%)[12]; we used 25% (20–30%) for clinically important GI bleeding[13]; and 25% (0–50%) for DVT.[14]

For economic outcomes, we used the NNT and the estimated reduction in hospital or ICU length of stay (LOS). Because estimates of attributable increased ICU LOS vary among studies, we used available mean values and ranges. For the attributable increased ICU LOS associated with VAP, we used 7 days (4–10 days)[12]; we used 6 days (4–8 days) for clinically significant GI bleeding[13] and 7 hospital days (0–14 days) for DVT prophylaxis.[15]

We estimated that the additional costs of an ICU and hospital day were $1,200 and $600, respectively. We used conservative cost estimates because we recognize that the costs for ICU days reduced by preventing these complications may be less than costs for initial ICU days.

Results

From the 30 questionnaires that were distributed, we received 16 completed surveys. Few of the 16 ICU nurses who completed the survey were aware of the evidence to support the use of all four therapies in ventilated patients: 10 (63%) for semirecumbent positioning, 12 (75%) for daily interruption of sedative-drug infusions, 8 (50%) for PUD prophylaxis, and 8 (50%) for DVT prophylaxis stated that they were aware of the evidence. Overall, 13 (80%) ICU nurses responded that they did not know there was evidence to support at least one of the therapies. Many of the ICU nurses attending our in-services identified barriers to compliance, including lack of physician order, lack of reminder system, patient refusal (for semirecumbent positioning), and disagreement among physicians. One provider also stated that a barrier was that it is "one more thing that we need to remember to do." All the ICU nurses attending our in-services agreed that the processes of care were important and should be provided to patients on mechanical ventilation.

All providers interviewed reported that the Daily Goals form had an easy-to-understand format and could be completed in less than three minutes. The ICU nurses also indicated that they found the form helpful in that they were frequently unable to listen to rounds without interruptions to provide patient care. As a result, ICU nurses indicated that the plan of care for the day was clearer when the checklist was used.

The percentage of ventilator days on which patients received each of the four care processes is provided in Table 2 (page 199). The percentage of ventilator days on which patients received all four care processes before the start of the intervention was 30%. After our interventions, the percentage of ventilator days on which patients received all four care processes increased to 96% ($p < .001$; Figure 1, page 200).

Table 2. Compliance with Processes and Estimated Impact on Clinical and Economic Outcomes*

Process	Pre (%)	Post (%)	NNT	Prevented complications	Prevented deaths (range) per year	Excess days (range) per year	Excess costs (range) per year
Prevention of VAP	11/36 (30)	27/28 (96)	4	87	21 (0–42)	609 ICU days (348–870 days)	$730,800 ($417,600–1,044,000)
Appropriate sedation	35/36 (97)	28/28 (100)	NA	NA	NA	NA	NA
Appropriate PUD prophylaxis	31/36 (86)	28/28 (100)	47	2	1 (0–1)	12 ICU days (8–16 days)	$14,400 ($9,600–19,200)
Appropriate DVT prophylaxis	33/36 (92)	28/28 (100)	6	19	5 (0–10)	133 hospital days (0–266 days)	$79,800 ($0–159,600)
All four processes	11/36 (30)	27/28 (96)	NA	NA	27 (0–53)	754 ICU and hospital days (356–1,152 days)	$825,000 ($427,200–1,222,800)

* Assuming that 1,750 admissions per year in the intensive care unit (ICU), that 30% of patient require mechanical ventilation during their ICU stays and that 2.7 days = average duration of mechanical ventilation. NNT, number needed to treat; VAP, ventilator-associated pneumonia; PUD, peptic ulcer disease; DVT, deep venous thrombosis; NA, not applicable (estimates not available).

This improvement in performance was sustained. We still audit performance on one random day per week, and 12 months after the start of our study, patients received all four care processes on 100% of the ventilator days. The educational intervention and Daily Goals form are now routinely used in the ICU. In fact, several other ICUs within our organization have adopted these tools for their use.

Using estimates of efficacy for these care processes to decrease morbidity and mortality, we estimate that our improvement in compliance may have prevented 27 (0–53) deaths and 754 (356–1152) excess hospital and ICU days and yielded $825,000 ($427,200–$1,222,800) in savings per year in the ICU (Table 2).

Discussion

The use of evidence-based therapies for patients receiving mechanical ventilation can reduce their morbidity and mortality and costs of care. Through these interventions, we increased the percentage of ventilator days when patients received evidence-based processes and thereby likely reduced morbidity, mortality, and costs of care in the ICU.

This study advances the science of QI in the ICU by providing a framework for grouping related care processes into a bundle and using the concept of independent redundancies (checklists) to ensure that patients receive them. The information provided in this article provides guidance on how caregivers can improve their performance on these important measures.

Several important lessons from this study can inform future efforts to improve the quality and safety of ICU care. First, the tremendous efforts of the ICU team, especially the ICU nurses, needs to be acknowledged. Without their dedication to improving patient care, these improvements may not have been possible. Our study clearly demonstrates the importance of providing nurses with the evidence regarding evidence-based therapies and the potential benefit of providing these therapies to their patients; as patient advocates, nurses can help ensure that patients receive the therapies they ought to. Yet the study suggests that we do not adequately educate ICU nurses regarding evidence-based therapies. If we want to engage nurses to ensure that they provide high-quality care, we will need to enhance our current process of nursing education.

Second, providers respond to educational efforts. In general, current models of nursing and physician education are not combined. Future educational efforts in the ICU should include combined physician and nurse team training. This concept of training together is rooted in Crew Resource Management in aviation, where teams that work together train together.[16]

Third, independent redundancy, through the use of a checklist, is an effective technique to ensure that patients

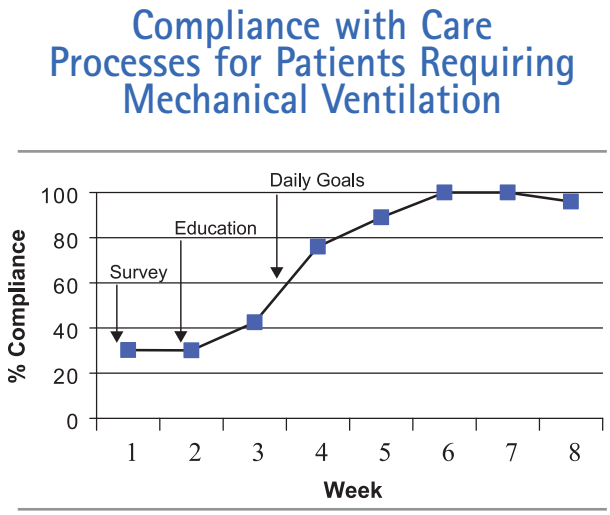

Figure 1. *The percentage of ventilator days on which patients received all four care processes increased from 30% before the start of the intervention to 96%.*

receive the care processes they should. Checklists are used extensively in the aviation industry[17] to create independent redundancies for key steps in a process. In this study the Daily Goals form asked providers whether patients were receiving therapies known to decrease the morbidity and mortality associated with mechanical ventilation. When all providers involved in the patient's care were aware of the goal to use these therapies, residents, nurses, respiratory therapists, and pharmacists could independently help ensure that patients receive these therapies. Both physicians and nurses perceived that using this form improved communication and patient care.[18] In addition, using the Daily Goals form helped the nurses feel that they were an active part of this patient care team, partnering with physicians to achieve a common goal.

This concept of creating independent redundancies has wide applicability in health care. For example, we have developed a checklist for the insertion of central venous catheters in the ICU to ensure compliance with evidence-based infection control practices.

We recognize several limitations of the study. First, we did not directly measure improved outcomes as a result of our improvement in providing evidence-based therapies, and the efficacy of the evidence-based process measures may not be generalizable to all patient populations.[19] Rather, we measured our performance on the process of care. The ICU did not routinely collect data on duration of mechanical ventilation, VAP rate, or incidence of DVT during the study period. Nonetheless, we selected process measures where the evidence regarding the association between the process and outcome is strong, thereby increasing the likelihood that improvement in the process measure will produce improvements in patient outcomes. Additional studies are needed to determine whether improvements in these process measures result in improved patient outcomes.

Second, we evaluated the interventions in a surgical ICU at an academic medical center, potentially limiting generalizability. Nonetheless, our interventions were not burdensome or expensive, and the experience of ICUs participating in the VHA's Transformation of the ICU collaborative that implemented similar interventions suggests that our results are generalizable. The overall incidence of VAP decreased by 29% (7.5 to 5.3 cases per 1,000 ventilator days), and the overall ICU LOS decreased by 15% (4.0 to 3.4 days). In addition, several ICUs nearly eliminated VAP.[20]

Third, we used a cross-sectional sampling strategy to evaluate whether patients were receiving the four care processes. For a process that patients can continuously be exposed to, we must decide how frequently to measure performance. The greater the frequency, the greater the burden. We elected to measure these processes once daily. This strategy may have biased our results, especially for semirecumbent positioning. Although caregivers could "game the system" and only elevate the head of the bed (HOB) for morning rounds, we audited random times of the day and found that performance on rounds reflected performance from randomly selected times. For example, we audited HOB elevation at a random time during each shift (7 A.M.–3 P.M., 3 P.M.–11 P.M., 11 P.M.–7 A.M.) for one week and found that the HOB was elevated for 32% (35/108) of ventilator days, compared with 30% (11/36) when we sampled during morning rounds (p = .84). In addition, we subsequently automated data collection for these four process measures and did not find any evidence to suggest that the cross-sectional sampling strategy introduced bias in our results.

Fourth, we did not evaluate other important evidence-based therapies that patients on mechanical ventilation should receive, including daily assessment of respiratory function and low tidal volume strategies for patients with acute respiratory distress syndrome. We chose to

evaluate these four process measures because we were able to reach consensus and gain buy-in from providers in our ICU, the evidence applies to all patients receiving mechanical ventilation, and the four care processes were selected by JCAHO as part of its initial set of ICU quality measures.

Fifth, we may have been able to improve performance with only one or two of the interventions instead of the three interventions outlined in our approach. Our goal, however, was to improve compliance with evidence-based therapies as quickly as possible rather than to identify which intervention resulted in the improvement we observed. Finally, other interventions, including a standardized admission order set, may have been equally efficacious. We explored the use of an admission order set and found it difficult to ensure that the orders were completed given the preprinted surgical procedure-specific order sets included in critical pathways currently in use at our institution. In addition, ICU admission order sets would do little to enhance compliance if mechanical ventilation was implemented following ICU admission and obtaining approval for standard order sets at our hospital is laborious, often taking more than six months to gain approval. We wanted to improve care in a shorter cycle time.

Summary

Our improvement model included interventions that resulted in significant improvement in the use of evidence-based therapies for patients receiving mechanical ventilation. One notable finding was the lack of provider awareness of the evidence. The improvement model can be broadly applied to improve the quality and safety of care provided and minimize the gap between best evidence and current practice for patients receiving mechanical ventilation. J

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References

1. Cook D.J., et al.: Risk factors for gastrointestinal bleeding in critically ill patients. Canadian Critical Care Trials Group. *N Engl J Med* 330:377–381, Feb. 10, 1994.
2. Kollef M.H.: The prevention of ventilator-associated pneumonia. *N Engl J Med* 340:627–634, Feb. 25, 1999.
3. Drakulovic M.B., et al.: Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: A randomised trial. *Lancet* 354:1851–1858, Nov. 27, 1999.
4. Kress J.P., et al.: Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. *N Engl J Med* 342:1471–1477, May 18, 2000.
5. Cook D., et. al.: A comparison of sucralfate and ranitidine for the prevention of upper gastrointestinal bleeding in patients requiring mechanical ventilation. Canadian Critical Care Trials Group. *N Engl J Med* 338:791–797, Mar. 19, 1998.
6. Attia J., et al.: Deep vein thrombosis and its prevention in critically ill adults. *Arch Intern Med* 161:1268–1279, May 28, 2001.
7. Berenholtz S.M., et al.: Qualitative review of intensive care unit quality indicators. *J Crit Care* 17:1–15, Mar. 2002.
8. Joint Commission on Accreditation of Healthcare Organizations: *Candidate Core Measures—ICU Pilot Test.* http://www.jcaho.org/pms/core+measures/candidate+core+measure+sets.htm (last accessed Jan. 26, 2004).
9. Cook D.J., et al.: Toward understanding evidence uptake: Semirecumbency for pneumonia prevention. *Crit Care Med* 30:1472–1477, Jul. 2002.
10. Cabana M.D., et al.: Why don't physicians follow clinical practice guidelines? A framework for improvement. *JAMA* 282:1458–1465, Oct. 20, 1999.
11. Pronovost P.J., Berenholtz S.M.: *A Practical Guide to Measuring Performance in the ICU.* https://www.vha.com/research/public/research_clinicalqualityimprovement.asp (last accessed Jan. 26, 2003).

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References, *continued*

12. Heyland D.K., et al.: The attributable morbidity and mortality of ventilator-associated pneumonia in the critically ill patient. Canadian Critical Care Trials Group. *Am J Respir Crit Care Med* 159:1249–1256, Apr. 1999.
13. Cook D.J., et al.: The attributable mortality and length of intensive care unit stay of clinically important gastrointestinal bleeding in critically ill patients. *Crit Care* 5:368–375, Dec. 2001.
14. Geerts W.H., et al.: Prevention of venous thromboembolism. *Chest* 119(suppl.):132S–175S, Jan. 2001.
15. Berenholtz S.M., et al.: Increased risk for venous thromboembolism associated with transfusion in patients undergoing colorectal cancer surgery (unpublished data). Baltimore: The Johns Hopkins Unversity, Sep. 2003.
16. Sexton J., et al.: Error, stress and teamwork in medicine and aviation: Cross sectional surveys. *BMJ* 320(7237):745–749, Mar. 18, 2000.
17. Institute of Medicine: *To Err Is Human: Building a Safer Health System.* Washington, DC: National Academy Press, 2000.
18. Pronovost P.J., et al.: Improving communication in the ICU using daily goals. *J Crit Care* 18:71–75, Jun. 2003.
19. Ibrahim E.H., et al.: Deep vein thrombosis during prolonged mechanical ventilation despite prophylaxis. *Crit Care Med* 30:771–774, Apr. 2002.
20. Pronovost P.J., Berenholtz S.M.: *Improving Sepsis Care in the Intensive Care Unit: An Evidence-Based Approach.* Irving, TX: VHA, Inc., VHA Research Series 2004. https://www.vha.com/research/public/sepsis_icu.pdf (last accessed Feb. 5, 2004).

Appendix 1. Questionnaire to Identify Barriers*

Performance Improvement Committee Survey

Please take 5 minutes to fill out the questions and place in the folder taped to the door of the lounge. The PI committee is conducting a survey. We will use the results from the survey to improve patient outcomes in the ICU. This is the first step of this project.

1. Does elevating the HOB improve patient outcomes for patients on mechanical ventilators?	Yes No Unknown
2. Why? (explain why you chose yes or no for the above question)	_____ _____
3. If elevating HOB improves outcomes, how high should it be?	_____ degrees
4. Do you think you elevate the HOB on your patients?	A. All of the time B. Most of the time C. Some of the time D. None of the time
5. Is there any benefit to holding sedation each day to assess whether the patient can follow commands while on mechanical ventilation?	Yes No Unknown
6. Why? (explain why you chose yes or no for the above question)	
7. Should all patients on mechanical ventilation receive peptic ulcer disease prophylaxis (Zantac, Protonix, Carafate, etc.)?	Yes No Unknown
8. If you answered NO to question 7, which types of patients should receive PUD prophylaxis?	
9. Should all patients on mechanical ventilation receive deep venous thrombosis prophylaxis?	Yes No Unknown
10. If you answered NO to question 9, which patients should receive DVT prophylaxis?	

* PI, performance improvement; ICU, intensive care unit; HOB, head of bed; PUD, peptic ulcer disease; DVT, deep venous thrombosis.

Appendix 2. Educational Intervention to Improve Compliance

FACT SHEET
ICU Process Measures

For mechanically ventilated patients:

- Semirecumbent positioning (head of bed elevation > 30 degrees) reduces the frequency and risk for nosocomial pneumonia compared to supine position.
- The use of thromboprophylaxis is effective for preventing deep venous thrombosis (DVT).
- The use of peptic ulcer disease (PUD) prophylaxis reduces the risk of upper gastrointestinal bleeding.
- Daily interruption of sedative-drug infusions decreases the duration of mechanical ventilation and length of stay (LOS) in the ICU.

Prevention of Ventilator-Associated Pneumonia

Bottom Line: In mechanically ventilated patients, head of bed (HOB) elevation ≥ 30 degrees reduces the frequency and risk for nosocomial pneumonia compared to supine position. Elevating the HOB ≥ 30 degrees is a simple no-cost intervention which will improve outcomes in our patients. The evidence supporting this therapy is from a study of patients who are mechanically ventilated in ICU. The incidence of aspiration was reduced from 38% in the supine group to 8% in the group with HOB elevation. Days on the ventilator and ICU length of stay were also reduced.

Appropriate DVT Prophylaxis

Bottom Line: In critically ill patients thromboprophylaxis is effective for preventing DVT. However, the method of prophylaxis proven in one group of patients cannot necessarily generalize to other patients, and multiple types of thromboprophylaxis appear to be effective. Nonetheless, there is agreement that patients who are critically ill or mechanically ventilated are at high risk for DVT and should receive thromboprophylaxis. Perhaps the best summary of this evidence comes from a recent review in critically ill patients admitted to medical and surgical ICUs. Multiple therapies for DVT prophylaxis were consistently reported to reduce the risk of DVT in critically ill patients. The effective therapies include unfractionated heparin, heparin, and mechanical prophylaxis such as with TED hose or sequential compression devices. Nonetheless, the studies varied in the populations studied. One of the important messages of these types of studies is that all of the therapies appear to be effective, and it is generally more important to use a therapy than to focus on a specific therapy.

Appropriate PUD Prophylaxis

Bottom Line: In mechanically ventilated patients the use of PUD prophylaxis reduces the risk of upper gastrointestinal bleeding. Mechanically ventilated patients have an increased risk for upper GI bleeding, and the evidence supports prophylaxis in these patients. In a study published by Cook in the *New England Journal of Medicine,* investigators found two important risk factors for gastrointestinal bleeding: mechanical ventilation > 48 hours and coagulopathy. The specific therapy may be less important. Multiple therapies for PUD prophylaxis are effective. For patients who are not mechanically ventilated, the literature regarding the need for PUD prophylaxis is controversial.

Appropriate Sedation

Bottom Line: Daily interruption of sedative drug infusions decreases the duration of mechanical ventilation and LOS in the ICU. The evidence supporting this measure comes from a study where patients were randomized to have their sedation held daily until they were able to follow commands or they became uncomfortable and agitated or they were able to have routine care. In the group that had daily interruption of sedation, the duration of mechanical ventilation was reduced by 33% and ICU LOS was reduced by 35%. Translating these results into days, the average duration of mechanical ventilation was reduced an average of 2.4 days and the ICU LOS was reduced 3.5 days. This study demonstrates the dramatic reduction in both mechanical ventilation and ICU LOS that can be achieved when patients are sedated such that they are able to follow commands daily.

References

1. Kress J.P., et al.: Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. *N Engl J Med* 342:1471–1477, May 18, 2000.

2. Drakulovic M.B., et al.: Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: A randomised trial. *Lancet* 354:1851–1858, Nov. 27, 1999.

3. Cook D.J., et al.: Risk factors for gastrointestinal bleeding in critically ill patients. Canadian Critical Care Trials Group. *N Engl J Med* 330:377–381, Feb. 10, 1994.

4. Attia J., et al.: Deep vein thrombosis and its prevention in critically ill adults. *Arch Intern Med* 161:1268–1279, May 28, 2001.

5. Ely E.W., et al.: Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. *N Engl J Med* 335:1864–1869, Dec. 19, 1996.

Appendix 3. Daily Goals*

Room Number _____ Date _____ / _____ / _____

– Initial as goals are reviewed –

Goals	Provider Response During Rounds	0700–1500	1500–2300	2300–0700
What needs to be done for the patient to be discharged from the ICU?				
What is this patient's greatest safety risk and what can we do to decrease the risk?				
Pain management / Sedation				
Cardiac / volume status; beta blockers; net goal for midnight				
Pulmonary/ventilator (elevate HOB, FSC once a day, weaning)				
Is this patient receiving DVT/PUD prophylaxis?				
Mobilization / OOB				
ID, cultures, drug levels				
GI / Nutrition / bowel regimen				
Medication changes (Can any be discontinued?)				
Tests / procedures today				
Review scheduled labs				
Morning labs and CXR; critical pathway				
Consultations				
Is the primary service up-to-date?				
Has the family been updated? Have social issues been addressed?				
Can catheters/tubes be removed?				

Fellow/attending Initials: _____

* ICU, intensive care unit; HOB, head of bed; FSC, follow simple command; DVT, deep venous thrombosis; PUD, peptic ulcer disease; OOB, out of bed; ID, infectious diseases; GI, gastrointestinal; CXR, chest x-ray.