Patient Positioning and Ventilator-Associated Pneumonia

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Rotational beds, prone position, and semi-recumbent position have been proposed as procedures to prevent ventilator-associated pneumonia (VAP). Rotational therapy uses a special bed designed to turn continuously, or nearly continuously, the patient from side to side; specific designs include kinetic therapy and continuous lateral rotation therapy. A meta-analysis of studies evaluating the effect of rotational bed therapy shows a decrease in the risk of pneumonia but no effect on mortality. Two studies reported a lower risk of VAP in patients placed in a prone position, with no effect on mortality. Studies using radiolabeled enteral feeding solutions in mechanically ventilated patients have reported that aspiration of gastric contents occurs to a greater degree when patients are in the supine position, compared with the semirecumbent position. One study reported a lower rate of VAP in patients randomized to semi-recumbent compared to supine position. Although each of the techniques discussed in this paper has been shown to reduce the risk of VAP, none has been shown to affect mortality. The available evidence suggests that semi-recumbent position should be used routinely, rotational therapy should be considered in selected patients, and prone position should not be used as a technique to reduce the risk of VAP. *Key words: continuous lateral rotation therapy, kinetic therapy, prone position, semi-recumbent position, rotational therapy, ventilator-associated pneumonia.* [Respir Care 2005;50(7):892–898. © 2005 Daedalus Enterprises]

Introduction

Ventilator-associated pneumonia (VAP) is the most common hospital-acquired infection in patients requiring mechanical ventilation.[1,2] In a retrospective matched cohort study of 9,080 patients, VAP occurred in 842 patients (9.3%).[3] VAP may have important clinical and economic consequences. Rello et al[3] reported that patients with VAP had a significantly longer duration of mechanical ventilation (14.3 ± 15.5 d vs 4.7 ± 7.0 d, $p < 0.001$), intensive care unit (ICU) stay (11.7 ± 11.0 d vs 5.6 ± 6.1 d, $p < 0.001$), and hospital stay (25.5 ± 22.8 d vs 14.0 ± 14.6 d, $p < 0.001$). VAP was also associated with an increase of

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more than \$40,000 in hospital charges per patient (\$104,983 ± \$91,080 vs \$63,689 ± \$75,030, $p < 0.001$). Hospital mortality did not differ significantly between patients with and without VAP (30.5% vs 30.4%, $p = 0.713$). Warren et al[4] reported that patients with VAP had a significantly higher length of stay in the ICU (26 d vs 4 d, $p < 0.001$), length of stay in the hospital (38 vs 13 d, $p < 0.001$), and hospital costs (\$70,568 vs \$21,620, $p < 0.001$). Warren et al[4] reported a higher mortality in patients with VAP (50% vs 34%, $p < 0.001$). Procedures used to prevent VAP include those related to patient position. These include rotational beds, prone position, and semi-recumbent position. The purpose of this paper is to review the evidence related to these procedures in relation to prevention of VAP.

Rotational Therapy

Normal persons, even during sleep, change their position approximately every 12 min, which Keane[5] called the minimum physiologic mobility requirement. In contrast, critically ill patients are often cared for in the supine position for extended periods of time. In the supine position, the functional residual capacity is decreased because of alveolar closure in dependent lung zones. Immobility may impair mucociliary clearance, with the accumulation of mucus in dependent lung regions. This can lead to atelectasis and infection of dependent lung zones. As standard practice, patients in the ICU are usually turned every 2 hours by the nursing staff.

Rotational therapy, which includes kinetic therapy and continuous lateral rotation therapy (CLRT), emerged in the 1980s for patients with prolonged immobilization.[6,7] Kinetic therapy is the continuous turning of a patient to at least 40 degrees on each side. The entire kinetic bed frame rotates the patient from side to side at a speed of about half a degree per second. Oscillating beds, or air-loss beds, accomplish turning by inflating and deflating compartments in the mattress of the bed, and the bed frame does not rotate. With CLRT, the degree of turn to each side is less than 40 degrees. The degree of turning and the length of time the patient spends on each side are programmable; kinetic beds can provide percussion and vibration therapy, and they allow for elevation of the head of the bed. Several studies have reported the effects of rotational therapy on the incidence of VAP (Table 1).

Review of the Evidence

Gentilello et al[8] evaluated the effect of kinetic bed therapy on the incidence of pneumonia in patients with orthopedic, head, or spinal injuries. Patients randomized to kinetic therapy received rotational therapy, except during the recording of vital signs or when receiving treatment requiring interruption of rotation; in reality, patients received rotation for 13.4 h/d. Control patients were turned manually every 2 hours. If a patient on a conventional bed developed a pulmonary complication, the patient was crossed over to the kinetic bed. One patient randomized to kinetic therapy developed an increased intracranial pressure that could not be controlled and was moved to a conventional bed. The diagnosis of pneumonia was based on clinical criteria. With rotational therapy there was a significantly lower rate of the combined end-point of atelectasis or pneumonia (66% for the control group, 33% for the kinetic therapy group, $p < 0.01$). The relative risk of pneumonia was lower in patients receiving rotational therapy (0.54), but this did not reach statistical significance (95% confidence interval [CI] 0.22 to 1.34). There was no significant difference in ventilator days or ICU length of stay between the groups. There was no difference in mortality between the groups (relative risk [RR] 1.97, 95% confidence interval 0.70 to 5.55).

Summer et al[9] evaluated the effect of kinetic bed therapy on the incidence of pneumonia in patients with a variety of diagnoses in a medical ICU. Control patients were turned manually every 2 hours. One patient was removed from the kinetic therapy group because of difficulty maintaining intravenous and monitoring lines during rotation. Because the first 2 awake patients were agitated during rotation, subsequent patients were enrolled only if obtunded or unconscious. The diagnosis of pneumonia was based on clinical criteria. The relative risk of pneumonia was lower in patients receiving rotational therapy (0.59), but this did not reach statistical significance (95% CI 0.19 to 1.85). Patients with sepsis and pneumonia who received kinetic therapy had a 3.5-day shorter adjusted length of stay in the ICU than patients in the control group ($p < 0.001$). Patients with chronic obstructive pulmonary disease who received kinetic therapy had almost 6 fewer days in the ICU and 4.5 days less mechanical ventilation ($p < 0.001$ in each case). There was no difference in mortality between groups (RR 0.93, 95% CI 0.44 to 1.95).

In a randomized controlled trial enrolling patients with blunt trauma, Fink et al[10] studied the effect of kinetic therapy. There were 13 patients randomized to kinetic therapy who were changed to a conventional bed because of orthopedic injuries, unstable facial fractures, concerns related to intracranial pressure, and patient intolerance. Patients were rotated 10–16 h/d. The diagnosis of pneumonia was based on clinical criteria. The relative risk of pneumonia was lower in patients receiving rotational therapy (0.35) and this was statistically significant (95% CI 0.16 to 0.75). There was no difference in mortality between groups (RR 1.18, 95% CI 0.51 to 2.73). Hospital length of stay and duration of intubation were significantly shorter for patients randomized to kinetic therapy.

Table 1. Summary of the Findings in Studies Reporting the Rate of Ventilator-Associated Pneumonia in Patients Receiving Rotational Therapy

Study	Therapy	Pneumonia Rate		RR of Pneumonia (95% CI)	Ventilator Days		WMD for Ventilator Days (95% CI)	ICU Days		WMD for ICU Days (95% CI)
		Therapy	Control		Therapy	Control		Therapy	Control	
Gentilello[8]	Kinetic	5/27	13/38	0.54 (0.22 to 1.34)	8.5 (mean)	10 (mean)	−1.5 (−4.8 to 1.79)	15 (mean)	16.8 (mean)	1.8 (−5.34 to 8.9)
Summer[9]	Kinetic	4/43	7/43	0.57 (0.18 to 1.81)	NR	NR	NR	7.3 (mean)	9.6 (mean)	NR
Fink[10]	Kinetic	7/51	19/48	0.35 (0.16 to 0.75)	4 (median)	7 (median)	NR	5 (median)	8 (median)	NR
deBoisblanc[11]	CLRT	6/69	11/51	0.40 (0.16 to 1.02)	6.1 (mean)	9.9 (mean)	−3.8 (−7.7 to 0.13)	7.8 (mean)	10.8 (mean)	−3.0 (−6.1 to 0.1)
Traver[12]	CLRT	8/44	17/59	0.63 (0.30 to 1.33)	3 (median)	3 (median)	NR	7 (median)	5 (median)	NR
Whiteman[13]	CLRT	10/33	14/36	0.78 (0.40 to 1.51)	13.8 (mean)	16.1 (mean)	−2.3 (−10.7 to 5.5)	29.8 (mean)	32.0 (mean)	−2.2 (−20.1 to 15.7)
MacIntyre[14]	CLRT	9/52	13/51	0.68 (0.32 to 1.45)	NR	NR	NR	NR	NR	NR
Kirschenbaum[15]	CLRT	3/17	10/20	0.35 (0.12 to 1.08)	55 (mean)	58 (mean)	−3.0 (−7.2 to 1.2)	NR	NR	NR
Ahrens[16]	CLRT	14/97	45/137	0.44 (0.26 to 0.75)	10.8 (mean)	10.1 (mean)	0.6 (−2.4 to 3.6)	13.5 (mean)	13.5 (mean)	−0.2 (−3.4 to 3.1)

RR = relative risk
CI = confidence interval
WMD = weighted mean difference
ICU = intensive care unit
NR = not reported
CLRT = continuous lateral rotation therapy

deBoisblanc et al[11] evaluated the effect of CLRT on the risk of pneumonia in critically ill medical patients. Patients were randomized to CLRT or manual turning every 2 hours. Three patients in the CLRT group withdrew due to discomfort. The diagnosis of pneumonia was based on clinical criteria. Patients in the CLRT group were oscillated at least 18 h/d. The relative risk of pneumonia was lower in patients receiving rotational therapy (0.40, 95% CI 0.16 to 1.02). There was no difference in mortality between groups (RR 1.43, 95% CI 0.84 to 2.43). Duration of mechanical ventilation, ICU length of stay, and hospital length of stay were not significantly different for patients randomized to CLRT.

Traver et al[12] evaluated CLRT in medical-surgical ICU patients. Patients were randomized to CLRT or manually turning every 2 hours. In the patients randomized to CLRT, the mean angle of rotation was 25.5 degrees, although the target was 40 degrees. Five patients were removed from CLRT because of patient or nurse request. The diagnosis of pneumonia was based on clinical criteria. The relative risk of pneumonia was lower in patients receiving rotational therapy, but this did not reach statistical significance (0.63, 95% CI 0.30 to 1.33). There was no difference in mortality between groups (RR 0.85, 95% CI 0.46 to 1.56). Duration of mechanical ventilation, ICU length of stay, and hospital length of stay were not significantly different for patients randomized to CLRT.

Whiteman et al[13] evaluated the effect of CLRT in perioperative liver transplantation patients in a randomized controlled trial. The diagnosis of pneumonia was based on clinical criteria. The relative risk of pneumonia was lower in patients receiving rotational therapy (0.78), but this did not reach statistical significance (95% CI 0.40 to 1.51). Mortality was not reported. Duration of mechanical ventilation and ICU length of stay were not significantly different for patients randomized to CLRT. Five subjects were removed from rotational therapy because of intolerance, and two of these reported neck and back stiffness when rotated.

MacIntyre et al[14] conducted a randomized controlled trial of CLRT in intubated medical-surgical patients in 4 centers. The diagnosis of pneumonia was based on clinical criteria (lower-respiratory-tract inflammatory score). The relative risk of pneumonia was lower in patients receiving rotational therapy (0.68), but this did not reach statistical significance (95% CI 0.32 to 1.45). There was no difference in mortality between groups (RR 1.05, 95% CI 0.57 to 1.95). Anxiety was noted in 8 of the 52 patients randomized to CLRT. An interesting finding of this study was a lower risk of urinary tract infection in patients receiving CLRT (11% vs 27%, $p < 0.05$). There was a greater rate of accidental extubation in the group receiving CLRT, but this did not reach statistical significance.

Kirschenbaum et al[15] evaluated the use of CLRT in an alternating-patient basis in patients requiring long-term mechanical ventilation. The diagnosis of pneumonia was based on clinical criteria. The relative risk of pneumonia was lower in patients receiving rotational therapy (0.35, 95% CI 0.12 to 1.08). The number of ventilator days before pneumonia was greater for patients receiving CLRT (29 ± 8 d vs 12 ± 2 d). There was no difference in mortality between groups (RR 0.59, 95% CI 0.06 to 5.94).

Ahrens et al[16] evaluated CLRT in medical-surgical patients in 6 centers. Patients received CLRT or manual turning every 2 hours on an alternating month basis. Of 118 patients assigned to CLRT, 21 did not tolerate the therapy and were not included in the analysis. The diagnosis of pneumonia was based on clinical criteria. The relative risk of pneumonia was significantly lower in patients receiving rotational therapy (0.44, 95% CI 0.26 to 0.75). There was no difference in mortality between groups (RR 1.00, 95% CI 0.74 to 1.35). There was no significant difference between groups for days of mechanical ventilation, length of stay in the ICU, and hospital charges.

Observations

Several issues arise relative to the methodologies used in these studies. All of the studies used a clinical diagnosis of pneumonia. Lacking an invasive confirmation of the presence of pneumonia (ie, bronchoalveolar lavage or protected specimen brush), it is possible that the diagnosis of pneumonia was overestimated. The nature of any study assessing specialized beds is that the investigators cannot be blinded. This raises the possibility of introducing bias into the study. Several of the studies did not use a randomized design, further increasing the risk of bias. In each of the studies there was poor control of concomitant therapy, raising the potential for confounding.

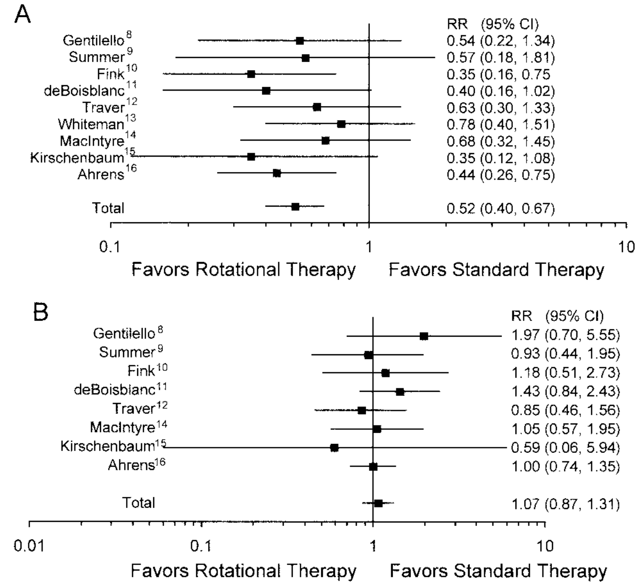

Fig. 1. A: Pooled analysis of ventilator-associated pneumonia in studies evaluating the use of rotational therapy. $p = 0.82$ for heterogeneity. $p < 0.00001$ for overall effect. B: Pooled analysis of mortality in studies evaluating the use of rotational therapy. $p = 0.82$ for heterogeneity. $p = 0.54$ for overall effect. RR = relative risk. CI = confidence interval.

From the published papers it remains unclear which patients are the best candidates for this therapy. This is in part because of the lack of a clearly established mechanism whereby rotational therapy might prevent pneumonia. Several studies report that patients withdrew from the treatment group due to intolerance of the therapy—this may be as high as 25% of patients placed on these beds. The safety of these beds is not entirely clear, and complications are probably under-reported. Although these beds allow for continuous rotation of the patient, in practice the degree of turning may be suboptimal because of practical considerations such as other care needs of the patient.

Many of the studies of kinetic therapy have relatively small sample sizes, raising the possibility of beta error. When this is the case, a meta-analysis may be useful. I conducted such an analysis, using a random-effects model to calculate relative risk and 95% confidence intervals for the pooled results of the studies reported here (RevMan Analyses software, version 1.0 for Windows, in Review Manager [RevMan] 4.2.7, The Cochrane Collaboration, Oxford, England, 2004). This analysis shows a decrease in the relative risk of pneumonia with the use of rotational therapy (RR 0.52, 95% CI 0.40 to 0.67, $p < 0.00001$) (Fig. 1). However, a meta-analysis for mortality shows no effect of rotational therapy (RR 1.04, 95% CI 0.85 to 1.26, $p = 0.71$) (Fig. 2). The results of this meta-analysis are similar to those reported by others.[7,17]

These devices are provided for a daily rental fee of about $200 (the actual amount is negotiated between the

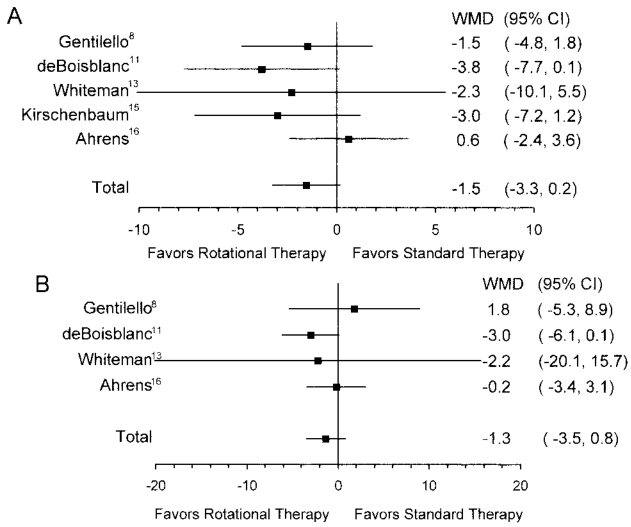

Fig. 2. A: Pooled analysis of ventilator days in studies evaluating the use of rotational therapy. p = 0.44 for heterogeneity. p = 0.08 for overall effect. B: Pooled analysis of days in the intensive care unit in studies evaluating the use of rotational therapy. p = 0.51 for heterogeneity. p = 0.22 for overall effect. WMD = weighted mean difference. CI = confidence interval.

hospital and the manufacturer). The cost/benefit of these beds remains to be determined. Although they do not appear to affect mortality, they may be cost-effective in appropriately selected patients. The daily rental cost of the bed must be balanced against ventilator days, ICU days, hospital days, and antibiotic use. Using decision analysis of the cost-effectiveness of kinetic therapy, Mullins et al[18] concluded that this therapy is cost-effective in trauma patients. However, they based their analysis on the results of Fink et al,[10] a study that reported a strong benefit for rotational therapy.

I conducted a meta-analysis, using a random effects model, to calculate weighted mean difference and 95% confidence intervals (RevMan Analyses) for the pooled results of the studies reporting mean ± standard deviation for ventilator days and days in the intensive care unit. This analysis shows no significant difference in either ventilator days (weighted mean difference −1.5, 95% CI −3.3 to 0.2, p = 0.08) or days in the intensive care unit (weighted mean difference −1.3, 95% CI −3.5 to 0.8, p = 0.22) (Fig. 2). The analysis of Mullins et al[18] may have been less positive if they had based it on the results of this meta-analysis. However, in the meta-analysis I conducted, the point estimates favor rotational therapy for ventilator days and ICU days, and the risk of beta error cannot be excluded.

Recommendations From Evidence-Based Guidelines

The use of rotational therapy for the prevention of ventilator-associated pneumonia has been addressed by several evidence-based guidelines statements. Collard et al[19] stated, "Although oscillating beds have no apparent benefit in general populations of medical patients, there is reasonably good evidence that this practice may be effective in surgical patients or patients with neurological problems." Dodek et al[20] stated, "The use of kinetic beds is associated with decreased incidence of VAP. However, feasibility and cost concerns may be barriers to implementation." According to the guidelines of the Centers for Disease Control and Prevention,[21] "No recommendation can be made for the routine use of turning or rotational therapy. . . for prevention of health care-associated pneumonia in critically ill and immobilized patients."

Prone Position

Prone positioning has been shown to increase the P_{aO_2} in many patients with acute lung injury and acute respiratory distress syndrome.[22,23] However, recent studies reporting no survival benefit for the use of prone positioning in acute respiratory distress syndrome have dampened enthusiasm for this technique.[24,25]

Several investigators have reported VAP rates in patients receiving prone versus supine positioning.[25,26] Beuret et al[26] evaluated the effect of prone positioning on the development of VAP in comatose, mechanically ventilated patients. This was a randomized controlled trial in which patients in the treatment group were placed into prone position for 4 hours once daily. VAP diagnosis was based on quantitative cultures from bronchoscopic protected-specimen-brush samples. Although the VAP rate was lower in the patients randomized to prone position (5/25 patients, 20%) than those assigned to supine position (10/26 patients, 38%), this did not reach statistical significance (p = 0.14). Similarly, there was no significant difference in mortality between the groups (7/25 [28%] for prone and 12/26 [46%] for controls). However, the small sample size does not exclude the possibility of beta error.

Guerin et al[25] conducted a large randomized controlled trial (21 ICUs) of mechanically ventilated patients with acute hypoxemic respiratory failure. Patients were assigned to prone positioning for at least 8 hours daily or supine positioning. The diagnosis of VAP was based on quantitative cultures from bronchoalveolar lavage. There was no significant difference in mortality between the 2 groups (134/416 for prone and 119/378 for supine, p = 0.77). However, the VAP rate was lower for patients randomized to prone position (85/413 for prone and for 91/378 supine, p = 0.045).

Although the rate of VAP is apparently reduced with the use of prone position, mortality is not affected (Fig. 3). Moreover, technical considerations preclude its routine use, and it is associated with an increased rate of complica-

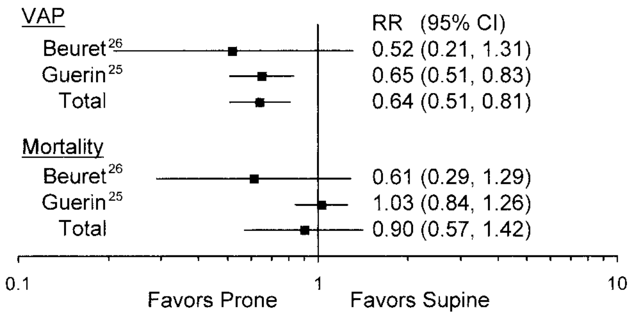

Fig. 3. Pooled analysis of ventilator-associated pneumonia (VAP) and mortality in studies evaluating the use of prone position. For VAP, p = 0.64 for heterogeneity and p = 0.0002 for overall effect. For mortality, p = 0.18 for heterogeneity and p = 0.65 for overall effect. RR = relative risk. CI = confidence interval.

tions, such as pressure sores, selective intubation, and endotracheal-tube obstruction.[24,25]

Semi-Recumbent Position

Several studies using radiolabeled enteral feeding solutions in mechanically ventilated patients have reported that aspiration of gastric contents occurs to a greater degree when patients are in the supine position, compared with the semi-recumbent position.[27–29] Ibanez et al[27] randomized orally intubated patients to supine or semi-recumbent position. Gastroesophageal reflux was present in 37/50 patients and was higher in the supine position (21/26) than in the semi-recumbent position (16/24), but this difference was not statistically significant (p = 0.26). In 20 patients without a nasogastric tube, the incidence of gastroesophageal reflux was 35%, and it was also higher in the supine (6/12 patients) than in the semi-recumbent position (1/8) (p = 0.16). There was a significant difference in gastroesophageal reflux in patients with and without a nasogastric tube (74% vs 35%, p = 0.0002).

Torres et al[28] conducted a randomized crossover trial of semi-recumbent position versus supine position in 19 mechanically ventilated patients. Patients were studied in supine or semi-recumbent position (head elevated 45 degrees) on separate days. After radioactive labeling of gastric contents, the authors assessed the radioactivity in endobronchial secretions; presumably any radioactivity in airway secretions is the result of silent aspiration of gastric contents. They found that radioactive counts in endobronchial secretions were higher in supine position compared to semi-recumbent position. Moreover, the same organisms were isolated from stomach, pharynx, and endobronchial samples in 68% of samples in supine position but from only 32% of samples in semi-recumbent position.

Orozco-Levi et al[29] studied 15 mechanically ventilated patients. In 5-hour periods separated by at least 48 hours, the patients were randomized to supine or semi-recumbent position (head elevated at a 45 degree angle) after radioactive labeling of the gastric contents. In results similar to those of Torres et al,[28] they found that radioactivity in bronchial secretions was significantly higher at 5 hours in the supine position compared with semi-recumbent position.

The only study to assess the effect of semi-recumbent position on VAP was reported by Drakulovic et al.[30] Mechanically-ventilated medical patients were randomized to supine or semi-recumbent position. VAP was determined by quantitative cultures from bronchoalveolar lavage or protected specimen brush. The trial was stopped at the first interim analysis for benefit in favor of semi-recumbent position. The rate of VAP was 2/39 for patients in the semi-recumbent position and 11/47 for patients in the supine position (RR 0.22, 95% CI 0.05 to 0.92, p = 0.04). Mortality, however, was similar in the 2 groups (7/39 for semi-recumbent position and 13/47 for supine position, RR 0.65, 95% CI 0.29 to 1.47, p = 0.30).

The use of semi-recumbent positioning has been addressed in evidence-based guidelines. Collard et al[19] state, "Semi-recumbent patient positioning is a low-cost, low-risk approach to preventing VAP." Dodek et al[20] state, "Semi-recumbent positioning is associated with decreased incidence of VAP. . . is a feasible and low-cost intervention." In their recommendations, the Centers for Disease Control and Prevention states,[21] "In the absence of medical contraindications, elevate at an angle of 30–45 degrees the head of the bed of a patient at high risk for aspiration (eg, a person receiving mechanical ventilation and/or who has an enteral tube in place)."

Summary

Each of the techniques discussed in this paper has been shown to reduce the risk of VAP, but none of them has been shown to affect mortality. Most clinicians would agree that reducing the rate of VAP is desirable even without an impact on mortality, provided that it can be done in a cost-effective manner, is relatively free of complications, and can be used in nearly all patients. The use of semi-recumbent position best meets these criteria. Rotational therapy can be used only in a fraction of patients who tolerate its use, and it adds additional cost in rental fees. Prone position can be used only in a fraction of patients who tolerate its use, its use is impractical, and it may be associated with serious complications. In conclusion, semi-recumbent position should be used routinely, rotational therapy should be considered in selected patients (unfortunately, selection criteria are ambiguous), and prone position should not be used as a technique to reduce the risk of VAP.

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Discussion

Rello: I understand that the mechanism of prevention in semi-upright position is prevention of aspiration; probably similar in prone position. But what would be the mechanism in rotational therapy?

Hess: I guess, presumably, better clearance of airway secretions. I don't think the mechanism has really been explored. Certainly, with semi-recumbent positioning we have good mechanistic studies[1–3] that preceded the RCT [randomized controlled trial] looking at VAP.

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Park: Given that most of the VAP diagnoses in the rotational therapy studies were clinical, I wonder if it just prevents atelectasis and makes it harder to diagnose VAP because the radiograph looks better?

Hess: Perhaps so, and in fact there were other studies that I did not review that looked at the use of rotational therapy to prevent atelectasis and suggested a benefit. I did not include those in this review, because this is a VAP talk not an atelectasis talk.

Niederman: Do you think that proning is like a poor man's rotational therapy? That it's doing effectively what rotational therapy is doing at a much lower cost? And, along those lines, with any of these strategies—and I'm sort of struggling with this still with the rotational therapy—why should it work? I just don't get it. It sounds nice, but are there any mechanistic studies that really show improved clearance?

Hess: Not that I am aware of, but I don't think that the mechanism has been studied. As far as whether prone positioning is the poor man's rotational therapy, I am not sure if our ICU nurses would agree with that statement, and certainly turning patients prone, as has been shown in both the Gattinoni et al study[1] and the Guerin et al study,[2] is associated with some serious complications: endotracheal tube occlusions, tubes coming out, vascular catheters coming out, and so forth. Although I might also add that some of those same complications have been reported for rotational therapy.

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Branson: I think anybody who has ever proned a patient mechanistically sees that the reason it might reduce VAP is that all the oropharyngeal secretions end up on the bed. They are no longer at the top of the endotracheal tube cuff, and I think that's probably important. Now that KCI [San Antonio, Texas] actually is introducing a bed that allows you to prone patients, if you use that bed, it will no longer be the poor man's answer (I'm sure) to continuous lateral rotation, because I'm sure that bed will be expensive as well. Prone positioning certainly has a mechanism for eliminating the gastro- or oropharyngeal secretions that CLRT does not. I've never understood that as well.

Hess: Getting back to the mechanistic discussion; there has been some animal work done by Kolobow's group, which was published in *Critical Care Medicine* last year.[1] It pointed out just what Rich said—in the prone position there are less secretions that get above the cuff on the endotracheal tube.

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MacIntyre: Just a comment about the semi-recumbent position: We have little signs in our ICU that say, "Head of bed 30 degrees." The problem is, you go in, and sure enough, the bed is usually at 30 degrees, but the patient has slid down. Thus the 30-degree angle is usually right at the *neck*. I have kidded with some of my friends in the bed industry that what we really need to do is get a Velcro strap on the back of patients so that it can hold them and the angle can truly be at the *hip*, where it belongs.

Hess: Interesting point, particularly as the BMI [body mass index] in our ICU is increasing, that seems to become increasingly an issue.

Chastre: Did you look at the duration of mechanical ventilation in your meta-analysis?

Hess: I have not yet. There are a couple of papers with the rotational therapy that have looked at that, and that's an analysis that I plan to do, but I haven't yet.* Because that's where the real cost-benefit comes in: if we can reduce the days on mechanical ventilation, days in the ICU, antibiotic load, and so forth, that's where I think the cost benefit potentially would arise. But it really hasn't been studied very well.

* Editor's note: This analysis is included in the paper but was not in the presentation preceding this discussion.