Lateral-Horizontal Patient Position and Horizontal Orientation of the Endotracheal Tube to Prevent Aspiration in Adult Surgical Intensive Care Unit Patients: A Feasibility Study

Tommaso Mauri MD, Lorenzo Berra MD, Kanya Kumwilaisak MD, Silvia Pivi MD, Jacob W Ufberg MD, Friedrich Kueppers MD, Antonio Pesenti MD, and Luca M Bigatello MD

BACKGROUND: Recent data suggest that during mechanical ventilation the lateral-horizontal patient position (in which the endotracheal tube is horizontal) decreases the risk of ventilator-associated pneumonia, compared to the recommended semi-recumbent position (in which the endotracheal tube slopes downward into the trachea). We tested the feasibility of the lateral-horizontal patient position, measured the incidence of aspiration of gastric contents, and watched for any adverse effects related to the lateral-horizontal position. METHODS: Ten adult intensive care unit patients were ventilated for 64 hours in the standard semi-recumbent position, and ten for 12–24 hours in the lateral-horizontal position. Tracheal secretions were collected every 8 hours and every 4 hours, respectively, and tested for pepsin, which is a marker of gastric contents. We also recorded clinical, physiologic, and outcome variables. RESULTS: The patients remained stable during ventilation in the lateral-horizontal position, and no adverse events occurred. Pepsin was detected in the trachea of 7 semi-recumbent patients and in five of the lateral-horizontal patients ($P = .32$). The number of ventilator-free days was 8 days (range 0–21 days) in the semi-recumbent patients, versus 24 days (range 12–25 days) in the lateral-horizontal patients ($P = .04$). CONCLUSIONS: Implementing the lateral-horizontal position for 12–24 hours in adult intubated intensive care unit patients is feasible, and our patients had no adverse events. The incidence of aspiration of gastric contents in the lateral-horizontal position seems to be similar to that in the semi-recumbent position. *Key words: lateral-horizontal position; pepsin; prevention; aspiration of gastric contents; ventilator-associated pneumonia.* [Respir Care 2010;55(3):294–302. © 2010 Daedalus Enterprises]

Introduction

Ventilator-associated pneumonia (VAP) is an important challenge for the intensivist. The chance of developing VAP increases 1–3% with every day of mechanical ventilation, and VAP has an attributable mortality of 30–50% and estimated costs of $40,000 per case.[1] VAP prevention is a major research field for intensivists, nurses, and respiratory therapists involved in the care of intubated patients.[2] Medicare's warning that they will discontinue reimbursements for all documented VAP cases may provide further stimulus for these studies.

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Aspiration of gastric contents into the airways of mechanically ventilated patients is a recognized risk factor for VAP.[1-4] Elevation of the back-rest of the bed to $\geq 30^{o}$ (semi-recumbent position) decreases the incidence of aspiration of gastric contents in intubated intensive care unit (ICU) patients,[3,5] and it is currently recommended as a

Tommaso Mauri MD and Antonio Pesenti MD are affiliated with the Department of Perioperative Medicine and Intensive Care, San Gerardo Hospital, University of Milano-Bicocca, Monza, Italy. Lorenzo Berra MD and Luca M Bigatello MD are affiliated with the Department of Anesthesia and Critical Care, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts. Kanya Kumwilaisak MD is affiliated with the Department of Anesthesia, Chulalongkorn University, Bangkok, Thailand. Silvia Pivi MD is affiliated with the Department of Anesthesia, S Orsola-Malpighi Hospital, Bologna, Italy. Jacob W Ufberg MD and Friedrich Kueppers MD are affiliated with the Department of Medicine, Temple University School of Medicine, Philadelphia, Pennsylvania.

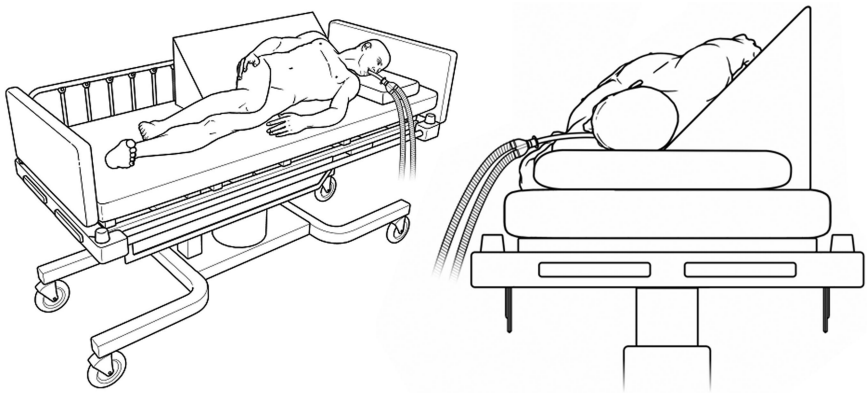

Fig. 1. The 45° lateral-horizontal patient position is achieved with a padded wedge behind the torso. The bed is horizontal, and the patient's head and the endotracheal tube rest laterally. The patient is turned from one side to the other every 2–4 hours.

standard measure to prevent VAP.[3] However, the incidence of VAP remains high despite the use of the semi-recumbent position.[6,7]

Recent experimental evidence suggests that maintaining the endotracheal tube (ETT) horizontal, with its external end below the level of the trachea, may be more effective than the semi-recumbent position in avoiding lung infections.[8,9] Horizontal ETT orientation in adult intubated ICU patients can be obtained with the lateral-horizontal position (Fig. 1), which is similar to the recovery position in basic life support.[10]

In the present study we tested the hypothesis that ventilating adult intubated ICU patients in the lateral-horizontal position is feasible, we recorded any adverse events connected to the implementation of the lateral-horizontal position, and we measured the incidence of aspiration of gastric contents in patients in the semi-recumbent and lateral-horizontal positions.

Methods

This study was performed in the surgical ICU of the Massachusetts General Hospital, Boston, Massachusetts, in collaboration with the Department of Medicine of Temple University School of Medicine, Philadelphia, Pennsylvania.

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To avoid potential conflict of interest, Dean R Hess RRT PhD FAARC, Editor in Chief of the Journal, was blinded to the peer-review process.

Correspondence: Luca M Bigatello MD, Department of Anesthesia and Critical Care, Massachusetts General Hospital, 55 Fruit Street, Boston MA 02114. E-mail: lbigatello@partners.org.

Study Design

This study was designed as a prospective pilot trial with 2 consecutive phases. Given current recommendations[3] that support ventilating patients in the semi-recumbent position to prevent aspiration of gastric contents, the Human Research Committee of Massachusetts General Hospital requested that we first provide evidence that aspiration occurs in the semi-recumbent position. Hence, a first group of patients was ventilated in the semi-recumbent position, according to the standard of care in our surgical ICU. Subsequently, after approval by the Human Research Committee, a second group was ventilated in the lateral-horizontal position. Informed verbal assent was obtained from each patient and/or next of kin.

Study Setting

All adult patients admitted to the surgical ICU of Massachusetts General Hospital between January 2007 and March 2008 and who had been intubated for less than 48 hours, and for whom the need for mechanical ventilation was not related to an acute pulmonary pathology (eg, pneumonia or transfusion-related acute lung injury) were screened for enrollment. This ICU has 20 beds and admits critically ill patients who have undergone major vascular, thoracic, orthopedic, and general surgical procedures, and patients who have suffered from trauma and severe infections. This ICU is staffed 24 hours a day with attending intensivists from the anesthesia or surgery department, and has continuous in-house coverage with dedicated trainees.

Study Population

Patients were excluded if they were expected to be intubated for < 72 hours; if they were hemodynamically unstable (ie, mean arterial blood pressure < 60 mm Hg,

and/or vasoactive drugs infused at rates of > 1 μg/kg/min of phenylephrine and > 0.05 μg/kg/min of norepinephrine); if they had recent esophageal, gastric, or pulmonary resection, or a head or spinal cord injury; if the patient, family, or clinical team objected to the patient's participation in the study; or if the protocol could not be conducted properly (eg, starting within 48 h from intubation) because of organizational limitations (eg, inability to perform some study procedures over the weekends).

Baseline Data Collection

At enrollment we recorded age, sex, body mass index, comorbidities, hours of intubation, reasons for intubation, Acute Physiology and Chronic Health Evaluation II (APACHE II) score,[11] clinical pulmonary infection score,[12] Richmond Agitation-Sedation Scale score,[13] stress ulcer prophylaxis use, tube feeding administration, and use of antibiotics, opioids, intravenous hypnotics, and vasoactive drugs.

Tube Feeding

Enteral feeding in our ICU is administered following a standardized protocol (specifying indications, infusion rates, stopping and restarting criteria, and gastric residual volume management), which was implemented with all of the subjects. Specifically, gastric residual volume is checked every 6 hours, and the enteral nutrition administration rate is reduced by 50% if gastric residual volume is > 200 mL. Gastric residual volume is checked again after 2 hours: if it is ≤ 200 mL, the tube feeding infusion rate is restored to the initial value, and gastric residual volume is checked after 6 hours. If, instead, gastric residual volume is again > 200 mL, metoclopramide 10 mg 3 times a day is initiated, the infusion rate is left at 50%, and gastric residual volume is checked every 2 hours. After 24 hours the tube feeding original infusion rate is restored if gastric residual volume is ≤ 200 mL; if not, enteral nutrition is stopped and organic reasons for intolerance are investigated and eventually solved or a naso-jejunal tube is placed. None of the patients enrolled in the present study had tube feeding stopped during the study protocol.

Semi-recumbent Group

In the first phase of the study, 10 consecutive patients were ventilated in the semi-recumbent position for 64 hours. The back-rest of the bed was positioned at an angle $\geq 30°$ degrees and the patient's back was assured to be lying properly on the bed. Nursing staff and study investigators monitored correct bed and patient positioning every hour with visual inspection and a goniometer. The ETT cuff pressure was checked every 4 hours and kept between 20 and 30 cm H_2O, per the unit's clinical protocol.

Lateral-Horizontal Group

In the second phase of the study, 11 consecutive patients were ventilated in the lateral-horizontal position (see Fig. 1). Patients were turned from one side to the other every 2–4 hours. One patient withdrew consent to the study within a few minutes from enrollment because the position was uncomfortable. The other 10 subjects were kept in the lateral-horizontal position for 12–24 hours. Appropriate positioning was monitored and documented by nursing staff and study investigators at least every hour. Appropriate ETT cuff pressure (20–30 cm H_2O) was checked and corrected, if needed, every 4 hours.

Feasibility and Adverse Events

In both groups, at baseline and after 12 and 24 hours (when available), we recorded: ventilator settings, arterial blood gases, hemodynamic variables, Richmond Agitation-Sedation Scale score, and sedative drug use to determine the effect of position on clinical and physiologic variables. In the lateral-horizontal group we performed a pilot evaluation of the position's safety and recorded the occurrence of the following adverse events: hypotension (mean arterial pressure < 60 mm Hg); catheter or tube displacement or obstruction; nausea or vomiting; ventilator circuit obstruction; and hypoxia (arterial oxygen saturation $< 92\%$ for ≥ 5 min).

Sample Collection

In both study groups we collected tracheal aspirates via deep tracheal suctioning at baseline and every 8 hours (in the semi-recumbent group) or 4 hours (in the lateral-horizontal group). We collected oral and gastric secretions at baseline and every 12 hours in both groups. Equal amounts of all samples were placed in identical specimen containers, coded, and stored in a freezer at $-80°$ C.

Pepsin Measurement

We tested for the presence of gastric contents in each sample, with a qualitative pepsin assay based on fibrinogen digestion.[14-16] Pepsin assays were performed at the Department of Emergency Medicine, Temple University School of Medicine, Philadelphia, Pennsylvania (by JWU and FK). The investigator was blinded to the time and site of sampling. Pepsin in vivo activity decreases with time, and the present test maintains its ability to detect pepsin for approximately 30–60 min following its appearance in the biological fluid tested.[16]

Clinical Outcomes

Patients were followed after study completion and until hospital discharge or death, to record incidence of VAP, ventilator-free days (ie, number of days the patient breathed without assistance for at least 48 consecutive hours from day 1 to day 28 after enrollment), ICU and hospital stay, and in-hospital mortality.

Ventilator-Associated Pneumonia Diagnosis

VAP was diagnosed by the attending physician, who was blinded to the pepsin assay results. The diagnoses of VAP were made according to the American College of Chest Physician clinical criteria,[17] which is the occurrence of new and persistent radiographic infiltrates after $>$ 48 hours of mechanical ventilation, associated with at least two of:

- Internal body temperature $>$ 38° C
- White blood cells count $>$ 12,000 cells/μL or $<$ 4,000 cells/μL
- Purulent tracheobronchial secretions

When available, we used bronchoscopically obtained bronchoalveolar lavage cultures with appropriate quantitative thresholds (ie, $\geq 10^4$ colony-forming units/mm^3) to support the VAP diagnosis.

Statistical Analysis

Our study was powered to detect a 50% decrease in the incidence of aspiration of gastric contents, as assessed via pepsin in tracheal secretions, between the 2 groups, at a significance level of .05 and a power of 80%. Since most numerical variables we measured (eg, age) showed non-normal distribution (via the Kolmogorov-Smirnov test), we used non-parametric statistical tests. Differences in baseline and post-treatment characteristics between the 2 study groups were tested with the Mann-Whitney U test. Fisher's exact test or chi-square test, as appropriate, was employed to test for differences between the 2 groups with counting values. Changes in clinical and physiologic variables from baseline to 12 and 24 hours of treatment within the 2 groups were tested with the Wilcoxon test. Fisher's exact test or chi-square test, as appropriate, was employed when counting values. Differences were considered significant when $P < .05$. Values are expressed as median and interquartile range unless otherwise specified. Statistical analyses were performed with statistics software (SPSS 13.0, SPSS, Chicago, Illinois).

Results

Table 1 shows the baseline clinical characteristics of the study subjects. All 10 patients in the semi-recumbent group completed the 64-hour study period. Of the 10 patients who completed the study in the lateral-horizontal group, 6 were studied for 12 hours, and 4 continued up to 24 hours. The reasons for limiting the study period to the minimum planned 12 hours were organizational (ie, need to perform a test or procedure that required a different position for $\geq$ 30 min).

Table 2 shows the physiologic and clinical variables over the first 24 hours. There were no significant hemodynamic changes in either group. In the lateral-horizontal group, the applied positive end-expiratory pressure was slightly higher after 12 hours, and the ratio of P_{aO_2} to fraction of inspired oxygen improved non-significantly, compared to baseline. The Richmond Agitation-Sedation Scale scores and sedative drugs administration remained unchanged in both groups.

No position-related adverse events were recorded in the lateral-horizontal group.

Table 3 shows the pepsin assay results. Twenty-four gastric, 30 oral, and 78 tracheal samples were tested in the semi-recumbent group, and 20 gastric, 30 oral, and 42 tracheal samples were tested in the lateral-horizontal group. Ten patients in the semi-recumbent group and 8 in the lateral-horizontal group had pepsin in their gastric samples. Four patients in each group had pepsin in their oral secretions at various times. Three patients in the semi-recumbent group and 1 in the lateral-horizontal group had pepsin in their tracheal aspirate at baseline ($P = .60$). Once positioned, 7 patients in the semi-recumbent group had pepsin in their tracheal secretions at various times (33% of all samples), and 5 (38% of all samples) in the lateral-horizontal group ($P = .32$). The first tracheal sample positive for pepsin was collected within 24 hours from the beginning of the study in all of the abovementioned 7 semi-recumbent patients.

Four patients in the semi-recumbent group developed VAP, compared to one patient in the lateral-horizontal group ($P = .15$) (Table 4). Ventilator-free days were 8 days (range 0-21 d) in the lateral-horizontal group, versus 24 days (range 12-25 d) in the semi-recumbent group ($P < .04$). ICU, hospital stay, and in-hospital mortality didn't differ between the 2 groups.

Discussion

There are 3 main findings of interest in our study. First, the lateral-horizontal position was feasible and free from adverse events in a pilot sample of 10 intubated postoperative and trauma adult ICU patients. Second, aspiration of gastric contents, as measured by pepsin in the airways,

Table 1. Baseline Characteristics of the Study Subjects

	Semi-Recumbent Group (n = 10)	Lateral-Horizontal Group (n = 10)	P*
Age (mean and range y)	67 (58–75)	62 (54–74)	.85
Female (n)	5	6	> .99
Body mass index (median and IQR kg/m^2)	26 (22–30)	26 (21.5–31.8)	.88
Co-morbidities (n)			
Diabetes mellitus	3	3	> .99
Hypertension	7	6	> .99
Gastroesophageal reflux	2	4	.63
Renal failure	1	0	> .99
Chronic obstructive pulmonary disease	2	3	> .99
Coronary-artery disease	2	3	> .99
Reasons for intubation (n)			
Sepsis	1	3	.57
Systemic inflammatory response syndrome	3	1	
Postoperative	4	4	
Trauma	2	2	
Hours of intubation prior to enrollment (median and IQR h)	18 (12–39)	26.5 (24–27)	> .99
APACHE II score (median and IQR)	17 (15–18)	14 (13–15)	.13
Patients on vasoactive drugs (n)	5	5	> .99
Clinical pulmonary infection score (median and IQR)	3 (2–5)	3 (2–4)	.79
Patients on antibiotics (n)	9	9	> .99
Richmond agitation-sedation scale score (median and IQR)	–2 (–2 to 0)	–2 (–3 to –1)	.13
Patients on intravenous opioids (n)	7	7	> .99
Patients on intravenous sedation (n)	7	8	> .99
Patients on stress ulcer prophylaxis (n)	10	10	> .99
Patients on tube feeding (n)	4	2	.62

* Via Mann-Whitney U test, Fisher's exact test, or chi-square test, as appropriate.
APACHE II = Acute Physiology and Chronic Health Evaluation II

was prevalent in these patients. Third, neither the semi-recumbent nor the lateral-horizontal position prevented aspiration of gastric contents, as measured by the pepsin assay.

Aspiration of gastric contents into the airways of mechanically ventilated patients is an important cause of VAP, and is facilitated by gastroesophageal reflux, nasogastric intubation, undrained oropharyngeal secretions, enteral nutrition, and coma.[18] The semi-recumbent position reduces the rate of aspiration of gastric contents, compared to the fully supine position,[6,19,20] so elevating the back-rest to $\geq 30^{o}$ is a recommended measure to prevent VAP.[3,18] However, the original studies on the comparison between the semi-recumbent and supine positions[19,20] lasted only 5 hours; diagnosed aspiration via an exogenous radioactive tracer, the clinical importance of which is unknown; and very strictly maintained (by study protocol) the 45^{o} semi-recumbent position throughout the study period.[19,20] Each of those factors inevitably become less robust in the clinical setting. Both our present study and a recent large observational study by Metheny et al[6] are closer to representing clinical practice, as they were carried out for longer periods and used an endogenous marker of aspiration (pepsin); they indicate how aspiration, as measured by pepsin in tracheal aspirates, still occurs in a substantial fraction of patients in the semi-recumbent position.[6]

Recent data showed how a dependent orientation of the ETT, with the external end of the tube below the horizontal plane of the trachea, may be more effective than semi-recumbent position in clearing tracheobronchial secretions and avoiding contamination of the distal airways. In a study with intubated sheep,[9] radio-opaque particles inserted in the trachea followed the direction of gravity, moving toward the distal airways and into the lungs of sheep ventilated in the head-up position (mimicking the semi-recumbent position), and toward the proximal airway and the outside in sheep ventilated in the head-down position (mimicking the lateral-horizontal position).[9]

Similarly, sheep intubated and mechanically ventilated in a head-down position for up to 72 hours had lower bacteria counts in the ETT and the airways than sheep ventilated in the head-up position.[8] Moreover, it is a common observation upon institution of the prone position (during which the external ETT end lies below the tracheal level) in patients with acute respiratory failure that secretion clearance is greatly facilitated. Accordingly, 2 con-

Table 2. Clinical and Physiologic Variables Over the First 24 Hours

	Semi-Recumbent Group*			Lateral-Horizontal Group*		
	Baseline (n = 10)	12 h (n = 10)	24 h (n = 10)	Baseline (n = 10)	12 h (n = 10)	24 h (n = 3)
Heart rate (median and IQR beats/min)	82 (70–87)	79 (73–91)	81 (76–87)	78 (71–89)	85 (74–91)	93 (85–94)
Mean arterial blood pressure (median and IQR mm Hg)	83 (75–88)	74 (73–78)	84 (74–86)	80 (76–88)	81 (74–89)	80 (73–89)
Patients on norepinephrine (n)	5	5	5	5	2	1 (33%)
Norepinephrine infusion rate (median and IQR μg/kg/min)	0 (0–0.065)	0.027 (0–0.089)	0.025 (0–0.064)	0.007 (0–0.021)	0 (0–0)	0 (0–0.011)
Respiratory rate (median and IQR breaths/min)	17 (16–20)	17 (15–20)	20 (17–23)	17 (16–18)	15 (14–18)	14 (12–14)
Mode of mechanical ventilation (n)						
Assisted	5	5	5	5	5	2 (67%)
Controlled	5	5	5	5	5	1 (33%)
Tidal volume (median and IQR mL/kg)	7.2 (6.0–8.3)	7.2 (5.9–8.2)	6.9 (5.6–8.5)	6.1 (5.2–7.4)	6.5 (5.6–8.7)	7.3 (6.3–8.9)
PEEP (median and IQR cm H_2O)	7 (5–10)	7 (5–10)	5 (5–10)	8 (5–10)	10 (6–10)	10 (9–10)
P_{aO_2}/F_{IO_2} (median and IQR mm Hg)	253 (171–276)	204 (172–255)	232 (206–255)	182 (157–248)	204 (173–246)	200 (184–220)
P_{aCO_2} (median and IQR mm Hg)	39 (37–50)	44 (35–50)	38 (34–46)	42 (40–45)	41 (36–44)	48 (46–48)
Arterial pH (median and IQR)	7.39 (7.35–7.46)	7.39 (7.32–7.45)	7.44 (7.37–7.48)	7.43 (7.35–7.47)	7.45 (7.43–7.48)	7.39 (7.36–7.42)
Richmond Agitation-Sedation Scale score (median and IQR)	–2 (–2 to 0)	–2 (–3 to 0)	–2 (–3 to –1)	–2 (–3 to 1)	–1 (–2 to 1)	–1 (–1 to 0)
Patients on intravenous opioids (n)	7	6	5	7	7	3 (100%)
Hydromorphone infusion rate (median and IQR mg/h)	0.5 (0–1.4)	0.5 (0–1.4)	0.3 (0–0.9)	0.3 (0–0.9)	0.3 (0–0.9)	0.5 (0.3–1.3)
Hydromorphone total amount (median and IQR mg)	0	7.3 (0.5–14.9)	13.5 (1–30.9)	0	4.9 (1–12.3)	7.8 (3.9–20.1)
Patients on propofol (n)	7	8	8	8	7	3 (100%)
Propofol infusion rate (median and IQR mg/kg/h)	0.6 (0.1–1.2)	0.4 (0.3–1.2)	0.6 (0.3–0.8)	0.9 (0.2–1.1)	0.8 (0.1–1.5)	1.8 (1.5–1.9)
Propofol total amount (median and IQR mg/kg)	0	6.1 (4.6–11.7)	11.1 (8.8–17)	0	7.3 (2.2–17.7)	40.2 (39.3–43.2)
Patients on lorazepam (n)	0	4	4	0	0	0
Lorazepam total amount (median and IQR mg)	0	0 (0–0.9)	0 (0–1.6)	0	0	0

* Clinical and physiological characteristics at 24 h of 1 patient from the lateral-horizontal group were not available. Differences in clinical and physiological variables between baseline and 12 h and between baseline and 24 h were tested within each group with the Wilcoxon test, Fisher's exact test, or chi-square test, as appropriate. Differences between the 2 groups at 12 h and 24 h were analyzed with the Mann-Whitney U test. None of the abovementioned differences were statistically significant.

PEEP = positive end-expiratory pressure

F_{IO_2} = fraction of inspired oxygen

trolled trials of prone ventilation for acute respiratory failure showed a slightly decreased VAP rate.[21,22] However, the prone position is cumbersome to routinely implement in post-surgical and trauma patients.

Alternatively, the lateral-horizontal position (see Fig. 1) is more practical, and may achieve the same goal of enhancing secretion clearance. Moreover, during lateral-horizontal positioning, the bed is horizontal, which may be helpful when caring for patients with low blood pressure. To our knowledge, the feasibility of the lateral-horizontal position has not been systematically investigated in adult intubated ICU patients. The only positioning method similar to lateral-horizontal previously tested in adult intubated patients is rotational bed therapy, which is not currently recommended because it has had inconsistent results,[23-25] higher cost, and requires more nursing effort. On the other hand, a study of 60 infants ventilated in the lateral-horizontal position for 72 hours showed less airway bacterial contamination than the fully supine position.[26]

In the present study we described the implementation of the lateral-horizontal position in adult intubated ICU patients, and some of its short-time effects. The lateral-horizontal position may be safe: no adverse events happened in any of the 10 patients who completed the study, and we

Table 3. Pepsin in Gastric, Oral, and Tracheal Secretions

Sampling Site	Semi-Recumbent Group ($n = 10$)	Lateral-Horizontal Group ($n = 10$)	P^*
Stomach (n)			
Patients with ≥ 1 positive sample	10	8	.47
Oral cavity (n)			
Patients with ≥ 1 positive sample	4	4	> .99
Trachea (n)			
Patients with positive baseline sample	3	1	.60
Positive samples (%)	33	38	.80
Patients with ≥ 1 positive sample (n)	7	5	.32

* Via Fisher's exact test or chi-square test, as appropriate.

Table 4. Clinical Outcomes

	Semi-Recumbent Group ($n = 10$)	Lateral-Horizontal Group ($n = 10$)	P^*
Ventilator-associated pneumonia† (n)	4	1	.15
Ventilator-free days (median and IQR d)‡	8 (0–21)	24 (12–25)	.04
Intensive care unit stay (median and IQR d)	14 (8–36)	10 (5–14)	.18
Hospital stay (mean and IQR d)	36 (25–45)	33 (26–43)	.70
Hospital mortality (n)	3	1	.29

* Via Mann-Whitney U test, Fisher's exact test, or chi-square test, as appropriate.
† Ventilator-associated pneumonia was diagnosed according to the American College of Chest Physicians clinical criteria.
‡ Number of days a patient breathed without assistance for at least 48 consecutive hours from day 1 to day 28 after enrollment.

did not detect any significant increase in the need for sedation or analgesia (see Table 2). However, the potential for an adverse event was lower for the lateral-horizontal group because the observation period was shorter.

One patient withdrew from the study shortly after enrollment because of general discomfort in the lateral-horizontal position. In addition, our nursing staff found the lateral-horizontal position labor-intensive and that not all patients accepted it smoothly. Some of the nurses were concerned about an increase in facial edema, but no extubation was delayed and there were no adverse events. It is important to emphasize that, although overall well tolerated, the lateral-horizontal position was not as simple to implement as the semi-recumbent position.

In our study the semi-recumbent position did not prevent the occurrence of aspiration of gastric contents in 7 of 10 subjects, whereas the lateral-horizontal position failed in 5 of 10 subjects ($P = .32$). As a proof-of-concept study, we had hypothesized that the lateral-horizontal position would nearly eliminate aspiration for the duration of our experiment, which did not happen. There are several possible explanations for our findings.

First, we tested for pepsin in tracheal secretions at more frequent intervals in the lateral-horizontal than in the semi-recumbent position, so we may have increased the sensitivity of the test in the lateral-horizontal group.

Second, even short interruptions of the lateral-horizontal position may have favored aspiration. The dependent orientation of the ETT is inevitably lost during the side-to-side rotation every 2 hours and during brief procedures (eg, chest radiography) in the semi-recumbent position (interruption of the lateral-horizontal position for < 5 min were allowed by our protocol).

Third, the pepsin assay we used[13] is not designed to discriminate between various magnitudes of airway contamination by gastric contents (ie, micro-aspiration vs macro-aspiration episodes).

Though the incidence of gastric-contents aspiration was similar, the lateral-horizontal group had a better progression of arterial oxygenation, a somewhat lower incidence of VAP, and a significantly shorter duration of mechanical ventilation. The lateral-horizontal position improves gas exchange,[27] respiratory mechanics,[28] and secretion clearance[29] in patients with acute respiratory failure. So clearance of lung secretions and edema may be enhanced by lateral-horizontal positioning, which would improve lung compliance and allow lower ventilator pressures[30] and thus lower the risk of ventilator-induced lung injury and possibly shorten the duration of mechanical ventilation. Our study design does not allow us to draw any relevant conclusion from these findings (see below), but we believe these results show how further studies, appropriately powered, are warranted to investigate the possible clinical benefits of the lateral-horizontal position in intubated adult ICU patients.

Limitations

First, this was not a randomized controlled trial but a feasibility study of an intervention that deviates from the current standard of care for mechanically ventilated patients in our hospital (ie, the semi-recumbent position). Despite our effort to study 2 comparable groups (see Table 1), the lack of randomization to concurrent study groups inevitably adds potential for selection bias.

Second, the accuracy of pepsin as a marker of aspiration is not fully understood. In particular, the current lack of a quantitative method puts in question its specificity, as small amounts of gastric-contents aspiration occur physiologically with no harmful consequences.

Third, the short duration of the study, particularly in the lateral-horizontal group, did not allow us to reliably investigate the relationship between the presence of pepsin and the subsequent onset of VAP. That relationship has been very difficult to demonstrate in all the studies of VAP herein referenced. Even in a study with a 4-day observation period, the causal relationship between aspiration and VAP was difficult to prove.[6]

Fourth, we did not record other possible determinants of aspiration of gastric contents, such as ETT cuff pressure, and frequency of supraglottic suctioning.

Fifth, two of the lateral-horizontal patients did not have pepsin detected in their gastric samples, which may imply an inability of our test to detect pepsin in tracheal aspirates from those patients too. This may have biased our results toward the lateral-horizontal group. However, those 2 patients subsequently did have pepsin detected in their tracheal aspirates. Our interpretation of this apparent contradiction is that the lack of pepsin detection in gastric aspirates must have been due to sampling errors (eg, we may have analyzed tube-feeding material, erroneously considering it gastric contents).

Sixth, there were more patients with baseline pepsin-positive tracheal samples in the semi-recumbent group than in the lateral-horizontal group, and this may be another bias toward the lateral-horizontal group. However, that difference was not statistically significant. As stated in the Methods section, pepsin in vivo activity decreases with time. The test we used maintains its ability to detect pepsin for approximately 30–60 min following its appearance in the biological fluid tested.[16] So we hypothesized that our timing between samplings (4 h and 8 h) would have allowed us to detect only brand new aspiration episodes.

Conclusions

Lateral-horizontal position implemented for 12–24 hours is feasible and was free from adverse events in 10 adult intubated ICU patients. The semi-recumbent and lateral-horizontal positions are associated with a similarly high incidence of gastric-contents aspiration, assessed via pepsin in tracheal secretions. Further studies are warranted to determine if the lateral-horizontal position is associated with physiologic or clinical benefits. Finally, it is important to devise new methods to reliably assess the degree of gastric-contents aspiration and its causal relationship with nosocomial pneumonia.

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