Saline instillation before tracheal suctioning decreases the incidence of ventilator-associated pneumonia*

Pedro Caruso, MD, PhD; Silvia Denari, PhD; Soraia A. L. Ruiz, RT; Sergio E. Demarzo, MD, PhD; Daniel Deheinzelin, MD, PhD

LEARNING OBJECTIVES

On completion of this article, the reader should be able to:

1. Describe technique for tracheal installation of saline.
2. Explain benefits and outcomes of tracheal installation of saline.
3. Use this information in a clinical setting.

The authors have disclosed that they have no financial relationships with or interests in any commercial companies pertaining to this educational activity.

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Objectives: **To compare the incidence of ventilator-associated pneumonia (VAP) with or without isotonic saline instillation before tracheal suctioning. As a secondary objective, we compared the incidence of endotracheal tube occlusion and atelectasis.**

Design: **Randomized clinical trial.**

Setting and Patients: **The study was conducted in a medical surgical intensive care unit of an oncologic hospital. We selected consecutive patients needing mechanical ventilation for >72 hrs. Patients were allocated into two groups: a saline group that received instillation of 8 mL of saline before tracheal suctioning and a control group which did not. VAP was diagnosed based on clinical suspicion and confirmed by bronchoalveolar lavage quantitative culture. The incidence of atelectasis on daily chest radiography and endotracheal tube occlusions were recorded. The sample size was calculated to a power of 80% and a type I error probability of 5%.**

Measurements and Main Results: **One hundred thirty patients were assigned to the saline group and 132 to the control group. The baseline demographic variables were similar between groups. The rate of clinically suspected VAP was similar in both groups. The incidence of microbiological proven VAP was significantly lower in the saline group (23.5% × 10.8%; $p = 0.008$) (incidence density/1.000 days of ventilation 21.22 × 9.62; $p < 0.01$). Using the Kaplan-Meier curve analysis, the proportion of patients remaining without VAP was higher in the saline group ($p = 0.02$, log-rank test). The relative risk reduction of VAP in the saline instillation group was 54% (95% confidence interval, 18%–74%) and the number needed to treat was eight (95% confidence interval, 5–27). The incidence of atelectases and endotracheal tube occlusion were similar between groups.**

Conclusions: **Instillation of isotonic saline before tracheal suctioning decreases the incidence of microbiological proven VAP. (Crit Care Med 2009; 37:32–38)**

KEY WORDS: pneumonia; ventilator-associated pneumonia; prevention; respiratory therapy

Ventilator-associated pneumonia (VAP) is a frequent mechanical ventilation (MV) complication associated to high mortality, morbidity, and cost (1–3).

Management of airway and its secretions, such as subglottic suctioning (4), manipulations or changes of the ventilator circuit (5, 6), and drainage of ventilator circuit condensate (7) may affect the incidence of VAP.

The isotonic saline instillation before tracheal suctioning (ISIBTS) represents an option to dilute and mobilize pulmonary secretions (8) and is a common practice in airway management. A national survey in the United States revealed that 74% of centers have airway management policies incorporating instillation of isotonic saline (9). Although its use before tracheal suctioning is a common practice, it remains controversial (10).

Considering VAP incidence, ISIBTS is a double-edged sword. ISIBTS could in-

***See also p. 330.**

Medical Doctor (PC, SED), Hospital A C Camargo, Sao Paulo, SP, Brazil; Medical Doctor (DD), Núcleo Avançado do Tórax, Hospital Sírio-Libanês, Sao Paulo, SP, Brazil; and Respiratory Therapist (SD, SR), Hospital A C Camargo, Sao Paulo, SP, Brazil.

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For information regarding this article, E-mail: pedro.caruso@hcnet.usp.br

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crease the incidence of VAP because it dislodges more viable bacterial colonies from the endotracheal tube than the insertion of a suctioning catheter without previous saline instillation (11). Such dislodgement could lead to contamination of the lower airways. However, ISIBTS could decrease VAP incidence because it increases the amount of secretions removed (12), stimulates coughing (13) that can bring secretions to the trachea for subsequent suctioning, and also thins secretions. Another reason for decreased VAP incidence upon ISIBTS is hypothetical. Given that some authors consider the endotracheal biofilm as a reservoir for VAP (14–16), the frequent rinsing of the endotracheal tube by saline instillation could potentially decrease it, thereby lessening VAP incidence. In the above context, we hypothesized that instillation of isotonic saline before tracheal suctioning could decrease the incidence of VAP.

Since the accumulation of secretions in the endotracheal tube leads to its obstruction, improved removal of secretions by ISIBTS could avoid tube obstruction. Similarly, better airway secretion removal by ISIBTS could decrease the incidence of atelectasis stemming from secretion.

The primary objective of this study was to compare the incidence of VAP with or without tracheal ISIBTS. As a secondary objective, we compared the incidence of both endotracheal tube obstruction due to secretion and atelectasis.

MATERIALS AND METHODS

Patients and Study Design. We designed a randomized clinical trial in a closed medical surgical intensive care unit (ICU) of a tertiary oncologic hospital.

We included consecutive patients expected to receive MV for >72 hrs through an orotracheal or tracheotomy tube, who were older than 18 yrs and had next of kin agreement. Exclusion criteria were previous MV within the last month, MV for >6 hrs before study enrollment, contraindication to bronchoscopy and being expected to die or undergo withdrawal of treatment within 48 hrs.

Patients were allocated into two groups. In the first group, tracheal suctioning was performed without prior saline instillation (control group) whereas in the second group there was instillation of 8 mL of isotonic saline before each tracheal suctioning (saline group).

The following variables that could interfere in the incidence of VAP were recorded: airway humidification, stress ulcer prophylaxis, antibiotic use, immunosuppression (leukocytes < 1.000/mm^3, continuous use of corticosteroids or chemotherapy in the last month), type of admission, cause of MV, and gastroenteral feeding tube.

All patients used a closed tracheal suctioning system (Trach-Care 14F, Kimberley-Clark, Neenah, WI) changed weekly or upon mechanical failure or visible soiling (17). Patients used heat and moisture exchangers (HME) (Hydrobac II-Hudson-Gibeck-Durham) changed every 72 hrs (18), except for copious airway secretion, thick tenacious secretion, hypothermia, hemoptysis (5), or weaning failure attributed to increased airway resistance (19). In the cases when HME was contraindicated, humidification was performed with a heated water humidifier. Patients' bed heads were instructed to be kept at an angle of 45 degree from the horizontal. Ventilator circuits were changed only if the circuits were soiled or mechanically disrupted (20). Selective decontamination of the digestive tract, oral decontamination with antiseptics or continuous aspiration of subglottic contents were not performed in any patients.

The attending physicians and nurses were blinded to the study group. Only respiratory therapists performed and recorded the type or number of tracheal suctions. If nurses or physicians asked for tracheal suctioning of a patient, those were evaluated and performed by the respiratory therapist. This was possible because in our intensive care unit (ICU) there are respiratory therapists on hand around the clock. Physicians were asked to order a bronchoscopy with bronchoalveolar lavage upon clinical suspicion of VAP.

The study was approved by the hospital ethics committee and an informed consent was obtained from next of kin.

Tracheal Suctioning Routine and Method. Aspirations were carried out when any one of the following situations occurred: visible airway secretion into the endotracheal tube, discomfort or ventilator-patient asynchrony, noisy breathing, increased peak inspiratory pressures or decreased tidal volume during ventilation attributed to airway secretion (8). Before aspirations, patients were preoxygenated at 100% oxygen for 2 mins (8). In the saline group, 8 mL of isotonic saline was instilled through the lavage/instillation port of the closed tracheal suctioning system located close to the junction with the endotracheal tube. Aspirations were performed at a negative pressure of 200 cm H_2O for 20 secs, during which the catheter was gently rotated and withdrawn. Aspirations in the control group were identical, except for the absence of saline instillation.

Diagnosis of Ventilator-Associated Pneumonia. VAP was confirmed only after 48 hrs of MV. The clinical suspicion of VAP was established when otherwise unexplained new or worsening pulmonary infiltrates on chest radiograph developed in conjunction with at least one of the following alterations: fever (>37.8°C), leukocytosis (>12.000) or leukopenia (<4.000) or appearance of purulent tracheal secretion (21). Bronchoalveolar lavage was performed in the wedge position with 120 mL of sterile saline in six aliquots, of which the first recovered aliquot was rejected. VAP was considered only if bronchoalveolar lavage fluid presented $\geq 10^4$ CFU/mL (22, 23). To avoid VAP diagnostic misclassification because of fungal colonization, we considered fungal VAP only in immunosuppressed patients who responded to antifungal treatment (24–26).

The indication, type, and duration of antibiotics were according to the attending physician decisions. If a patient had more than one episode of VAP only the first was considered.

Chest Radiograph Analysis. For the first 176 patients, daily bed chest radiography was performed while patients were included in the protocol. Two pulmonologists with expertise in intensive care medicine analyzed the chest radiography and recorded the incidence of pulmonary, lobar, and segmental atelectasis. They independently analyzed the chest radiography and both were blinded to the study group.

Tube obstruction, Change of Heat And Moisture Exchangers, and Closed Tracheal Suctioning System. The orotracheal or tracheostomy tubes were considered obstructed by secretion if they have been clinically suspected and the substitution of the tube would have reverted the clinical picture. Macroscopical examination was used to confirm the suspicion. Endotracheal tube obstruction was considered only if diagnosed by the attending physician.

We recorded the number of HME and closed tracheal suctioning system changes due to secretion. Programmed changes were not considered.

Statistical Analysis. Based on a 50% reduction of VAP incidence (from 30% to 15%), a significance level of 5% and a power of 80% to reject the null hypothesis, the ideal number of patients in each group was 133. Comparisons between groups were performed using the Student's t test for continuous variables and the chi-square statistic (χ^2) for categorical variables. The time to occurrence of VAP was analyzed by the Kaplan-Meier method and tested by the log-rank test (27, 28).

We performed a logistic regression analysis to prevent treatment effect from being influenced by covariate imbalances. The dependent variable was microbiological proven VAP and five independent variables were elected based on a $p < 0.2$ at univariate analysis: age, immunosuppression, antibiotics at admission, antibiotics during ICU stay and study group.

Agreement regarding chest radiograph analysis between both physicians was measured with Cohen's kappa (κ-statistic). A value of 1 indicates perfect agreement whereas a value of 0 indicates that agreement is no better than chance (29).

Relative risk reduction and the number needed for treatment were calculated according to standard formulas.

Values are expressed in mean ± SD for continuous variables. All reported p values are two sided. Statistical analysis was performed using SPSS software (SPSS, Chicago, IL).

RESULTS

Patients. From August 2001 through December 2004, 493 patients were eligible for the study. One hundred thirty patients in the saline group, and 132 in the control group completed the study (Fig. 1). Patient characteristics at the study enrollment were similar (Table 1).

The ICU mortality (51.9% for saline and 49.6% for control group; $p = 0.71$), MV (11.2 ± 11.2 for saline and 11.1 days ± 9.0 for control group; $p = 0.92$), and ICU (17.2 ± 12.3 for saline and 17.6 days ± 12.8 for control group; $p = 0.77$) length of stay were similar between groups. However, ICU mortality, MV, and ICU length of stay were statistically higher in patients with VAP (Table 2).

After study enrollment, tracheotomy was performed in 20 patients from each group ($p = 1.0$) and the time to tracheotomy was similar for both groups (12 ± 7.6 for saline and 11 ± 7.4 days for control group; $p = 0.89$).

Ventilator-Associated Pneumonia. In the control group, 3 patients had more than 1 episode of VAP (2 with 2 episodes and 1 with 3 episodes) and in the saline group 1 patient had 2 episodes of VAP.

The incidence density and proportion of microbiological proven VAP were significantly higher in the control group (Table 3). Using the Kaplan-Meier curve analysis, the proportion of patients remaining without VAP was higher in the saline group ($p = 0.02$, log-rank test) (Fig. 2). The rate of clinically suspected VAP was similar in both groups.

The relative risk reduction of VAP in the saline instillation group was 54% (95% confidence interval [CI] 18%–74%) and the number needed to treat was 8 (95% CI 5–27).

In the logistic regression analysis, the only independent variable associated to microbiological proven VAP was allocation into the control group (Odds ratio 2.48 [95% CI 1.24–4.96]; $p = 0.010$).

The proportion of monomicrobial and polymicrobial VAP were similar between groups. Also, the proportions of VAP caused by Gram-positive cocci, Gram-negative bacilli, and yeast were similar between groups (Table 4). Since all fungal VAP (n = 3) occurred in the control group, we analyzed data excluding these patients. This exclusion did not change the result that ISIBTS decreased the incidence of VAP (χ^2 $p = 0.02$ and log-rank $p = 0.04$). There were two cases of VAP caused by coagulase-negative *Staphylococcus*, both as polymicrobial VAP, one associated with *Pseudomonas aeruginosa* and the other with *Stenotrophomonas maltophilia*.

Tube Obstruction, Heat And Moisture Exchangers, and Closed Tracheal Suctioning System Changes. Four patients presented endotracheal tube obstruction in the control group (one episode each) and one patient in the saline group (one episode). However, the difference did not reach statistical significance (Table 5).

The number of tracheal suctions per day, HME changes due airway secretions and tracheal closed system suctioning changes due airway secretions were similar between groups (Table 5).

Chest Radiograph Analysis. Agreement regarding chest radiograph analysis between physicians was high (for pulmonary atelectasis κ-statistic = 0.80, $p < 0.01$; for lobar atelectasis κ-statistic = 0.41, $p < 0.01$, and for segmental atelectasis κ-statistic = 0.74, $p < 0.01$). The incidence of pulmonary, lobar, and

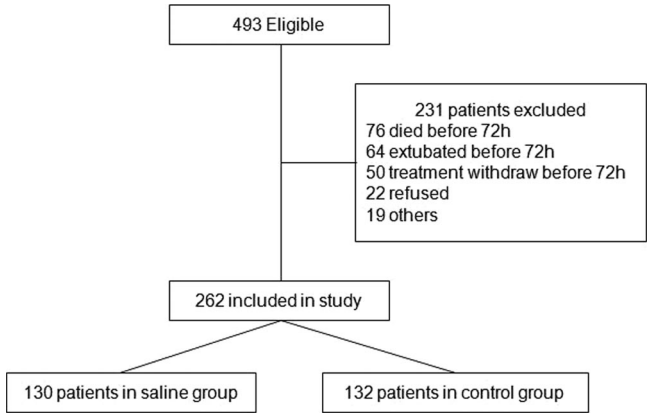

Figure 1. Patients eligible, excluded and included in the study.

Table 1. Patients' characteristics at study enrollment

	Total	Saline	Control	p
Number of patients (%)	262	130 (49.6)	132 (50.4)	
Age (yrs)	64.1 ± 15.3	65 ± 14	63 ± 16	0.14
Male (%)	136 (51.9)	66 (50.8)	70 (53.0)	0.85
Causes of mechanical ventilation				0.17
Pneumonia (%)	73 (28.0)	43 (33.3)	30 (22.7)	
Hypoxemic respiratory failure (%)	76 (29.1)	34 (26.4)	42 (31.8)	
Coma (%)	57 (21.8)	26 (20.2)	31 (23.5)	
Shock (%)	26 (10)	16 (12.4)	10 (7.6)	
Neuromuscular disease (%)	5 (1.9)	2 (1.6)	3 (2.3)	
Others (%)	24 (9.2)	8 (6.2)	16 (12.1)	
PaO_2/FIO_2	228 ± 105	233 ± 102	223 ± 109	0.42
Simplified acute physiologic score II at intensive care unit admission	52.5 ± 15.6	52.4 ± 15.0	52.6 ± 16.1	0.92
Simplified acute physiologic score II at intubation	55.1 ± 15.3	55.5 ± 15.0	54.7 ± 15.7	0.65
Immunosuppression (%)	78 (29.8)	36 (27.7)	42 (31.8)	0.50
Leucopenia ($<1.000/mm^3$) (%)	11 (4.2)	6 (4.6)	5 (3.8)	0.77
Gastric ulcer prophylaxis (%)	208 (80.0)	102 (79.7)	106 (80.3)	1.00
Type of gastric ulcer prophylaxis				0.87
H_2 blocker (%)	74 (35.4)	37 (35.9)	37 (34.9)	
Proton pump inhibitor (%)	135 (64.6)	66 (64.1)	69 (65.1)	
Nasogastric tube (%)	112 (42.9)	56 (43.4)	56 (42.4)	0.90
Chronic obstructive pulmonary disease (%)	49 (18.7)	23 (17.7)	26 (19.7)	0.75
Type of airway humidification				1.00
Heat and moisture exchange (%)	257 (98.1)	128 (98.5)	129 (97.7)	
Heated humidifier (%)	5 (1.9)	2 (1.5)	3 (2.3)	
Tracheotomy (%)	13 (5.0)	8 (6.2)	5 (3.8)	0.41

Hypoxemic respiratory failure means hypoxemic respiratory failure excluding pneumonia. Values are n (%).

Table 2. Characteristics of patients with and without VAP

	Total	VAP+	VAP−	p
Number of patients (%)	262	45 (17.2)	217 (82.8)	
Age (years)	64 ± 15	60 ± 14	65 ± 15	0.043
Male (%)	136 (51.9)			
Causes of MV				0.37
Pneumonia (%)	73 (28)	12 (27.3)	61 (28.1)	
Hypoxemic respiratory failure (%)	76(29.1)	17 (38.6)	59 (27.2)	
Coma (%)	57 (21.8)	5 (11.4)	52 (24.0)	
Shock (%)	26 (10)	6 (13.6)	20 (9.2)	
Neuromuscular disease (%)	5 (1.9)	1 (2.1)	4 (1.8)	
Others (%)	24 (9.2)	3 (6.8)	21 (9.7)	
Simplified acute physiologic score II at ICU admission	52.5 ± 15.6	51.3 ± 15.8	52.7 ± 15.5	0.57
Simplified acute physiologic score II at intubation	55.1 ± 15.3	54.2 ± 15.6	55.2 ± 15.3	0.69
Immunosuppression (%)	78 (29.8)	17 (37.8)	61 (28.1)	0.21
Leucopenia (<1.000/mm^3) (%)	11 (4.2)	4 (8.9)	7 (3.2)	0.1
Gastric ulcer prophylaxis (%)	208 (80.0)	33 (73.3)	175 (81.4)	0.22
Type of gastric ulcer prophylaxis				1.0
H_2 blocker (%)	74 (35.4)	12 (36.4)	62 (35.2)	
Proton pump inhibitor (%)	135 (64.6)	21 (63.6)	114 (64.8)	
Nasogastric tube (%)	112 (42.9)	16 (36.4)	96 (44.2)	0.40
Chronic obstructive pulmonary disease (%)	49 (18.7)	11 (24.4)	38 (17.5)	0.29
Type of airway humidification				1.0
Heat and moisture exchange (%)	257 (98.1)	44 (97.8)	213 (98.2)	
Heated humidifier (%)	5 (1.9)	1 (2.2)	4 (1.8)	
Tracheotomy at admission (%)	13 (5.0)	3 (6.7)	10 (4.6)	0.47
Antibiotics at ICU admission (%)	187 (71.4)	30 (66.7)	157 (72.4)	0.47
Antibiotics during ICU stay (%)	258 (98.5)	45 (100)	213 (98.2)	1.0
Mechanical ventilation length (days)	11.1 ± 10.1	18.2 ± 10.8	9.7 ± 9.4	<0.01
ICU length (days)	17.4 ± 12.1	25.4 ± 14.9	15.7 ± 10.7	<0.01
ICU mortality	132 (50.8)	30 (66.7)	104 (47.9)	0.032

VAP+, patients who developed ventilator-associated pneumonia; VAP−, patients who did not develop ventilator-associated pneumonia. Hypoxemic respiratory failure means hypoxemic respiratory failure excluding pneumonia. Values are n (%).

Table 3. Incidence of VAP and use of antibiotics

	Total	Saline	Control	p
Number of patients (%)	262	130 (49.6)	132 (50.4)	
Clinically suspected VAP events (%)	74 (28.2)	32 (24.6)	42 (31.8)	0.22
Microbiological proven VAP (%)	45 (17.2)	14 (10.8)	31 (23.5)	0.008
Incidence density/1.000 MV days	15.44	9.62	21.22	0.011
Early-onset VAP (2–5 days of MV) (%)	13 (5.0)	4 (3.1)	9 (6.8)	0.98
VAP between 5 and 10 days of MV) (%)	16 (6.1)	7 (5.4)	9 (6.8)	0.17
VAP after 10 days of MV (%)	16 (6.1)	3 (2.3)	13 (9.8)	0.31
Patients using antibiotics at intensive unit care admission (%)	188 (72.0)	98 (76.0)	90 (68.2)	0.17
Patients using antibiotics at the day of clinically suspected VAP (%)	74 (28.2)	31 (23.8)	38 (28.8)	0.38
Patients that used antibiotics during intensive unit care stay (%)	258 (98.5)	130 (100)	128 (97)	0.12

VAP, ventilator-associated pneumonia, MV, mechanical ventilation. Values are n (%).

segmental atelectasis was similar between groups (Table 5).

DISCUSSION

In the present study, the instillation of isotonic saline before tracheal suctioning decreased the incidence of microbiological proven VAP. The incidence of endotracheal tube occlusion and atelectasis were similar between groups.

We speculate two reasons upon the decrease in VAP incidence due to ISIBTS. The first reason was a probable airway secretion removal improvement, mainly due to cough stimulation. The second reason was a probable decrease in endotracheal tube biofilm.

In patients with VAP, tracheal colonization precedes pneumonia in the majority of patients (30, 31), and microorganisms present in tracheal aspirate and protected specimen bush are concordant (32). Trachea can be considered as an inert passage for microorganisms or as a reservoir of microorganisms. We consider trachea a significant VAP reservoir because the mucosal surface area, volume of pooled secretions, and clearance difficulties are equal or higher in the trachea than in the oropharynx. Considering trachea as a VAP reservoir, ISIBTS may decrease the incidence of VAP because it increases tracheal secretion removal (12). The reasons for secretion removal improvement after saline instillation are speculative. Among them, one probable reason is cough stimulation. The increase in coughing associated to saline instillation was reported in three previous studies (13, 33, 34). Because of in our ICU we avoid deep levels of sedation, cough stimulation could have been an important determinant of VAP incidence decrease.

Many authors consider the endotracheal tube biofilm as a reservoir for VAP (14–16). We can speculate that the frequent rinsing of the endotracheal tube by ISIBTS may have decreased the endotracheal tube biofilm, thereby lessening VAP incidence. However, one study showed that ISIBTS increased viable bacterial dis-

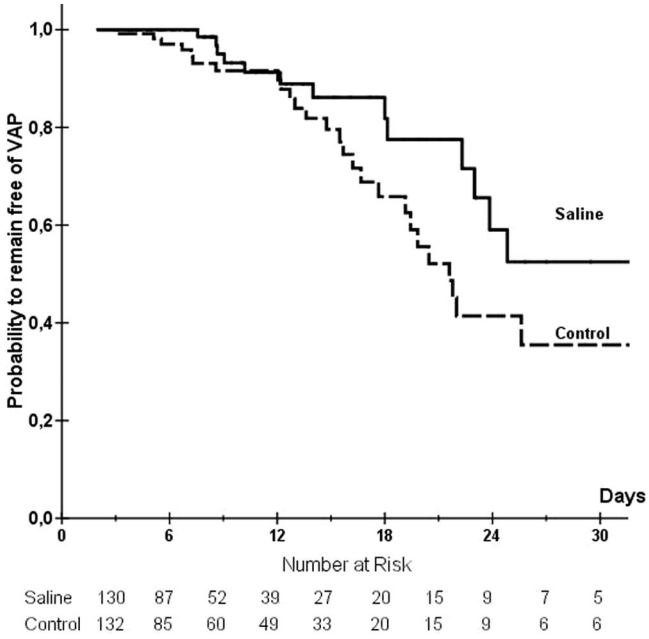

Figure 2. Kaplan-Meier curve. Probability of remaining free from ventilator-associated pneumonia (*VAP*). Log-rank = 0.02.

Table 4. Microorganisms causing VAP

	Total	Saline	Control	*p*
Number of patients (%)	262	130 (49.6)	132 (50.4)	
Type of infection				0.99
Monomicrobial VAP (%)	35 (13.4)	11 (8.5)	24 (18.2)	
Polymicrobial VAP (%)	10 (3.8)	3 (2.3)	7 (5.3)	
Gram-positive cocci				0.54
Methicillin-resistant *Staphylococcus aureus*	6	1	5	
Coagulase-negative Staphylococci	2	0	2	
Gram-negative bacilli				0.59
Pseudomonas aeruginosa	16	7	9	
Acinetobacter species	6	1	5	
Stenotrophomonas maltophilia	8	3	5	
Enterobacteriaceae	10	4	6	
Burkholderia cepacia	1	0	1	
Candida species	3	0	3	0.25

VAP, ventilator-associated pneumonia.
Values are n (%).

Table 5. Atelectasis, tracheal suctions per day, endotracheal tube obstruction, Heat and moisture exchange and closed tracheal suction system changes

	Total	Saline	Control	*p*
Number of patients (%)	262	130 (49.6)	132 (50.4)	
Endotracheal tube occlusion (%)	5 (1.9)	1 (0.8)	4 (3.0)	0.37
Heat and moisture exchange change due to secretion/100 days of MV	9 ± 18	9 ± 19	10 ± 18	0.97
Closed tracheal suctioning system change due to secretion/100 days of MV	2 ± 5	1 ± 4	2 ± 5	0.41
Tracheal suctions per day	4.8 ± 1.2	4.7 ± 0.9	4.9 ± 1.4	0.14
Chest radiograph analysis				
Number of patients (%)	174	88 (50.6)	86 (49.4)	
Pulmonary atelectasis/100 days of MV	0.21 ± 2.1	0.13 ± 1.3	0.30 ± 2.8	0.61
Lobar atelectasis/100 days of MV	0.39 ± 1.9	0.23 ± 1.6	0.55 ± 2.1	0.26
Segmental atelectasis/100 days of MV	39.8 ± 39.6	41.2 ± 40.8	38.4 ± 38.5	0.64

MV, mechanical ventilation.
Chest radiograph films for two patients, one from each group, were lost. Values are n (%).

lodgement (11). Nevertheless, authors used a very simple *in vitro* model that did not consider the anatomical complexity of the airways, especially its branching. In addition, saline instillation was applied once, and it is possible that subsequent instillations would dislodge less viable bacteria than successive suctioning without saline instillation.

An interesting result of the present study was the proportional decrease in VAP type (monomicrobial or polymicrobial) and pathogens. This finding corroborates the above hypotheses that a decrease in the microbiological burden in trachea and/or endotracheal biofilm constitutes the mechanism of VAP decrease.

Further studies are necessary to elucidate the mechanisms of the benefit of ISIBTS. We believe that a clinical randomized study with a control and saline group and quantification of the bacterial tracheal tube biofilm and cough intensity is necessary.

Although the incidence of microbiological proven VAP was higher in the control group, the incidence of clinically suspected VAP was similar between the groups. It was not an unexpected result because we adopted a criterion of low specificity to the diagnosis of clinically suspected VAP (radiographic abnormality plus one of three criteria) leading to many false-positive results (21) that probably diluted any significant difference between groups.

Higher airway secretion removal in the saline group could lead to a decrease in the incidence of atelectases due to secretion plugging. Pulmonary or lobar atelectases are usually obstructive. In our study, the incidence of pulmonary and lobar atelectasis in the control group was more than twice that in the saline group, but the difference did not reach statistical significance, probably because the number of events was small. The incidence of segmental atelectasis was similar between groups. This was expected, because segmental atelectasis, especially at the lower lobes, have causes other than secretion plugging, such as increased abdominal pressure, hypoventilation, diaphragm dysfunction, sedation, and the presence of pleural effusion (35).

As previously speculated, saline instillation could prevent encrustations in the endotracheal tube (36). Since this speculation sounds plausible, one could expect a significant decrease in the endotracheal tube obstruction in the saline group. There was one episode of endotracheal

tube obstruction in the saline group and four in the control group. However, the difference did not reach statistical significance, probably because of the small number of events.

There are concerns about the safety of ISIBTS, especially the occurrence of hypoxemia. The results are controversial (37) because some studies did not reveal hypoxemia in infants (38) or adults (12, 33) subjected to ISIBTS, whereas another did (39). However, in the latter study the decrease in arterial hemoglobin saturation, while statistically significant, was clinically irrelevant given the difference in saturation was around 1%. Two previous studies have revealed that saline instillation did not cause alterations in blood pressure or heart rate (33, 38).

In the present study, there was an apparent lack of impact on patient outcomes such as mortality, MV, and ICU length of stay. Although one could expect an impact on these outcomes because of VAP incidence decrease, it did not occur because our simple size was calculated to compare VAP incidence and not mortality attributed to VAP between groups. In Table 2, we compared the above-mentioned outcomes between patients with and without VAP whereby the occurrence of VAP negatively affected these outcomes. In the present study, there was a high ICU mortality, a expected finding because most of our patients were cancer patients submitted to MV, a known risk factor for ICU death in cancer patients (40). Other studies with similar populations have found a similar or higher mortality (41, 42).

A limitation of the present study is its single-center design. Nevertheless, the incidence (1, 3, 43, 44) and microbiology (43, 45) of VAP were similar to other studies. This appraisal is important because, as an oncologic hospital, the presence of immunosuppressed patients was elevated. Notwithstanding, we did not expect that a high percentage of immunosuppressed would affect our results because VAP has been considered a category distinct from pneumonia in immunosuppressed patients, given that pathogenesis differs (46). Besides, the prevalence of immunosuppression was similar between groups. It is worthy of note that the present study was conducted in an ICU with high incidence of VAP and in patients with long MV length of stay using HME, so our study requires confirmation in ICU patients with shorter MV length of stay, use of heated water humidifiers or lower incidence of VAP. Another limitation is the lack of blinding of the respiratory therapists, but we believe that this did not bias the results, because the ICU physicians were unaware of the patient group.

CONCLUSIONS

Instillation of isotonic saline before tracheal suctioning decreases the incidence of microbiological proven VAP. The incidence of endotracheal tube obstruction, pulmonary, and lobar atelectasis did not differ.

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