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Major article

Subglottic secretion drainage and continuous control of cuff pressure used together save health care costs

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Background: Preventive strategies to reduce ventilator-associated respiratory infection (VARI) include the use of an endotracheal tube incorporating a lumen for subglottic secretion drainage (SSD) and a system for continuous control of endotracheal tube cuff pressure (CCCP). The health care costs associated with the combined use of these 2 measures aimed at preventing VARI are not known, however. The objective of this study was to determine whether the simultaneous use of these 2 preventive measures for VARI could save health care costs.

Methods: We performed a prospective observational study of patients who needed mechanical ventilation in an intensive care unit. The health care costs considered here included only the costs of the endotracheal tube, cuff control, and antimicrobials used to treat VARI.

Results: The study cohort comprised 656 patients, including 241 with intermittent control of cuff pressure and without SSD (standard group), 260 with CCCP and without SSD (CCCP group), 84 with intermittent control of cuff pressure and with SSD (SSD group), and 71 with CCCP and SSD (CCCP + SSD group). The incidence of VARI and health care costs were lower in the CCCP + SSD group compared with the standard, CCCP, and SSD groups.

Conclusions: The combined use of SSD and CCCP reduced the incidence of VARI and saved health care costs.

Ventilator-associated pneumonia (VAP) continues to be an important cause of morbidity and mortality in critically ill patients.[1-6] Subglottic secretions may accumulate above the endotracheal cuff and descend along the folds of the cuff wall to the lower respiratory tract, causing VAP. Various preventive strategies have been proposed to avoid microaspiration of subglottic secretions, including removing these secretions via an endotracheal tube incorporating a lumen for subglottic secretion drainage (SSD) and avoiding a loss of intracuff pressure via a system for continuous control of endotracheal tube cuff pressure (CCCP). Several previous studies found that SSD reduced the incidence of VAP,[7-10] and drainage has been recommended in a number of guidelines.[11-18]

The use of a CCCP system was found to reduce the incidence of VAP in a randomized controlled trial[19] and an observational study[10]; however, another randomized controlled trial found no significant differences in the incidence of VAP between a group managed with a continuous endotracheal tube cuff pressure control system and a group managed with an intermittent endotracheal tube cuff pressure control system.[20] Several guidelines for the prevention of VAP do not even consider the issue of endotracheal tube cuff pressure control.[11-14] Other guidelines recommend maintaining optimal tube cuff pressure, but include no recommendations regarding the use of a continuous or intermittent tube cuff pressure control system.[15-18]

To our knowledge, no previous studies have reported the costs of care according to the combined use of these VAP preventive measures. The aim of the present study was to determine whether the joint use of these preventive measures to avoid ventilator-associated respiratory infection (VARI) could reduce health care costs.

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METHODS

Study design

A prospective observational study with an incidental sample of 656 patients was performed at the 24-bed medical-surgical intensive care unit (ICU) of the University Hospital of the Canary Islands, a 650-bed tertiary hospital, over a 1-year period. The study was approved by the hospital's Institutional Ethics Review Board. Informed consent was obtained from all patients or legal guardians. The inclusion criterion was the need for mechanical ventilation.

VAP prevention measures

The following endotracheal tubes were used: Mallinckrodt TaperGuard Evac Oral Tracheal Tube (Covidien, Mansfield, MA), which incorporates a tapered PVC cuff and a suction lumen for SSD, which was performed intermittently during 1-hour periods with a 10-mL syringe, and the Mallinckrodt Hi-Lo Tracheal Tube (Mallinckrodt, Atholone, Ireland), which has a cylindrical PVC cuff without a lumen for SSD. During part of the study period, only endotracheal tubes with a suction lumen for SSD were available, owing to financial constraints.

Patients who were admitted to an odd-numbered ICU cubicle were managed with a CCCP system (Mallinckrodt Pressure Control; VBM Medizintechnik, Sulz am Neckar, Germany) and those admitted to an even-numbered ICU cubicle were managed with an intermittent cuff pressure system (Mallinckrodt Pressure Manometer; Mallinckrodt, Atholone, Ireland). In both patient groups, intracuff pressure was maintained at 25 cm H_2O and checked every 8 hours, with pressure values recorded in the patient's chart. Each type of cuff pressure system was used from the initiation of connection to mechanical ventilation.

Oral cleansing was performed by nurses every 8 hours as follows. First, the endotracheal cuff pressure was tested, and oropharyngeal secretions were aspirated. Then gauze impregnated with 20 mL of 0.12% chlorhexidine digluconate was used to cleanse the teeth, tongue, and mucosal surfaces, followed by the injection of 10 mL of 0.12% chlorhexidine digluconate into the oral cavity. After 30 seconds, the oropharyngeal area was suctioned.

No routine changes were made in the ventilator circuits. Tracheal suction, when necessary, was performed with an open system and strict barrier measures before airway management (ie, handwashing, use of gloves and face masks).

Patient body position (semirecumbent) was checked every 4 hours to maintain an angle of 40 degrees. Residual gastric volume was checked every 6 hours; a residual gastric volume <250 mL was considered acceptable. No selective digestive decontamination was performed. Short-course (2 days) systemic antibiotic therapy was administered to patients with a decreased level of consciousness at the time of intubation. Sedative drugs were adjusted to achieve a score of 3-4 on the Ramsay scale.[21]

Microbiological vigilance

Tracheal aspirate samples were obtained during endotracheal intubation, then twice a week, and finally on extubation. Throat swabs were obtained on admission to the ICU, then twice a week and finally at discharge from the unit.

Definitions

A diagnosis of pneumonia was established when all of the following criteria were met: (1) new onset of purulent bronchial sputum, (2) body temperature $>38^{\circ}C$ or $<35.5^{\circ}C$, (3) white blood cell count $>10{,}000/mm^3$ or $<4000/mm^3$, (4) chest X-ray showing new or progressive infiltrates, and (5) quantitatively significant ($>10^6$ cfu/mL) culture of respiratory secretions obtained by tracheal aspirate. The criteria for a diagnosis of tracheobronchitis were the same as those for pneumonia but without chest X-ray changes. Respiratory infection, including pneumonia or tracheobronchitis, was considered ventilator-associated when diagnosed after 48 hours of mechanical ventilation. The diagnosis of respiratory infection was made by an expert panel blinded to the type of endotracheal tube and cuff pressure system.

VARIs were classified according to the pathogenicity of the organism found in the throat flora as primary endogenous, secondary endogenous, or exogenous.[22] An infection was considered primary and endogenous when caused by microorganisms already present in the patient's oropharyngeal flora on admission to the ICU. Secondary endogenous infections were those caused by microorganisms not found on admission but detected in the patient's oropharyngeal flora during his or her ICU stay. Respiratory infections caused by microorganisms that were never detected in the patient's oropharyngeal flora were considered exogenous.

Variables recorded

The following variables were recorded for each patient: sex, age, diagnostic group, type of admission, smoking status, chronic obstructive pulmonary disease, diabetes mellitus, use of chemotherapeutic agents, use of steroid agents, hematologic tumor, solid tumor, diagnosis group, Acute Physiology and Chronic Health Evaluation (APACHE)-II score,[23] duration of mechanical ventilation, antibiotic use before onset of VAP onset, use of paralytic agents, tracheotomy, reintubation, enteral nutrition, type of endotracheal tube cuff pressure control system (continuous or intermittent), type of endotracheal tube (with or without a small-bore lumen for SSD), positive end-expiratory pressure, Ramsay Scale score,[21] head-of-bed angle elevation, red blood cell transfusion, cuff pressure, and ICU mortality.

Health care costs

Health care costs included only the costs of the endotracheal tube, cuff control, and antimicrobials used to treat respiratory infection. All data on the cost of consumables and antimicrobial agents were obtained from the hospital's Accounting Department. An endotracheal tube without SSD cost was 1.22 euros, an endotracheal tube with SSD cost 29.41 euros, gloves and the syringe for SSD cost 0.82 euros/day, and consumables for CCCP cost 0.40 euros.

Statistical analysis

Qualitative variables are reported as frequencies and percentages, and were compared using the χ^2 test or Fisher's exact test as appropriate. Quantitative variables are reported as mean $\pm$ standard deviation and were compared using ANOVA. Poisson regression analysis for unconditional maximum likelihood inference with exact P values was used to compare respiratory infections per 1000 days of mechanical ventilation and daily health care costs between pairs of groups.[24] Bonferroni correction was applied to correct for multiple testing. The probability of remaining free of VARI was plotted using the Kaplan-Meier method, and comparisons between groups were done using the log-rank test. A P value $<.05$ was considered statistically significant. Statistical analyses were performed using SPSS version 17.0.0 (SPSS, Chicago, IL) and StatXact version 5.0.3 (Cytel Software, Cambridge, MA).