**BRIEF REPORT**

Stijn I. Blot
Sonia Labeau
Dominique Vandijck
Paul Van Aken
Brigitte Claes
Executive Board of the Flemish
Society for Critical Care Nurses

# Evidence-based guidelines for the prevention of ventilator-associated pneumonia: results of a knowledge test among intensive care nurses

Stijn I. Blot and Sonia Labeau are the joint primary authors.

The authors have written this article on behalf of the Executive Board of the Flemish Society for Critical Care Nurses.

S. I. Blot (✉) · D. Vandijck
Ghent University Hospital, Department of Intensive Care,
De Pintelaan 185, 9000 Ghent, Belgium
e-mail: stijn.blot@UGent.be
Tel.: +32-9-2406216
Fax: +32-9-2404995

S. I. Blot · S. Labeau
University College Ghent, Faculty of Healthcare,
Keramiekstraat 80, 9000 Ghent, Belgium

D. Vandijck
Ghent University, Faculty of Medicine and Health Science,
De Pintelaan 185, 9000 Ghent, Belgium

P. Van Aken · B. Claes
University Antwerp, Department of Intensive Care,
Wilrijkstraat 10, 2650 Edegem, Belgium

**Abstract** *Objective:* To determine intensive care nurses' knowledge of evidence-based guidelines for the prevention of ventilator-associated pneumonia (VAP). *Design:* A survey using a validated multiple-choice questionnaire, developed to evaluate nurses' knowledge of VAP prevention. The questionnaire was distributed and collected during the annual congress of the Flemish Society for Critical Care Nurses (Ghent, November 2005). Demographic data included were gender, years of intensive care experience, number of critical beds, and whether respondents hold a special degree in emergency and intensive care. *Main results:* We collected 638 questionnaires (response rate 74.6%). Nineteen percent of the respondents recognized the oral route as the recommended way for intubation. It was known by 49% of respondents that ventilator circuits should be changed for each new patient. Heat and moisture exchangers were checked as the recommended type of humidifier by 55% of respondents, but only 13% knew that it is recommended to change them once weekly. Closed suctioning systems were identified as recommended by 17% of respondents, and 20% knew that these must be changed for each new patient only. Sixty percent and 49%, respectively, recognized subglottic drainage and kinetic beds to reduce the incidence of VAP. Semi-recumbent positioning is well known to prevent VAP (90%). The average knowledge level was higher among more experienced nurses (> 1 year experience) and those holding a special degree in emergency and intensive care. *Conclusion:* Nurses lack knowledge regarding recommendations for VAP prevention. Nurses' schooling and continuing education should include support from current evidence-based guidelines.

**Keywords** Evidence-based guidelines · Prevention · Survey · Ventilator-associated pneumonia

## Introduction

Ventilator-associated pneumonia (VAP) leads to a considerable excess in morbidity and mortality, and to a significant economic burden [1–5]. Prevention of VAP focuses primarily on avoiding microaspiration of subglottic secretions, preventing oropharyngeal colonization with exogenous pathogens, and contamination of ventilator equipment. Although research efforts have been undertaken to determine the value of numerous preventive measures, interpretation of the results is not always obvious [6]. There may be flaws in the study design and results from different studies may not be concordant. The positive effect of preventive measures may decrease with length of

time at risk. Moreover, continuous aspiration of subglottic secretions has a favorable effect on the incidence of early onset VAP, but the effects on late-onset VAP are less convincing [7–9]. Also, preventive measures may be effective, but are too expensive, for general implementation [10–12]. In response to the complexity of the issue, studies of expert panels have resulted in evidence-based guidelines [2, 10].

Surveys evaluating compliance of practices with the recommendations have been published [13–16]. Yet, to our knowledge, surveys evaluating knowledge of guidelines for VAP prevention by means of a knowledge test have not been performed. While knowledge does not insure adherence, a lack of knowledge may be a barrier to adherence.

This study aimed to determine intensive care nurses' knowledge of evidence-based recommendations for VAP prevention.

## Materials and methods

A multiple-choice questionnaire was developed [17], following the evidence-based VAP prevention guidelines by Dodek et al. [10]. Selection of items was limited to signifi-

**Table 1** Nurses' answers on multiple-choice questions regarding prevention of ventilator-associated pneumonia (*VAP*)

| Item | Answers (%) |
|---|---|
| 1. Oral vs nasal route for endotracheal intubation | |
| Oral intubation is recommended | 18.7* |
| Nasal intubation is recommended | 11.1 |
| Both routes of intubation can be recommended | 59.6 |
| I do not know | 10.7 |
| 2. Frequency of ventilator circuits changes | |
| It is recommended to change circuits every 48 h (or when clinically indicated) | 19.4 |
| It is recommended to change circuits every week (or when clinically indicated) | 27.4 |
| It is recommended to change circuits for every new patient (or when clinically indicated) | 48.6* |
| I do not know | 4.5 |
| 3. Type of airway humidifier | |
| Heated humidifiers are recommended | 17.2 |
| Heat and moisture exchangers are recommended | 54.7* |
| Both types of humidifiers can be recommended | 12.5 |
| I do not know | 15.5 |
| 4. Frequency of humidifier changes | |
| It is recommended to change humidifiers every 48 h (or when clinically indicated) | 58.8 |
| It is recommended to change humidifiers every 72 h (or when clinically indicated) | 11.4 |
| It is recommended to change humidifiers every week (or when clinically indicated) | 13.3* |
| I do not know | 16.5 |
| 5. Open vs closed suction systems | |
| Open suction systems are recommended | 3.3 |
| Closed suction systems are recommended | 16.9* |
| Both systems can be recommended | 69.3 |
| I do not know | 10.5 |
| 6. Frequency of change in suction systems | |
| Daily changes are recommended (or when clinically indicated) | 45.1 |
| Weekly changes are recommended (or when clinically indicated) | 22.3 |
| It is recommended to change systems for every new patient (or when clinically indicated) | 19.6* |
| I do not know | 13.0 |
| 7. Endotracheal tubes with extra lumen for drainage of subglottic secretions | |
| These endotracheal tubes reduce the risk for VAP | 60.3* |
| These endotracheal tubes increase the risk for VAP | 3.6 |
| These endotracheal tubes do not influence the risk for VAP | 8.2 |
| I do not know | 27.9 |
| 8. Kinetic vs standard beds | |
| Kinetic beds increase the risk for VAP | 1.3 |
| Kinetic beds reduce the risk for VAP | 48.7* |
| The use of kinetic beds does not influence the risk for VAP | 19.3 |
| I do not know | 30.7 |
| 9. Patient positioning | |
| Supine positioning is recommended | 0.8 |
| Semi-recumbent positioning is recommended | 90.3* |
| The position of the patient does not influence the risk for VAP | 5.5 |
| I do not know | 3.4 |

The table reviews the percentage of answers to the respective response choices. For each of the nine items, the correct answer is indicated with an asterisk

cant strategies for nursing practice and adapted to an expert validation panel's comments [17].

Demographic data gathered were gender, years of experience in an intensive care unit (ICU), number of critical beds in the hospital where respondents are put to work, and whether they hold a degree in emergency and intensive care. This degree can be achieved after the basic 3-year nursing education (Bachelor degree) and is acknowledged as a Bachelor-after-Bachelor degree. Although it is not obligatory to hold this degree to work in a Flemish ICU, it is strongly promoted by hospital directors since ICU licenses depend on a minimum number of nurses employed who hold this special degree (50%).

The questionnaire was distributed during the annual congress of the Flemish Society for Critical Care Nurses (Ghent, 25 November 2005) and presented plenary by a Board member. The contextual framework was explained and some time was provided to fill in the demographic data. Then, each question was read aloud while projected in the congress hall. Thirty seconds were left between two questions. Finally, the questionnaires were collected immediately after this procedure.

Continuous variables are described as median (interquartile range). Chi-square test, Mann-Whitney U-test and Kruskal-Wallis test were used as appropriate. Relationships between total scores and demographic data were assessed using linear regression analysis. Variables with $p < 0.15$ were stepwise removed from the regression model. Statistical analysis was performed using SPSS for Windows 12.0.0 (SPSS, Chicago, Ill.).

## Results

Of the 855 registered participants of the congress, 638 completed the questionnaire (74.6%). Most respondents were female ($n = 472$; 74.0%). About one-quarter ($n = 153$; 24.0%) had < 1 year of ICU experience, 111 (17.4%) 1–5 years, 100 (15.7%) 6–10 years, and 274

**Table 2** Average scores (on nine questions) according to respondents' characteristics

| Characteristic | Mean (%) | Median (interquartile range) | Significance (p) |
|---|---|---|---|
| Total cohort | 3.71 (41.2) | 4 (3–5) | – |
| Gender | | | 0.545 |
|   Female | 3.69 (41.0) | 4 (3–5) | |
|   Male | 3.77 (41.9) | 4 (3–5) | |
| No. of ICU beds | | | 0.401 |
|   < 8 beds | 3.72 (41.3) | 4 (2–5) | |
|   8–15 beds | 3.97 (44.1) | 4 (3–5) | |
|   > 15 beds | 3.93 (43.7) | 4 (3–5) | |
| Years of ICU experience | | | < 0.001 |
|   < 1 year | 2.85 (31.7) | 3 (2–4) | |
|   1–5 years | 3.70 (41.1) | 4 (3–5) | |
|   6–10 years | 4.16 (46.2) | 4 (3–5) | |
|   > 10 years | 4.03 (44.8) | 4 (3–5) | |
| Special title in emergency and intensive care | | | < 0.001 |
|   Yes | 3.94 (43.7) | 4 (3–5) | |
|   No | 3.22 (35.8) | 3 (2–4) | |

The table shows the mean (%) of correct answers on nine multiple-choice questions according to the total cohort or the subgroups identified. The *p*-value indicates how scores differ according to the subgroups

**Table 3** Adjusted relationships (linear regression) with the average knowledge regarding the prevention of ventilator-associated pneumonia

| | B ± standard error | 95% confidence interval | Significance (p) |
|---|---|---|---|
| ICU experience (per class increase) [a] | 0.31 points ± 0.05 [b] | 0.20–0.41 | < 0.001 |
| Degree in emergency and intensive care | 0.32 points ± 0.14 [b] | 0.03–0.58 | 0.032 |

[a] Classes are < 1 year, 1–5 years, 6–10 years, or > 10 years of ICU experience

[b] On a total of nine questions (one point per question)

The table shows the result of a linear regression analysis ($R^2 = 0.1$) indicating independent relationships between nurses' mean scores on the multiple choice questions ($n = 9$) of the questionnaire and years of ICU experience and whether they held a degree in emergency and intensive care. Gender and number of ICU beds were not withheld by the model. The analysis revealed that years of ICU experience (per class increase) was independently associated with an increase in total score of 0.31 points (95% CI: 0.20−0.41) on nine questions. Holding a degree in emergency medicine and intensive care was associated with an independent increase in total score of 0.32 points (95% CI: 0.03–0.58) on nine questions

(43.0%) > 10 years. A majority (*n* = 274; 42.9%) worked in a hospital with > 15 ICU beds, 177 (27.7%) with 8–15 beds, and 104 (16.3%) with < 8 beds. A degree in emergency and critical care was held by 68% (*n* = 437) of respondents. Nurses from 91 ICUs attended the congress.

The questionnaire and nurses' answers are shown in Table 1. Average scores according to respondents' characteristics are demonstrated in Table 2. The average score was 3.7 on nine questions (41.2%). No substantial differences were found between males and females, nor did the number of beds affect the results. Nurses with < 1 year experience performed worse than nurses with > 1 year experience. Nurses holding the degree had significantly better scores than those not holding it. Linear regression analysis identified years of experience (per class increase) and degree to be independently associated with better knowledge (Table 3).

## Discussion

We evaluated Flemish nurses' knowledge of VAP guidelines. Overall the results were poor. Our results can be compared with four previously published reports [13–16]. Rello et al. distributed a questionnaire in 22 countries to indicate whether practices were according to a recent review article, thus identifying barriers to physicians' adherence to guidelines [14, 18]. The study by Heyland et al. described the use of strategies for VAP prevention prior to publication of the Canadian Critical Care Trials Group's guidelines [13]. In the survey by Sierra et al., practices on prevention and diagnosis of VAP were explored among physicians in 28 Spanish ICUs [16]. The study by Ricart et al. is the only one focussing on nursing adherence to VAP guidelines [15]. The most important difference between our study and those reporting care practices [13–16] is that our questionnaire was designed to measure knowledge. Nevertheless, we assume that our results also reflect, at least to some extent, practice in Flemish ICUs.

Sierra et al. found that in 75% of the ICUs ventilator circuits were changed every 72 h or later [16]. This is in accordance with our findings where nurses indicated to change circuits weekly or later in 76% of respondents. Fifty-five percent of our respondents identified heat and moisture exchangers as the recommended type of airway humidification. In the studies by Heyland et al [13], Ricart et al [15], and Sierra et al. [16], respectively, 80, 84, and 96% of the respondents used heat and moisture exchangers.

It is recommended to change airway humidification systems weekly or when clinically indicated [10]. Only 12% of our respondents were aware of this recommendation, suggesting that, in daily practice, humidification systems are changed too frequently. Also in the studies by Rello et al [14] and Ricart et al. [15], heat and moisture exchangers were changed on a daily basis in 59 and 75%, respectively.

In our survey only 17% of respondents recognized closed systems as recommended. In Canada closed suction systems are used in 88% of the ICUs, whereas in Spain open tracheal suctioning was reported in 96% of the ICUs [13, 16]. In Flanders, closed suction systems are not commonly used, and thus the results of our survey reflect nurses' unfamiliarity with those systems.

Sixty percent of respondents knew that draining subglottic secretions decreases the risk for pneumonia. The beneficial effect of kinetic beds was recognized by about half of the nurses; however, for these two issues, 28 and 31% of nurses, respectively, reported not to know the answer, which suggests that these strategies are seldom used in Flemish ICUs. Finally, in our survey semi-recumbent positioning was well acknowledged to prevent VAP [13–16].

Generally, more experienced nurses had a higher knowledge level than those with < 1 year experience. The knowledge level among nurses holding a special degree was also higher (Table 2). After adjustment for years of ICU experience, the advantage of the special degree remained significant (Table 3).

Our findings demonstrate that nurses' awareness about VAP guidelines is low, and stress the need for thorough education based on current recommendations. One might question the importance of pure knowledge versus degree of application in practice. We believe that thorough understanding of the recommended strategies supports adherence and overcomes potential barriers as previously identified [14, 15]. Additionally, increasing the average level of knowledge has been the first step in successful multifaceted educational programs [19, 20]. Guidelines themselves only have a limited impact on changing behavior [15]. Within institutions, efforts must be taken to organize educational programs to fine-tune practice with guidelines. The favorable value of such programs has been demonstrated [19, 20].

As with all surveys, the present study suffers from selection bias. Individuals with a higher interest in the topic are more likely to participate. Moreover, the questionnaire was distributed at the annual congress of the Flemish Society for Critical Care Nurses. Nurses attending congresses might be more skilled or motivated; however, this bias is limited by the fact that the federal government requests at least 16 h of education yearly to maintain the degree.

Also knowledge of recommendations does not necessarily reflect practice. Nurses may change ventilator circuits for every new patient, not knowing this is a guideline. Furthermore, no weights were linked to the different strategies' relative importance. For example, supine positioning can be considered as a higher risk for VAP than changes of heat and moisture exchangers per 48 h. In this way, the higher scores achieved for patient positioning and subglottic secretions drainage are in favor of the study population.

This study is a preliminary investigation in a strict geographical region. Its results cannot be extrapolated. A multi-country study should be conducted to draw more general conclusions.

Despite the geographical restriction, our major strength is the large sample size. We collected 638 questionnaires. The number of Flemish ICU nurses being approximately 3000, our sample covers > 20% of potential respondents.

In conclusion, Flemish nurses' knowledge of VAP prevention guidelines is low. Their education should include supplementary support from current evidence-based guidelines.

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