Mechanical ventilation is a life-saving invasive procedure performed in intensive care units (ICUs) where critical patients are given advanced support. The purpose of this study was to assess the effect of personnel training on the incidence of ventilator-associated pneumonia (VAP). The study, performed prospectively in the ICU, was planned in two periods. In both periods, patient characteristics were recorded on patient data forms. In the second period, ICU physicians and assistant health personnel were given regular theoretical and practical training. Twenty-two cases of VAP developed in the pre-training period, an incidence of 31.2. Nineteen cases of VAP developed in the post-training period, an incidence of 21.0 ($P<0.001$). Training reduced development of VAP by 31.7 %. Crude VAP mortality was 69 % in the first period and 26 % in the second ($P<0.001$). Statistically significant risk factors for VAP in both periods were prolonged hospitalization, increased number of days on mechanical ventilation, and enteral nutrition; risk factors determined in the first period were re-intubation, central venous catheter use and heart failure and, in the second period, erythrocyte transfusion $>5$ units ($P<0.05$). Prior to training, compliance with hand washing (before and after procedure), appropriate aseptic endotracheal aspiration and adequate oral hygiene in particular were very low. An improvement was observed after training ($P<0.001$). The training of personnel who will apply infection control procedures for the prevention of healthcare-associated infections is highly important. Hand hygiene and other infection control measures must be emphasized in training programmes, and standard procedures in patient interventions must be revised.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is a significant hospital infection that needs to be prevented because of the high mortality frequently encountered in the intensive care unit (ICU) (Albertos et al., 2011). Risk factors for development of VAP include patient defence mechanism failure, immune response suppression, prolonged mechanical ventilator (MV) use, presence of underlying disease (diabetes mellitus, chronic obstructive pulmonary disease, etc.), drugs used (steroid, previous antibiotics, H2 receptor blocker and antacid use, etc.), presence of tracheotomy, surgical procedures performed, re-intubation and invasive procedures (Albertos et al., 2011; American Thoracic Society & Infectious Diseases Society of America, 2005). Various strategies have been developed to prevent airway colonization and contaminated secretion aspiration, major mechanisms in VAP (American Thoracic Society & Infectious Diseases Society of America, 2005; Coffin et al., 2008). In order for standard recommendations regarding infection control to be capable of implementation, hospital units and ICU personnel in particular need to have available sufficient information on the subject. Personnel training in all hospitals must therefore primarily target hospital staff including nurses, technicians, physicians, anaesthetists and infection control teams.

Abbreviations: ARICU, anaesthesia and reanimation intensive care unit; CVC, central venous catheter; ICU, intensive care unit; MV, mechanical ventilator; VAP, ventilator-associated pneumonia.
The purpose of this study was to assess the effect of personnel training on the development of VAP.

METHODS

Study design. The study was performed prospectively at the anaesthesia and reanimation ICU (ARICU). The study was approved by the Medical Ethical Board of the Medical Faculty (ethical approval no. 2009-50). The ARICU provides tertiary health services and consists of eight beds for the monitoring of patients exposed to trauma and intoxication and subjects requiring intensive care after surgery. Personnel include physicians with primary responsibility, specialist anaesthetists with appropriate intensive care training, nurses, technicians and ancillary staff. Professional experience of the permanent personnel ranges from 2 to 11 years. Branch physicians attend for consultation. An infectious disease specialist performs day-to-day monitoring.

The study was intended to assess the effect of training on VAP and was planned in two periods. In the first 6-month period, patient characteristics were recorded on patient data forms. In the second 6-month period, ARICU physicians and assistant health personnel were given regular theoretical and practical training. During this period, patient characteristics were again recorded on patient data forms.

Patients hospitalized in the ICU for longer than 48 h were included in the study, and patients attached to MVs were monitored without intervention. VAP was diagnosed by infectious disease specialist outside the study team on the basis of CDC criteria (Horan et al., 2008). Changes in patients' physical examination findings, temperature, white cell count and mucus properties were monitored daily. Cultures were taken from potential foci of infection, including endotracheal aspirate, urine, blood and others from all patients with fever. Differential diagnosis was performed in terms of foci of infection and non-infection=us causes that might be responsible for fever, other than pneumonia. Demographic data, underlying diseases, risk factors for infection, symptoms of infection, foreign bodies used, diagnoses of infection and treatment administered for all patients monitored during both stages were recorded on patient record forms. Personnel were given no information about VAP levels in the first period, while in the second period, all personnel were informed about VAP levels on a monthly basis. VAP rate and ventilator use levels were calculated using the following formulae: VAP rate=VAP number/ventilator days×1000, and ventilator use rate=ventilator days/patient days (Horan et al., 2008).

Training. Training was provided for ARICU physicians, nurses and ancillary health personnel: 15 nurses, 6 technicians, 9 cleaning staff and 20 doctors. Before the training began, knowledge assessment tests consisting of 56 questions were drawn up for the doctor, nurse and technician group and 40 questions for the ancillary personnel group. These consisted of true/false/do not know and fill in the box-type questions. Tests were scored out of 100. The group scheduled for training received seminars and meetings at which information was provided about the definition, epidemiology, distribution, aetiology, pathogenesis, risk factors, costs and treatment of VAP; protection and control measures; our hospital ICU VAP rates; and comparisons with figures for Turkey and worldwide. Since colonization and aspiration of oropharyngeal and gastric secretions is an important factor in the pathology of VAP, we particularly concentrated on the need for a semi-seated position, monitoring of stomach volume, monitoring of cuff pressure, avoidance of unnecessary antibiotic use and the need for stress ulcer prophylaxis. The EATS/CDC recommendations for the prevention of VAP were adopted as a guide during training (American Thoracic Society & Infectious Diseases Society of America, 2005). A guideline containing health procedures and pneumonia protection and control measures was distributed to the entire group. Mixed five-member groups (doctor, nurse, technician and ancillary personnel) and theoretical and practical training were repeated in the presence of patients attached to MVs. The knowledge assessment test was repeated after training. Training was repeated on an individual basis for individuals scoring less than 80% on the knowledge assessment test. The test was then re-administered.

Our aim in providing training was to develop guideline-appropriate behaviour, attitudes, beliefs and knowledge among personnel. In line with that objective, application of the recommendations was encouraged throughout the training period, regular reminders were issued and feedback concerning our findings was provided to increase personnel compliance. In order to observe the effect of training and assess personnel compliance, a group of VAP precautions to be monitored was determined. Care was taken in determining the subject matter to be monitored in that it should be soundly based on the literature, aiming at preventing orogastric colonization and aspiration, which are important in the pathogenesis of VAP, of direct concern to personnel, easy to apply and sensitive. The group of measures consisted of hand hygiene before and after aspiration, the taking of barrier measures, wearing of gloves, a semi-seated position, aseptic endotracheal procedure appropriate to the technique used, endotracheal cuff pressure monitoring (>20 cm H\(_2\)O) and good oral hygiene (once every shift and whenever necessary). Infection control procedures were observed at least twice a day before and after training in order to determine the effect of training by the infection control team. Unnecessary antibiotic use was evaluated once per day by the infection control team. Aspiration procedures were observed at least twice per day during monitoring, and records were kept.

Statistical analysis. Data recorded on Microsoft Excel were transferred to SPSS software. Normal distribution of data obtained by measurement was analysed using the Kolmogorov–Smirnov test. Normally distributed data were analysed using the Student's t-test, and non-normally distributed data were analysed using Mann–Whitney U test. Data obtained by measurement were expressed as mean±SD, and data obtained by counting were expressed as percentages and were analysed using the chi-square test. Significance was set at P<0.05.

RESULTS

Of the 91 patients treated in the ICU in the first period, 71 were attached to MVs, for a total of 706 ventilator days. MV use rate was 81%. Twenty-two diagnoses of VAP were made in 16 patients, and an incidence of 31.2 per 1000 ventilation days was determined. In the second period, 84 of the 89 patients treated in the ICU were attached to MVs, for a total of 906 ventilator days. MV use rate was 78%. Nineteen diagnoses of VAP were made in 19 patients, and an incidence of 21.0 per 1000 ventilation days was determined. Training reduced the occurrence of VAP by 31.7% (P<0.001). Crude VAP mortality was 69% in the first period and 26% in the second (P<0.001). Characteristics of the patients monitored in both periods and a risk factor analysis are shown in Table 1. Statistically significant risk factors for VAP in both periods were prolonged hospitalization, increased number of MV days and enteral nutrition; risk factors determined in the first period were reintubation, central venous catheter (CVC) use and heart failure and, in the second period, erythrocyte trans-fusion >5 units (P<0.05).

Mean score in the pre-training period was 59.6±6.2, rising to 92.8±2.9 after training. A statistically significant improvement in knowledge assessment test score was determined after training (P<0.001). Prior to training, compliance with hand washing (before and after procedure),
appropriate aseptic endotracheal aspiration and adequate oral hygiene in particular were very low. An improvement was observed after training, albeit not at the desired level (P<0.001). Glove use, cuff pressure and use of a semi-seated posture, levels of which were not low before training, did not increase statistically significantly between the two periods when they were applied after training (P=0.06, P=0.096 and P=0.086, respectively). Pre- and post-training values of parameters monitored to observe personnel compliance with training are shown in Table 2.

**DISCUSSION**

VAP, which may develop as a result of intubation and MV use, is the most common nosocomial infection in the ICU and significantly increases mortality and prolongs hospitalization (Zilberberg & Shorr, 2011). According to National Healthcare Safety Network data, median VAP rates in different ICUs range from 0.7 to 8.3, with values corresponding to the 90th percentile ranging from 4.1 to 16.7 (Horan et al., 2008). A study from France reported an incidence of VAP of 15, and figures of 5.5 in Germany and 35 in Italy have been reported (Bouza et al., 2003; Giard et al., 2008; Meyer et al., 2009). The INICC has reported an incidence of VAP in developing countries of 18.4 per 1000 ventilator days and an incidence of 21.4 in Turkey (Leblebicioglu et al., 2014; Rosenthal et al., 2012) Levels of ventilator use and incidence of VAP in this study were, respectively, four to five times higher than and approximately the same as those in developing countries. The decrease in the incidence of VAP despite ventilator use rates being similar in both periods is significant in revealing the effect of training and the subjects emphasized in that training.

Several studies have investigated VAP development and risk factors. Age, type of mechanical ventilation, underlying diseases, gastric content aspiration, coma Acute Physiology and Chronic Health Evaluation II score, respiratory failure, chronic and immunosuppressive conditions, abdominal–thoracic surgery, frequently used therapeutic methods such as previous antibiotic drug use, endotracheal aspiration,
presence of vascular catheter, nasogastric tube, H2 blocker use, enteral nutrition, tracheotomy, changing ventilator cycles before 48 h, intensive care hospitalization and length of invasive procedures have all been considered as potential risk factors (Agarwal et al., 2006; Albertos et al., 2011; Carrilho et al., 2007; Erbay et al., 2004; Meric et al., 2005). This study involved two periods, pre- and post-training, and risk analyses were performed separately for patients diagnosed with VAP in both periods. Prolonged hospitalization, prolonged MV days and enteral nutrition were identified as risk factors for VAP in both periods; re-intubation, CVC use and heart failure, as risk factors in the first period; and erythrocyte transfusion >5 units as a risk factor in the second period. The decrease in the incidence of VAP, although there was no difference between the two groups in terms of underlying risk factors, reveals the importance of such training.

VAP prevention measures must commence before the intubation procedure and be maintained until extubation. At the same time, these measures must be evidence based, easy to apply and cost-effective. Studies performed in the USA some 30 years ago showed that nosocomial infections can be reduced by 30% with infection control programmes (Haley et al., 1985). Additionally, the optimal approach to prevention of VAP is uncertain (Babcock et al., 2004; Zack et al., 2002). Studies have shown that health worker failure is associated with increased VAP levels and that VAP prevention measures are either not widely or badly applied (Ricart et al., 2003; Thoren et al., 1995). One study performed in France and Canada, applying seven strategies for the prevention of VAP, revealed that compliance with guidelines was low in both countries (Cook et al., 2000). In a similar study from Europe, compliance with recommendations was at the 37% level (Rello et al., 2002). Therefore, training of all health personnel must be a precondition for infection control in all ICUs, and particularly units with limited resources, in order to increase compliance with these recommendations (Babcock et al., 2004). The results of studies investigating the effects of training on VAP prevention are successful and instructive. Results from such studies are summarized in Table 3 (Babcock et al., 2004; Berenholtz et al., 2011; Danchaivijitr et al., 2005; Kellegan et al., 1993; Rosenthal et al., 2006; Salahuddin et al., 2004; Zack et al., 2002). Incidence of VAP in our study was 31.2 per 1000 ventilator days before training and 21.0 after training (P<0.001).

Combinations of different models have been used as training methods in studies investigating the effects of training on levels of infection. The training methods generally used include lectures, video presentations, posters, surveys and practical training sessions (Coopersmith et al., 2004). In our study, training was provided in the form of detailed information with visual presentations (definition of VAP, epidemiology, distribution, pathogenesis, risk factors, costs, treatment, protection and control measures). Levels of knowledge were assessed using tests. Guidelines were given to all personnel. Practical sessions were held at the bedside. Guideline compliance levels were reported to the staff on a regular basis. Good post-training results were achieved from knowledge assessment tests performed to evaluate the quality and effect of training.

Aspiration into the lower respiratory tract of pathogenic bacteria colonizing the respiratory and digestive tracts is the most important factor in the pathogenesis of VAP (Ricart et al., 2003). Therefore, in determining clinical strategies to prevent VAP, there has been considerable emphasis on simple measures (hand washing, appropriate removal of respiratory secretions, glove use, etc.) that can prevent this colonization and aspiration (Albertos et al., 2011; Ricart et al., 2003). Since hand hygiene represents the basis of infection control, studies have emphasized the importance and effects of compliance with hand hygiene (Albertos et al., 2011; Boyce et al., 2002). An educational study showing the effectiveness of specific control procedures (respiratory tract care and application of aseptic procedures) reported that hand-washing levels increased from 5% to 63% and that the incidence of VAP decreased from 113 per 1000 ventilator days to 40 (Berg et al., 1995). One other study applied a 2-year multifaceted education programme for the prevention of VAP and observed compliance with training of the personnel engaged in patient care. The compliance markers

### Table 2. Levels of appropriate personnel procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Pre-training (%)</th>
<th>Post-training (%)</th>
<th>P</th>
<th>OR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand hygiene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-procedure (n=50)</td>
<td>26</td>
<td>74</td>
<td>&lt;0.001</td>
<td>0.20</td>
<td>0.08–0.50</td>
</tr>
<tr>
<td>Glove use (n=50)</td>
<td>30</td>
<td>72</td>
<td>&lt;0.001</td>
<td>0.17</td>
<td>0.06–0.43</td>
</tr>
<tr>
<td>Aspiration technique (n=50)</td>
<td>86</td>
<td>98</td>
<td>0.06</td>
<td>0.13</td>
<td>0.01–1.09</td>
</tr>
<tr>
<td>Semi-seated position (n=100 days)</td>
<td>72</td>
<td>96</td>
<td>0.086</td>
<td>0.11</td>
<td>0.003–0.34</td>
</tr>
<tr>
<td>Cuff pressure (n=100)</td>
<td>84</td>
<td>96</td>
<td>0.096</td>
<td>0.22</td>
<td>0.06–0.73</td>
</tr>
<tr>
<td>Oral care (n=100 days)</td>
<td>14</td>
<td>58</td>
<td>&lt;0.001</td>
<td>0.12</td>
<td>0.06–0.25</td>
</tr>
</tbody>
</table>

OR, odds ratio; CI, confidence interval.
Hand hygiene, glove use, elevation of bed head, endotracheal tube cuff pressure level, oro gastric tube use, gastric volume monitoring, oral hygiene and avoidance of unnecessary tracheal aspiration procedures were monitored, and compliance with recommendations was shown to affect the incidence of VAP (Bouadma et al., 2010).

‘Care bundle’ concepts have recently been developed from the expectation that better and more effective results could be obtained from the use in groups of evidence-based ideas in the prevention of infection. The best-known and most widely used ‘ventilator care bundle’ was developed by the Institute of Healthcare Improvement (Berwick et al., 2006). That bundle consisted of raising the bed head to 30–45 °, daily sedation vacation and assessment for extubation, and prophylaxis for peptic ulcer and deep vein thrombosis. The Institute of Healthcare Improvement also recommended the addition to this bundle of the components personnel training, compliance with hand hygiene, oral care with chlorhexidine, weekly changing of ventilator tubes, aspiration of subglottic secretions and constant cuff pressure monitoring.

One study performed in the USA that observed changes in the incidence of VAP according to compliance with five recommendations, including shortening the period of MV use together with a ventilator care bundle, reported a pre-education level of compliance with procedures of 32 %, rising to 75 % after 18 months and 84 % after 30 months. Pre-intervention incidence of VAP was 5.5, decreasing to 3.4 after 18 months and 2.4 after 30 months (Berenholtz et al., 2011).

On the basis of our observations in the pre-training period in the ICU, we determined personnel compliance with standard infection prevention and measures to prevent aspiration of infected secretions into the respiratory tract as a care bundle. That bundle involved hand washing before and after procedures, indication-appropriate glove use, aseptic endotracheal aspiration, correct bed head position, cuff pressure monitoring and oral hygiene procedures of sufficient quality and number.

Compliance with hand hygiene before patient intervention and aspiration procedures was very low (26 %), and hand hygiene compliance after the same procedures was also low (30 %). Patient care and aspiration procedures are generally performed by nurses and health technicians, and no difference was observed in hand hygiene levels between the two groups. In addition to this low level of hand hygiene, personnel wore the same gloves before every procedure and were able to continue with procedures even after if they had touched contaminated secretions with the same gloves. Appropriate instruction was provided during training, with particular attention paid to hand hygiene indications. Post-training, pre-procedure hand hygiene compliance level was 64 % and post-procedure hand hygiene compliance was 72 %. Pre-procedure hand hygiene compliance increased by 80 % with training, and post-procedure compliance increased by 83 %. While this finding shows the effectiveness of the training, it is insufficient for the purposes of our study, which was intended to prevent hospital infections and VAP. Frequent provision and repetition of training sessions, personnel compliance with hand hygiene and feedback about incidences of infection are highly important.

Neglect or improperly understood procedures were observed in the opening of sterile aspiration probes, aspiration being performed once and for 15 s at most, the probe being washed and the interior of the mouth being aspirated following endotracheal aspiration, and the probe being washed and disposed of following the procedure. The level of correct application of aspiration was 22 % before training, rising to 66 % after training. Training improved application by 85 %. We believe that regular and controlled training needs to be provided in order to increase compliance still further and change previous incorrect practices.

Control of hospital infections is possible only if appropriate infection measures are taken, with infections being monitored using standard techniques and problems being identified. A 31.7 % decrease in the incidence of VAP was observed following training provided on the basis of the problems identified in this study. The successful results from this and education studies show that the training of ICU personnel who will apply infection control measures is very important to the prevention of VAP and other hospital infections. Hand hygiene, the basic component of infection control, must be emphasized in training provided, and standard procedures in patient interventions must be reviewed.

### Table 3. Studies showing the effect of training on VAP rates

<table>
<thead>
<tr>
<th>Place–year</th>
<th>Reference</th>
<th>Pre-training</th>
<th>Post-training</th>
<th>RR (95 CI%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA–1993</td>
<td>Kelleghan et al. (1993)</td>
<td>7 cases/100 patients</td>
<td>3 cases/100 patients</td>
<td>0.43 (NR)</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>USA–2002</td>
<td>Zack et al. (2002)</td>
<td>12.6/1000 ventilator days</td>
<td>5.7/1000 ventilator days</td>
<td>0.45 (NR)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>USA–2004</td>
<td>Babcock et al. (2004)</td>
<td>8.75/1000 ventilator days</td>
<td>4.74/1000 ventilator days</td>
<td>0.54 (NR)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Argentina–2004</td>
<td>Salahuddin et al. (2004)</td>
<td>13.2/1000 ventilator days</td>
<td>6.5/1000 ventilator days</td>
<td>0.52 (0.30–0.91)</td>
<td>P=0.02</td>
</tr>
<tr>
<td>Thailand–2005</td>
<td>Danchaijiritt et al. (2005)</td>
<td>40.5 %</td>
<td>24 %</td>
<td>0.59 (NR)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Argentina–2006</td>
<td>Rosenthal et al. (2006)</td>
<td>51.3/1000 ventilator days</td>
<td>35.5/1000 ventilator days</td>
<td>0.69 (0.49–0.98)</td>
<td>P=0.003</td>
</tr>
<tr>
<td>USA–2011</td>
<td>Berenholtz et al. (2011)</td>
<td>5.5/1000 ventilator days</td>
<td>0/1000 ventilator days</td>
<td>0.51 (0.41–0.64)</td>
<td>P&lt;0.001</td>
</tr>
</tbody>
</table>
In conclusion, guidelines must be adopted in the prevention of hospital-acquired infections, and every country, hospital and ICU must take infection control measures on the basis of its own local problems. Personnel awareness of their duties must be increased, training must be regarded as indispensable for the prevention of infections, and preventable risk factors must be minimized.

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REFERENCES


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