# Bacterial nosocomial infections in mechanically ventilated children

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SUMMARY:. Çıtak A, Karaböcüoğlu M, Üçsel R, Uğur-Baysal S, Uzel N. Bacterial nosocomial infections in mechanically ventilated children. Turk J Pediatr 2000; 42; 39-42.

Of 480 patients admitted to the Pediatric Intensive Care Unit of the Institute of Child Health Children's Hospital in İstanbul, 97 required mechanical ventilation (MV). Sixty of these children were included in a retrospective analysis aiming to determine the frequency of and factors contributing to the development of nosocomial infections (NI). NI rate was 45 percent, ventilator-associated pneumonia (VAP) accounted for the greater part (66.7%) of the NI, followed by urinary tract infections (16.7%), septicemia (13.3%), and meningitis (3.3). Pseudomonas aeruginosa was the most frequent cause of VAP. The duration of the MV and invasive interventions were important risk factors for the development of VAP.

*Key words: nosocomial infections, mechanical ventilation pediatric intensive care unit, ventilator-associated pneumonia.*

Nosocomial infections (NI) are a major health problem due to the excessive morbidity, mortality and need for prolonged hospitalization. A significant portion (25%) of all NI occur in intensive care units[1-4]. Pneumonia ranks second in frequency among hospital-acquired infections, and patients in Pediatric Intensive Care Units (PICU) have a higher incidence of nosocomial pneumonia than other pediatric hospital patients. Peumonia is also the most common fatal nosocomial infection in PICU. Depending on the causative organism and the primary illness, mortality rates ranging from 20 to 70 percent are reported in PICU patients with pneumonia[1,4]. Causative organisms are often antibiotic resistant[1-3].

The severity of the primary condition and exposure to life-saving invasive procedures are closely associated with the development of NI. Other related factors are the length of stay in intensive care and the use of antibiotic therapy that may alter the patient's flora[4-6]. Age is another important factor, with patients in the youngest and oldest age brackets having the highest infection rates[5,7-9].

In this retrospective analysis, we aimed to evaluate the incidence of NI and the risk factors leading to NI in the PICU of a university hospital in İstanbul. Our experience with nosocomial pneumonia in critically ill patients requiring mechanical ventilation will also be presented.

## Material and Methods

This study was conducted by analyzing the files of patients admitted to the PICU of the Institute of Child Health in İstanbul during a one year period from January 1 to December 30, 1996. This Unit functions with a capacity of four beds and admits around 400 patients yearly.

All patients who required mechanical ventilation (MV), with the exception of newborn babies and patients who stayed in the Unit for a period shorter than 48 hours, were included in the analysis. data on age, sex, length of MV, other invasive procedures used (central venous catheters, bladder catheterization), nutrition (parenteral, enteral), and the use of $H_2$-receptor antagonists were collected retrospectively from patient charts. The microbial cultures of infections were also reviewed.

Criteria for dignosis of nosocomial infection were based on clinical (fever higher than 38 °C, systemic symptoms) and laboratory (a peripheral leukocyte count greater than 10,000 per $mm^3$ and presence of microorganisms in cultures) findings. A diagnosis of pneumonia was made when, in addition to clinical and laboratory evidence of infection, auscultatory findings were indicative of pneumonia, and/or when pulmonary infiltrates appeared on the chest radiograph. A nosocomial infection was considered ventilator-associated

when its onset occurred after a minimum period of 48 hours following the initiation of mechanical ventilation[9-11]. In the patients who were in mechanical ventilation due to infectious disease, a nosocomial infection was considered when these conditions appeared: recurrence of fever, requisite changing of mechanical ventilation parameters, increase of a peripheral leukocyte count greater than 10,000 per $mm^3$, alterations in chest radiograph and detection of microorganism in cultures. If there was no evidence of an infection with clinical, radiological and laboratory findings, the microbiological agents detected in the endotracheal aspirate cultures were regarded as colonization[9-11].

The data of patients who developed NI were compared with data from those who did not, using Student's t-test or comparison of proportions.

## Results

During the 12-month period a total of 480 patients were admitted to PICU and 97 patients required MV. Sixty of these 97 patients conformed to the criteria described above and were included in the study; 27 (45%) of these patients developed NI. The pertinent features of the patients are shown in Table I. All patients were directly referred to the Intensive Care Unit upon arrival to hospital. In 80 percent of the patients, an endotracheal tube was in the first 24 hours and mechanical ventilation was initiated. In the remaining 20 percent, endotracheal tubes were administered in the first 48 hours. Patients who developed NI and those who did not were similar in age and sex, but there were statistically significant differences between the two groups with regard to duration of MV and use of central venous catheter, of total parenteral nutrition and of $H_2$-receptor antagonists.

Ventilator-associated pneumonia (VAP) was the most common NI (66.7%) in mechanically ventilated patients. Urinary tract infeactions (16.7%), septicemia (13.3%) and meningitis (3.3%) were the other nosocomial infections (Fig. 1):

Table I. Characteristics of the Study Population

| | NI absent | NI present | p |
|---|---|---|---|
| Number of patients | 33 | 27 | |
| Female/Male ratio | 1.03 | 1.07 | |
| Age (decimal years) | | | |
| Mean | 0.83±1.38 | 1.49±2.20 | p=0.74 |
| Range | 33 days-12 years | 2 months-11 year | |
| Duration of MV (days) | | | |
| Mean | 3.6±1.5 | 15.1±16.7 | p<0.001 |
| Range | 2-8 | 3-90 | |
| Interventions | | | |
| Central venous catheter | 0 | 22% | p=0.0001 |
| Urinary catheter | 96% | 100% | p=0.249 |
| Parenteral nutrition | 6% | 56% | p=0.002 |
| $H_2$ blocker | 57.6% | 89% | p=0.016 |
| Mortality | 27% (9) | 26% (7) | p=0.836 |

NI: nosocomial infections; MV: mechanical ventilation.

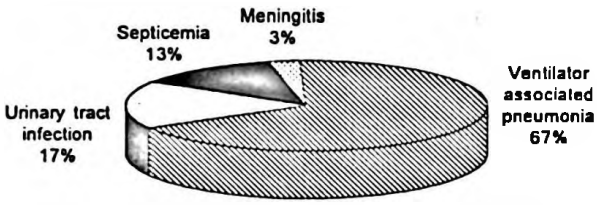


Fig. 1. The distribution of nosocomial infections.

Primary diseases in patients with and without NI are shown in Table II. mortality rate was 26 percent in the NI group and 27 percent in the group free of nosocomial infections ($p > 0.05$).

Table II. Primary Disease in Patients with and without NI

| Disease | NI absent (n) | NI present (n) |
|---|---|---|
| Sepsis | 14 | 11 |
| Bronchopneumonia | 4 | 3 |
| Bronchiolitis | 2 | 2 |
| Congenital heart disease | 2 | – |
| Meningitis | | 1 |
| Bacterial | 2 | – |
| Viral | 1 | – |
| Tuberculosis | 1 | 1 |
| Encephalitis | 3 | 2 |
| Meningococcemia | 2 | – |
| Myocarditis | 1 | – |
| Carbon monoxide poisoning | 1 | – |
| Status epilepticus | – | 4 |
| Guillain-Barré syndrome | – | 1 |
| Hemolytic uremic syndrome | – | 1 |
| Congenital metabolic disorders | – | 2 |
| Total | 33 | 28 |

NI: nosocomial infections.

Pseudomonas aeruginosa was the most frequent cause of nosocomial pneumonia (Table III). Candida albicans was the most frequent cause of the urinary infections. Methicillin-resistant Staphylococcus aureus (MRSA) and Klebsiella pneumoniae were frequent causes of septicemia.

The vast majority of patients presenting to our institution primarily with an infectious disease had already received oral or parenteral antibiotics and their cultures remained sterile.

## Discussion

Sepsis was the most common primary clinical diagnosis in patients admitted to our PICU. The frequency of sepsis as a primary diagnosis was similar in the NI group (42%) and in patients free of NI (40%). This finding may reflect the

Table III. Microorganisms Identified and Culture Source

| Endotracheal tubes n. 25 | Urine n: 5 | Blood n: 4 | Cerebrospinal fluid n: 1 |
|---|---|---|---|
| P. aeruginos (8) | Candida albicans (3) | Methicillin-resistant staphylococcus (2) | Methicillin-resistant staphylococcus (1) |
| Methicillin-sensitive staphylococcus (4) | E. coli (1) | Klebsiella (1) pneumoniae | |
| Methicilin-resistant staphylococcus (3) | Klebsiella pneumoniae (1) | Other Gram-negative organisms (1) | |
| Klebsiella pneumoniae (2) | | | |
| Acinetobacter (1) | | | |
| Enterobacter (1) | | | |
| Klebsiella oxytoca (1) | | | |
| α-hemolytic streptococci (1) | | | |
| Stenotrophomonas maltophilia (1) | | | |
| H. influenza (1) | | | |
| other Gram-negative organisms (2) | | | |

high frequency of infections as a cause for hospitalization in the Turkish pediatric population. Indeed, infections comprise 30 percent of total admission to the University Children's Hospital of İstanbul. On the other hand, bacteria were demonstrated in only 13 percent of our patients with NI. This lower frequency may be due to the low positive culture ratios obtained in our hospital laboratory.

Haley et al.[12] found that the pneumonia frequency in MV patients was 21 times greater than in non-ventilated patients. In our patients we also found pneumonia related to ventilation to be the most frequent NI. Multiple factors play a role in the pathogenesis of ventilation-related pneumonia, but two of these, namely, aspiration of highly colonized oropharyngeal secretions and inhalation of contaminated aerosol, have been to be of special significance[10,13,14]. The severity of the disease, duration of hospitalization in the intensive care unit, age of the patient, antibiotic therapy, endotracheal intubation, tracheostomy, H2 receptor blockers and/or antacids, malnutrition, presence of any lung disease, uremia, gastric colonization, hand disinfection of the patient and of the medical personnel and nasogastric tubing are all major factors causing a high colonization in the oropharynx[13,15,16]. A positive correlation can also be found between the duration of MV and ventilator-related pneumonia frequency[13,15,16,18]. Fagon et al.[18] found that ventilator-related pneumonia risks increased by one percent for each day the patient stayed on the ventilator. In our study, we also showed that nosocomial infections, especially ventilator-associated pneumonia, were significantly related to the duration of MV, with the NI rate increasing with longer duration (Table I). Use of central venous catheters and total parenteral nutrition were additional risk factors.

Gram-negative bacteria, usually of gastrointestinal source, are reported as the main agents causing pneumonia[12-14]. When examined from this aspect, there is a relationship between gastric colonization and oropharyngeal colonization. In our study, the most frequent agent in ventilator-associated pneumonia was the Pseudomonas species and the second most frequent was staphylococcus.

As gastric pH is decreased in patients on H2-receptor antagonists, Gram-negative bacilli can easily be colonized in the gastrointestinal tract. It has been shown that ventilator-related pneumonia probability is twice as high in H2-receptor blocker and/or antacid-using patients[1,10,11]. In our study, the H2-receptor blocker prescription rate was significantly greater in the patients who developed ventilator-associated pneumonia.

Bacterial nosocomial infections, especially nosocomial pneumonia, acquired in the intensive care unit are a major cause of morbidity and mortality[1,17,18]. In our study, the mortality rate in the NI group was not statistically different from that in the NI-free group. It is difficult to interpret this unexpected result which may be related to the small number of patients.

Ventilator-related pneumonia is seen more frequently in winter and autumn months. Viral and mycoplasma infections are thought to play

an important role in this[1,6]. However, there is insufficient data to justify a necessity for routine cultures for these microorganisms.

In conclusion, our data support previous findings and indicate that a high frequency of NI, especially of ventilator-associated pneumonia, is encountered in MV patients, with the duration of MV and use of invasive procedures begin major risk factors in the development of NI. The data also show that Gram-negative bacteria continue to occupy first rank in NI among pediatric patients in a developing country setting.

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## REFERENCES

1. Stein F, Trevino R. Nosocomial infections in the pediatric intensive care unit. Pediatr Clin North Am 1994; 41: 1245-1255.
2. Preston GA, Larson EL, Stamm WE. The effect of private isolation rooms on patient care practices, colonization and infection in an intensive care unit. Am J Med 1981; 70: 641-645.
3. Craven DE, Kunches LM, Kilinsky V, Lichtenberg DA, Make BJ, McCabe WR. Risk factors for pneumonia and fatality in patients receiving continuous mechanical ventilation. Am Rev Respir Dis 1986; 133: 792-796.
4. Özsüt H. Nosocomial Infections in Intensive Care Units. İstanbul: Office Print; 1997: 54.
5. Çakar N, Tütüncü A. The hospitalisation in intensive care unit, invasive procedures and the problem of infections. Klimig Derg 1996; 9: 3-5.
6. Merritt WT, Green M. Nosocomial infections in the pediatric intensive care unit. In. Rogers MC (ed). Textbook of Pediatric Intensive Care. Philadelphia: Williams&Wilkins; 1996: 975-1010.
7. Rouby JJ, Lassale EM, Poete P, et al. Nosocomial bronchopneumonia in the critically ill. Am Rev Respir Dis 1992; 146: 1059-1066.
8. Chastre J, Fagon JY, Trouillet JL. Diagnosis and treatment of nosocomial pneumonia in patients in intensive care units. Clin Inf Dis 1995; 21 (Suppl): 226-237.
9. Celis R, Torres A, Gatell JM, Almella M, Roisin RR, Vidal AA. Nosocomial pneumonia. Chest 1988; 92: 318-324.
10. Torres A, Aznar R, Gatell JM, et al. Incidence, risk, and prognosis factors of nosocomial pneumonia in mechanically ventilated patients. Am Rev Respir Dis 1990; 142: 523-528.
11. Rello J, Torres A, Ricart M, et al. Ventilator-associated pneumonia by Staphyloccus aureus. Am Respir Crit Care Med 1994; 150: 1545-1549.
12. Meta-analysis of randomised controlled trials of Selective Decontamination of the Digestive Tract Trialists Collaborative Group. Br Med J 1993; 28: 525-532.
13. Hammond JM, Potgieter PD, Saunders GL, Forder AA. Double-blind study of selective decontamination of digestive tract in intensive care. Lancet 1992; 340: 5-9.
14. A'Court C, Garrard CS. 1-Nosocomial pneumonia in the intensive care unit: mechanism and significance. Thorax 1992; 47: 465-473.
15. Bonten MJ, Bergmans DC, Ambergen AW, et al. Risk factors for pneumonia, and colonization of respiratory tract and stomach in mechanically ventilated ICU patients. Am Respir Crit Care Med 1996; 154: 1339-1346.
16. Winfield JA, Rosenthal P, Kanter RK, Casella G. Duration of intracranial pressure monitoring does not predict daily risk of infectious complications. Neurosurgery 1993; 33: 424-431.
17. Craven DE, kunches LM, Lichtenberg DA, et al. Nosocomial infections and fatality in medical and surgical intensive care unit patients. Arch Intern Med 1988; 148: 1161-1168.
18. Fagon JY, Chastre J, Hance AJ, et al. Nosocomial pneumonia in ventilated patients: a cohort study evaluating attributable mortality and hospital stay. Am J Med 1993; 94: 281-288.