Eur Respir J 2002; 20: 1483–1489
DOI: 10.1183/09031936.02.00012902
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European Respiratory Journal
ISSN 0903-1936

Nosocomial tracheobronchitis in mechanically ventilated patients: incidence, aetiology and outcome

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Nosocomial tracheobronchitis in mechanically ventilated patients: incidence, aetiology and outcome. S. Nseir, C. Di Pompeo, P. Pronnier, S. Beague, T. Onimus, F. Saulnier, B. Grandbastien, D. Mathieu, M. Delvallez-Roussel, A. Durocher. ©ERS Journals Ltd 2002.

ABSTRACT: The aim of this study was to determine the incidence, the organisms responsible for and the impact on outcome of nosocomial tracheobronchitis (NTB) in the intensive care unit (ICU).

This prospective observational cohort study was conducted in a 30-bed medical/surgical ICU over a period of 6.5 yrs. All patients ventilated for >48 h were eligible. Patients with nosocomial pneumonia (NP) without prior NTB were excluded. Patients with first episodes of NTB were compared with those without NTB by univariate analysis.

The study diagnosed 201 (10.6%) cases of NTB. *Pseudomonas aeruginosa* was the most common bacteria. NP rates were similar in patients with NTB compared with patients without NTB. Even in the absence of subsequent NP, NTB was associated with a significantly higher length of ICU stay and duration of mechanical ventilation in both surgical and medical populations. Mortality rates were similar in NTB patients without subsequent NP compared with patients without NTB. Antimicrobial treatment in NTB patients was associated with a trend to a better outcome.

Nosocomial tracheobronchitis is common in mechanically ventilated intensive care unit patients. In this population, nosocomial tracheobronchitis was associated with longer durations of intensive care unit stay and mechanical ventilation. Further studies are needed to determine the impact of antibiotics on outcomes of patients with nosocomial tracheobronchitis.

Eur Respir J 2002; 20: 1483–1489.

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Keywords: Intensive care unit
mechanical ventilation
nosocomial lower respiratory tract infections
nosocomial pneumonia
nosocomial tracheobronchitis

Received: February 15 2002
Accepted after revision: July 26 2002

Nosocomial lower respiratory tract infections (NLRTI) are the most common nosocomial infections in the intensive care unit (ICU) [1]. Pathogenic mechanisms of NLRTI in ICU patients have been progressively elucidated in the last decade. They are dominated by two processes: colonisation of the oropharynx and its contiguous structures, such as sinuses, dental plaque, trachea and gastric reservoir, and aspiration of the contaminated secretions into the lower airway [2].

Patients who receive mechanical ventilation *via* an orotracheal or nasotracheal tube have a substantially increased risk for developing NLRTI; both orotracheal and nasotracheal tubes bypass natural host defences, permit leakage of bacteria and secretions around the cuff into the trachea, damage the ciliated epithelium of the trachea and reduce bacterial clearance [3]. Endotracheal tube biofilm also plays an important role as a reservoir for infecting microorganisms. Furthermore, fragments of biofilm may be dislodged and carried further into the lung by ventilator gas flow, and bacteria encased in this biofilm are relatively resistant to the action of antimicrobials and host defences [4].

Although incidence, risk factors and outcome of nosocomial pneumonia (NP) have been investigated in several studies, little is known about nosocomial tracheobronchitis (NTB). NLRTI other than pneumonia are the second most frequent nosocomial infections in European ICUs [1]. According to the few available studies [5, 6], the incidence of NTB ranges from 2.7–3.7% in ICU patients.

To the authors' knowledge, the impact of NTB on outcome has never been reported. However, increased morbidity and mortality may be observed in patients with NTB. This nosocomial infection could be associated with higher length of ICU stay, duration of mechanical ventilation and mortality rate, resulting in possible weaning difficulties and subsequent NP in mechanically ventilated ICU patients. Therefore, a prospective observational cohort study was designed to determine the incidence, the causing organisms and the impact on outcome of NTB.

Patients and methods

Study subjects

This study was conducted in a 30-bed university medical/surgical ICU. From March 1993 to September

1999, all patients ventilated for >48 h were included. Immunocompromised patients, trauma patients and those with NP without prior NTB were excluded.

Patients were intubated, either *via* the oral or nasal route according to the clinical status and the habits of the physicians in charge. Patients were kept in semirecumbent position during most of their period of mechanical ventilation except when contraindications were present.

The ventilator circuit was not changed routinely. In all patients a heat-moisture exchanger was positioned between the Y-piece and the patient. The heat-moisture exchangers were changed every 48 h or more frequently if visibly soiled. The oropharyngeal cavity was cleaned four times a day with chlorhexidine solution. There was no routine stress ulcer prophylaxis.

Strategies for prevention of nosocomial infections included adequate hand washing between patient contacts and isolation techniques with protective gowns and gloves in patients with multiresistant bacteria. Antimicrobial therapy for NTB was at the discretion of the physician in charge.

Study design and data collection

NTB were identified by prospective surveillance of nosocomial infections. Data on demographics and patient characteristics were collected by trained infection-control nurses and evaluated weekly and at ICU discharge by the attending physician.

Definitions

For the purpose of this study only first episodes of NTB were taken into account. Subsequent episodes of NTB after ICU discharge were not studied.

Tracheobronchial infections were defined as follows: fever (>38°C) with no other recognisable cause, new or increased sputum production, and a positive tracheal aspirate culture without radiographic evidence of pneumonia. This definition was based on the Centers for Disease Control criteria [7].

To define NP, a second set of criteria developed by the Centers for Disease Control [7] was used, which consist of a chest radiographic examination showing: 1) new or progressive infiltration, condensation, cavitation, or pleural effusion; and 2) any of the following: purulent sputum of new onset or a change in character of sputum, a pathogenic organism isolated from blood culture, a pathogenic organism isolated from a specimen obtained by tracheal aspiration, bronchial brushing or biopsy, isolation of virus or detection of viral antigen in respiratory secretion, a diagnostic single antibody titre immunoglobulin (Ig)M or a four-fold increase in paired serum samples (IgG) for a pathogen.

Patient characteristics

Patient characteristics collected at admission were age, sex, location before ICU admission, history of diabetes mellitus, chronic obstructive pulmonary disease (COPD), antibiotic use in the previous 2 weeks and surgery. Cardiovascular, respiratory, renal, digestive and neurological distress were defined by organ-system failure criteria [8]. Severity of illness was assessed by measurement of the Simplified Acute Physiology Score II [9].

Patient characteristics collected during hospitalisation were length of ICU stay, duration of mechanical ventilation, which was defined as any period of respiratory support with tracheal intubation, number of antibiotics administrated and mortality.

Microbiological studies

Throughout the study, tracheal aspirates for quantitative bacterial cultures were obtained routinely on admission, weekly thereafter and whenever NTB or NP were suspected. In keeping with the results of an earlier study conducted in the centre [10], tracheal aspirate culture were considered positives at 1×10^6 colony forming units·mL^{-1}.

Pleural fluid culture, urinary culture, blood culture and bronchoalveolar lavage were performed during the stay according to clinical status. Specimens were sent to the laboratory immediately after collection, a Gram stain of tracheal aspirate was performed in all cases. Bacterial identification and susceptibility testing were conducted using standard methods.

Statistical methods

Results are given in mean±SD (median (range)) for quantitative values, and n (%) for qualitative values. Differences between patients was considered significant if the p-value was <0.05. Patients with NTB were compared with patients without NTB by univariate analysis, which was performed for all patient characteristics in order to identify those significantly associated with NTB. Surgical patients and medical patients were analysed separately.

Frequencies were compared by means of Chi-squared statistics or Fisher's exact test where appropriate. Continuous variables were compared using the Mann-Whitney U-test. Odds ratios (OR) and 95% confidence intervals (CI) were calculated for all qualitative variables significantly associated with NTB.

The outcomes of surgical and medical NTB patients were compared with those without NTB. Surgical and medical NTB patients treated by antibiotics were compared with those who did not receive antibiotics in order to determine the impact of antimicrobial therapy on outcomes in NTB patients.

Results

Patient characteristics

During the study period, 2,128 patients were ventilated for >48 h, including 283 (13.2%) surgical patients and 1,845 (86.7%) medical patients. Of these,

Table 1. – Main characteristics of surgical and medical patients

	Surgical patients			Medical patients		
	NTB patients	No NTB patients	p-value	NTB patients	No NTB patients	p-value
Patients n	36	198		165	1490	
On admission						
Aged >60 yrs % (n)	58.3 (21)	70.2 (139)	NS	79.3 (131)	68.0 (1014)	0.001
Sex male % (n)	72.2 (26)	64.5 (128)	NS	67.9 (112)	68.7 (1024)	NS
Secondary hospitalisation % (n)	97.2 (35)	99.5 (197)	NS	84.8 (140)	82.6 (1232)	NS
SAPS II mean±SD	38.6±20.6	35.4±16.6	NS	35.8±15.2	37.8±16.4	NS
Diabetes mellitus % (n)	16.7 (6)	13.1 (26)	NS	16.3 (27)	14.0 (209)	NS
COPD % (n)	36.1 (13)	25.2 (50)	NS	71.5 (118)	61.4 (916)	0.007
Organ failure % (n)						
Respiratory	66.7 (24)	60.6 (120)	NS	91.5 (151)	89.3 (1331)	NS
Cardiac	11.1 (4)	20.7 (41)	NS	20.0 (33)	24.4 (365)	NS
Neurologic	2.8 (1)	10.6 (21)	NS	13.9 (23)	16.5 (247)	NS
Digestive	11.1 (4)	11.1 (26)	NS	3.6 (6)	3.0 (46)	NS
Renal	30.5 (11)	25.2 (50)	NS	12.1 (20)	9.8 (147)	NS
ATB[#] % (n)	86.1 (31)	81.3 (161)	NS	56.9 (94)	45.5 (693)	0.007
During hospitalisation						
ATB % (n)	75.0 (27)	37.3 (74)	<0.001	66.6 (110)	51.3 (765)	<0.001
ATB·patient^{-1} mean±SD	1.6±1	0.7±1	<0.001	1.1±0.9	0.9±0.9	0.002
0% (n)	25.0 (9)	62.6 (124)		33.3 (55)	48.7 (725)	
1% (n)	0 (0)	5.6 (11)		20.6 (34)	13.7 (204)	
2% (n)	55.6 (20)	22.2 (44)		41.8 (69)	33.3 (496)	
>2% (n)	19.4 (7)	9.6 (19)		4.2 (7)	4.4 (65)	

NTB: nosocomial tracheobronchitis; SAPS: simplified acute physiology score; COPD: chronic obstructive pulmonary disease; ATB: antibiotic; NS: nonsignificant. [#]: antibiotic use during the 2 weeks preceding intensive care unit admission.

239 (11.2%) were excluded for NP without prior NTB. Of the remaining 1,889 patients, 201 NTB cases (10.6%) were diagnosed; surgical patients were more likely to develop NTB than medical patients (36 of 234 (15.3%) *versus* 165 of 1,655 (9.9%), respectively; p=0.01, OR: 1.64, 95% CI: 1.11–2.42).

Mean times from ICU admission to NTB onset were 15.2±11.3 days (11.5 (3–55) days) in surgical patients and 13.5±10.1 days (10 (3–52) days) in medical patients. Mean times from mechanical ventilation initiation to NTB onset were 11.8±7.2 days (10 (3–28) days) in surgical patients and 13.1±9.3 days (11 (3–49) days) in medical patients. Antimicrobial therapy during hospitalisation was significantly associated with NTB in surgical patients (OR: 5.02, 95% CI: 2.24–11.27; p<0.001) and in medical patients (OR: 1.89, 95% CI: 1.35–2.66; p<0.001).

Significant associations were observed between NTB in medical patients and age >60 yrs (OR: 1.80, 95% CI: 1.22–2.67; p=0.001), COPD (OR: 1.57, 95% CI: 1.10–2.24; p=0.007), and antimicrobial therapy during the 2 weeks preceding ICU admission (OR: 1.52, 95% CI: 1.10–2.10; p=0.007). The main characteristics of patients with NTB and patients without NTB are shown separately for medical and surgical patients in table 1.

Microbiological results

In surgical patients, 44 organisms were isolated in NTB patients; eight of the 36 NTB (22.2%) were polymicrobial. In medical NTB patients, 207 bacteria were isolated; 42 of the 165 NTB (25.4%) were polymicrobial in this population. The most common bacteria in surgical and medical patients were *Pseudomonas aeruginosa* (31.8% and 28%, respectively), *Staphylococcus aureus* (20.4% and 17.8% respectively), and *Acinetobacter baumannii* (13.6% and 26.5%, respectively). Results of microbiological studies are reported in table 2.

Table 2. – Bacteria isolated from 201 episodes of nosocomial tracheobronchitis

	Surgical patients	Medical patients
Patients n	36	165
Gram-negative microorganisms	34 (77.2)	162 (78.7)
Pseudomonas aeruginosa	14 (31.8)	58 (28)
Acinetobacter baumannii	6 (13.6)	55 (26.5)
Klebsiella spp.	4 (9.0)	6 (2.8)
Enterobacter aerogenes	3 (6.8)	4 (1.9)
Serratia spp.	2 (4.5)	11 (5.3)
Stenotrophomonas maltophilia	2 (4.5)	7 (3.3)
Escherichia coli	1 (2.2)	8 (3.8)
Haemophilus influenzae	0	4 (1.9)
Other	2 (4.5)	9 (4.3)
Gram-positive microorganisms	10 (22.7)	45 (21.7)
MRSA	7 (15.9)	31 (14.9)
MSSA	2 (4.5)	6 (2.8)
Streptococcus pneumoniae	1 (2.2)	8 (3.8)

Data are presented as n (%). MRSA: methicillin-resistant *Staphylococcus aureus*; MSSA: methicillin-sensitive *Staphylococcus aureus*.

Outcomes of patients with nosocomial tracheobronchitis

In both surgical and medical patients, NTB was significantly associated with longer duration of mechanical ventilation and increased length of ICU stay. Mortality rate was higher in patients with NTB than in those without NTB (38.7 *versus* 32.1%; p=0.051) but only in medical patients. Three surgical and 15 medical NTB patients developed subsequent NP, representing 8.9% of the 201 overall NTB patients.

After exclusion of NTB patients who developed subsequent NP, the length of ICU stay and duration of mechanical ventilation were still higher in NTB patients than in patients without NTB in both surgical and medical populations, and the mortality rate became slightly higher in medical NTB patients than in those without NTB (36.0 *versus* 32.1%, p=NS). Comparison of NP rates between NTB patients and those without NTB showed no significant difference in both surgical (three of 36 (8.3%) *versus* 49 of 247 (19.8%); NS) and medical (15 of 165 (9.0%) *versus* 190 of 1,680 (11.3%); NS) populations. Outcomes of surgical and medical patients with or without NTB are shown in tables 3 and 4, respectively.

Impact of antibiotics on outcomes of nosocomial tracheobronchitis patients

Subsequent NP rates were similar in NTB patients who received antibiotics compared with those who did not receive antibiotics in surgical patients (three of 27 (11.1%) *versus* none of nine (0%); NS) and in medical patients (11 of 110 (10.0%) *versus* four of 55 (7.2%); NS).

Lengths of ICU stay and mechanical ventilation were slightly shorter (NS) in surgical and medical NTB patients who were treated by antibiotics than in those who did not receive antibiotic medication. In medical NTB patients only, mortality rate was statistically lower (p=0.04) in those who received antibiotics compared with those who did not receive antibiotics. Outcomes of surgical and medical NTB patients who were treated by antibiotics and those who did not receive antibiotics are reported in table 5.

Discussion

Little is known about the incidence of NTB in critically ill patients. In two major prevalence studies conducted in ICUs in Europe and the USA [1, 11], NLRTI other than pneumonia rate ranges 4.0–17.8%. Unfortunately, NTB rate was not specifically reported in these studies. However, two other studies have evaluated NTB incidence [5, 6]. The first was a multicentre study that included 515 patients hospitalised in German ICUs. The second investigated 161 multiple trauma patients in a single ICU. According to these studies, NTB incidence ranges from 2.7–3.7% in ICU patients.

Table 3. – Impact of nosocomial tracheobronchitis (NTB) on outcomes of surgical patients

	NTB patients	NTB patients without NP[#]	No NTB patients	p-value[¶]
Subjects	36	33	198	
ICU LOS days				
Mean±SD	39.2±32	35.3±26.8	18.1±15.1	<0.001/<0.001
Median (range)	31 (10–148)	29 (10–134)	14 (3–106)	
Length of MV days				
Mean±SD	32.2±31.1	27.3±24.5	13.6±12.5	<0.001/<0.001
Median (range)	23 (3–132)	20 (3–132)	10 (3–94)	
Mortality %	55.5	56.2	56.1	NS

NP: nosocomial pneumonia; ICU: intensive care unit; LOS: length of stay; MV: mechanical ventilation; NS: nonsignificant. [#]: patients with NTB excluding those who developed subsequent NP; [¶]: NTB patients compared with no NTB patients/NTB patients without NP compared with no NTB patients.

Table 4. – Impact of nosocomial tracheobronchitis (NTB) on outcomes of medical patients

	NTB patients	NTB patients without NP[#]	No NTB patients	p-value[¶]
Patients n	165	150	1490	
ICU LOS days				
Mean±SD	33.4±20.9	31.7±20.0	12.8±19.1	<0.001/<0.001
Median (range)	28.5 (5–110)	27.0 (5–110)	9.0 (5–373)	
Length of MV days				
Mean±SD	26.0±17.1	24.1±15.4	8.8±7.4	<0.001/<0.001
Median (range)	22.5 (5–93)	21.0 (5–75)	6.0 (3–78)	
Mortality %	38.7	36.0	32.1	NS (0.051)/NS

NP: nosocomial pneumonia; ICU: intensive care unit; LOS: length of stay; MV: mechanical ventilation; NS: nonsignificant. [#]: patients with NTB excluding those who developed subsequent NP; [¶]: NTB patients compared with no NTB patients/NTB patients without NP compared with no NTB patients.

Table 5. – Impact of antibiotics on outcomes of surgical and medical patients with nosocomial tracheobronchitis (NTB)

	Surgical NTB patients			Medical NTB patients		
	ATB	No ATB	p-value	ATB	No ATB	p-value
Subjects n	26	10		110	55	
ICU LOS days						
Mean±SD	36.6±27.6	46.6±43.5	NS	33.2±21.7	33.9±19.4	NS
Median (range)	30.5 (10–148)	31.0 (11–134)		28.0 (5–110)	29.0 (6–95)	
Length of MV days						
Mean±SD	30.6±28.9	37.0±38.4	NS	25.1±17.1	27.9±17.1	NS
Median (range)	23.0 (3–127)	28.0 (11–132)		22.0 (5–79)	23.0 (5–93)	
Mortality %	50.0	70.0	NS	37.6	49.0	0.04

ATB: antibiotic; ICU: intensive care unit; LOS: length of stay; MV: mechanical ventilation; NS: nonsignificant.

The 10.6% rate (201 of 1,889 patients) of NTB found in this study is greater than that previously reported. The higher NTB rate in the current population could be explained by the presence of those patients only ventilated for >48 h, as well as by the large proportion of patients with COPD, representing 58% of the overall study population.

Surgical and medical ICU patients differ in many ways and are likely to have different risk factors for NLRTI and different outcomes [12]. These results are in keeping with earlier data, showing that surgical patients are at greater risk for NTB than medical patients (15.3 *versus* 9.9%; OR: 1.64, 95% CI: 1.11–2.42, p=0.01). Although antimicrobial therapy during the 2 weeks preceding ICU admission is associated with NTB only in medical patients (OR: 1.52, 95% CI: 1.10–2.10; p=0.007), antibiotic administration during hospitalisation is associated with the development of NTB in both surgical (OR: 5.02, 95% CI: 2.24–11.27; p<0.001) and medical patients (OR: 1.89, 95% CI: 1.35–2.66; p<0.001). Previous studies identified antibiotic treatment as a risk factor for NP [13, 14]. By contrast, in other studies antibiotic medication was associated with decreased risk for early-onset pneumonia [15] and with protective effect against ventilator-associated pneumonia (VAP) that disappeared after 2–3 weeks [16].

In medical patients, an age of >60 yrs is significantly associated with NTB (OR: 1.80, 95% CI: 1.22–2.67; p=0.001). This may reflect the impairment of systemic defences in these patients. COPD is a known risk factor for VAP [17] and for respiratory tract colonisation by Gram-negative bacilli. Factors predisposing to colonisation are impairment of mucosal clearance and loss of mucosal integrity [18]. In this study, COPD was significantly associated with NTB in medical patients (OR: 1.57, 95% CI: 1.10–2.24; p=0.007).

The most frequently isolated bacteria were *P. aeruginosa*, *A. baumannii* and methicillin-resistant *S. aureus*. This high rate of antimicrobial-resistant bacteria may be related to the great number of patients transferred from another ward (84.9%) and treated by antibiotics before ICU admission (51.8%), as well as to the long mean time from ICU admission to NTB diagnosis (15±11 days and 13±10 days, in surgical and medical patients, respectively). It is well known that late-onset VAP is frequently due to multidrug-resistant bacteria [19]. In addition, there is firm evidence that prolonged antibiotic treatment is associated with VAP due to multiresistant organisms [20].

Microbiological findings also showed that *P. aeruginosa* was the most common causative organism of NTB (31.8% of surgical patients and 28.0% of medical patients). This result could be explained by the high rate of patients with COPD, the long mean duration of mechanical ventilation in the population and the great number of patients with prior antibiotic medication. These factors have been identified in a multivariate analysis as independent risk factors for VAP due to *P. aeruginosa* [21].

Although colonisation of the lower respiratory tract by bacteria, such as *P. aeruginosa* and *S. aureus*, is correlated with the subsequent development of overt pneumonia [22, 23], the impact of NTB on length of ICU stay, duration of mechanical ventilation, mortality rate and subsequent pneumonia rate has not been reported. The authors found NTB to be significantly associated with longer length of ICU stay and duration of mechanical ventilation in surgical and medical patients. Mortality rate was higher in patients with NTB than in patients without NTB but only in medical patients (38.7 *versus* 32.1%; p=0.051). However, NP rates were similar in patients with NTB compared with those without NTB in both surgical and medical populations.

After exclusion of NTB patients who developed subsequent NP, two observations were made. First, differences in length of ICU stay and duration of mechanical ventilation were still statistically significant and secondly, mortality rate became slightly higher in medical NTB patients compared with those without NTB (36.0 *versus* 32.1%; NS). These findings suggest that the higher mortality rate found in medical NTB patients was probably related to subsequent NP, and that NTB was not associated with increased mortality rate in the absence of NP. Conversely, and even in absence of subsequent NP, NTB is associated with longer durations of ICU stay and mechanical ventilation. One potential explanation to this higher morbidity is that NTB could generate weaning difficulties in mechanically ventilated patients. These weaning difficulties may increase lengths of mechanical ventilation and ICU stay. No data are available in the literature against which to compare these findings.

Antimicrobial treatment did not have a protective effect against subsequent NP in patients with NTB. Whereas lengths of ICU stay and mechanical ventilation were slightly shorter (NS) in surgical and medical NTB patients who were treated by antibiotics than in those who did not receive antibiotic medication, mortality rate was statistically lower ($p=0.04$) in medical NTB patients who received antibiotics compared with those who did not receive antibiotics. These results suggest that antimicrobial treatment for patients with NTB was associated with a trend to a better outcome.

Overuse of antibiotic therapy for patients with pulmonary infiltrates in the ICU has been demonstrated to be associated with higher costs, antimicrobial resistance and superinfections, without decreasing the length of stay or mortality rate [24]. Furthermore, several investigators have found a close association between previous use of antibiotics and the emergence of subsequent antibiotic resistance in both Gram-negative and Gram-positive bacteria [20, 25, 26]. However, in a recent randomised, placebo-controlled trial that was conducted in COPD patients ventilated for community-acquired acute exacerbation without pneumonia, antibiotic treatment was shown to be associated with better outcomes [27]. Further studies are necessary to determine whether antibiotic medication for mechanically ventilated patients with NTB could improve their outcomes.

This study has two major limitations that deserve to be acknowledged. First, the results may not be applicable to other ICU patients because of the large proportion of patients with COPD in the current population. Secondly, the possibility of a type II error in accepting the null hypothesis cannot be excluded because of the small number (36) of surgical NTB patients and the small number (18) of NTB patients who developed subsequent NP. Some trends observed in this study could have reached statistical significance if the study sample size had been larger.

In conclusion, the results of this study indicate that tracheobronchitis is a common nosocomial infection in mechanically ventilated intensive care unit patients. In the present population, nosocomial tracheobronchitis was associated with a significantly increased length of intensive care unit stay and duration of mechanical ventilation in both surgical and medical patients. Further studies are needed to confirm these findings and to evaluate the impact of antibiotic treatment on outcome of patients with nosocomial tracheobronchitis.

References

1. Vincent JL, Bihari DJ, Suter P, *et al.* The prevalence of nosocomial infection in intensive care units in Europe. *JAMA* 1995; 274: 639–644.
2. Torres A, El-Ebiary M, Rano A. Respiratory infectious complications in the intensive care unit. *Clin Chest Med* 1999; 20: 287–301.
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. Adair CG, Gorman SP, Feron BM, *et al.* Implications of endotracheal tube biofilm for ventilator-associated pneumonia. *Intensive Care Med* 1999; 25: 1072–1076.
5. Kampf G, Wischnewski N, Schulgen G, Schumacher M, Daschner F. Prevalence and risk factors for nosocomial lower respiratory tract infections in German hospitals. *J Clin Epidemiol* 1998; 51: 495–502.
6. Rello J, Ausina V, Castella J, Net A, Prats G. Nosocomial respiratory tract infections in multiple trauma patients. *Chest* 1992; 102: 525–529.
7. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections. *Am J Infect Control* 1988; 16: 128–140.
8. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. Prognosis in acute organ-system failure. *Ann Surg* 1985; 202: 685–693.
9. Le Gall JR, Lemeshow S, Saulnier F. A new simplified acute physiology score (SAPS II) based on a European/North American multicenter study. *JAMA* 1993; 270: 2957–2963.
10. Marquette CH, Georges H, Wallet F, *et al.* Diagnosis efficiency of endotracheal aspirates with quantitative bacterial cultures in intubated patients with suspected pneumonia. *Am Rev Respir Dis* 1993; 148: 138–144.
11. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in medical intensive care units in the United States. *Crit Care Med* 1999; 27: 887–892.
12. Cunnion KM, Weber DJ, Broadhead WE, Hanson LC, Piper CF, Rutala WA. Risk factors for nosocomial pneumonia: comparing adult critical-care populations. *Am J Respir Crit Care Med* 1996; 153: 158–162.
13. Kollef MH. Ventilator-associated pneumonia. A multivariate analysis. *JAMA* 1993; 270: 1965–1970.
14. Crouch Brewer S, Wunderink RG, Jones CB, Leeper KV. Ventilator-associated pneumonia due to *Pseudomonas aeruginosa. Chest* 1996; 109: 1019–1029.
15. Rello J, Diaz E, Roque M, Valles J. Risk factors for developing pneumonia within 48 hours of intubation. *Am J Respir Crit Care Med* 1999; 159: 1742–1746.
16. Cook DJ, Walter SD, Cook RJ, *et al.* Incidence of and risk factors for ventilator-associated pneumonia in critically ill patients. *Ann Intern Med* 1998; 129: 433–440.
17. Torres A, Aznar R, Gattel JM, *et al.* Incidence, risk, and prognosis factors of nosocomial pneumonia in mechanically ventilated patients. *Am Rev Respir Dis* 1990; 142: 523–528.
18. Reynolds HY. Bacterial adherence to respiratory tract mucosa. A dynamic interaction leading to colonization. *Semin Respir Infect* 1987; 2: 8–19.
19. Campbell GD, Niederman MS, Broughton WA, *et al.* Hospital-acquired pneumonia in adults: diagnosis, assessment of severity, initial antimicrobial therapy, and preventive strategies: a consensus statement. *Am J Respir Crit Care Med* 1996; 153: 1711–1725.
20. Trouillet JL, Chastre J, Vuagnat A, *et al.* Ventilator-associated pneumonia caused by potentially drug-resistant bacteria. *Am J Respir Crit Care Med* 1998; 157: 531–539.
21. Rello J, Ausina V, Ricart M, *et al.* Risk factors for infection by *Pseudomonas aeruginosa* in patients with ventilator-associated pneumonia. *Intensive Care Med* 1994; 20: 193–198.
22. Sirvent JM, Torres A, Vidaur L, Armengol J, de Batlle J,

Bonet A. Tracheal colonization within 24h of intubation in patients with head trauma: risk factor for developing early-onset ventilator associated pneumonia. *Intensive Care Med* 2000; 26: 1369–1372.
23. 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 J Respir Crit Care Med* 1996; 154: 1339–1346.
24. Singh N, Rogers P, Atwood CW, Wagner MM, Yu VL. Short-course empiric antibiotic therapy for patients with pulmonary infiltrates in the intensive care unit. *Am J Respir Crit Care Med* 2000; 162: 505–511.
25. Edmond MB, Ober JF, Weinbaum DL, *et al.* Vancomycin-resistant *Enterococcus faecium* bacteremia: risk factors for infection. *Clin Infect Dis* 1995; 20: 1126–1133.
26. Husni RN, Goldstein LS, Arroliga AC, *et al.* Risk factors for an outbreak of multi-drug resistant *Acinetobacter* nososcomial pneumonia among intubated patients. *Chest* 1999; 115: 1378–1382.
27. Nouira S, Marghli S, Belghith M, Besbes L, Elatrous S, Abroug F. Once daily oral ofloxacin in chronic obstuctive pulmonary disease exacerbation requiring mechanical ventilation: a randomised placebo-controlled trial. *Lancet* 2001; 358: 2020–2025.