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BRIEF REPORT

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Tracheal colonisation within 24 h of intubation in patients with head trauma: risk factor for developing early-onset ventilator-associated pneumonia

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Abstract *Objective*: To investigate if tracheal colonisation within 24 h of intubation is a risk factor for developing early-onset ventilator-associated pneumonia (EP) in patients with head trauma.
Design: A prospective study in an intensive care unit of a university hospital.
Population: One hundred intubated patients were included with head trauma and Glasgow coma score at admission ≤ 12.
Methods: We took tracheal aspirate samples within 24 h of intubationand performed a protected bronchoalveolar mini-lavage when clinical diagnosis of pneumonia was made.
Measurements and results: On admission time 68 patients (68 %) were colonised in trachea, 22 patients were colonised by *Staphylococcus aureus*, 20 by *Haemophilus influenzae*, six by *Streptococcus pneumoniae* and 20 by gram-negative bacilli. The incidence of EP was 26 %, and the microorganisms involved were *Staph. aureus* (44 %), *H. influenzae* (31 %), *Strep. pneumoniae* (12 %), and gram-negative bacilli (13 %). A multivariate logistic regression analysis showed that the tracheal colonization by *Staph. aureus*, *H. influenzae* or *Strep. pneumoniae* within 24 h of intubation was an independent risk factor for developing EP (odds ratio: 28.9; 95 % confidence interval: 1.59–52.5).
Conclusion: Colonisation of the trachea within 24 h of intubation by *Staphylococcus aureus, Haemophilus influenzae* or *Streptococcus pneumoniae* is a risk factor for developing EP in patients with head trauma.

Key words Tracheal colonisation · Head trauma · Risk factor · Early-onset · Ventilator-associated pneumonia

Introduction

Colonisation of the upper respiratory tract by *Staphylococcus aureus (Staph. aureus)* occurs in 25–30 % of the healthy non-hospital population. Other microorganisms involved in the colonisation of the upper respiratory tract in healthy people are probably related to alcohol intake or a smoking habit as occurs with *Haemophilus influenzae (H. influenzae)* or *Streptococcus pneumoniae (Strep. pneumoniae)* [1].

In severe head trauma patients, the colonised microorganisms which are in the nose or trachea may spread into the lower respiratory tract at the time of injury or during emergent tracheal intubation, and the patients may develop pneumonia a few days later [2, 3].

The aim of this study is to investigate if tracheal colonisation within 24 h of intubation is an independent risk factor for developing early-onset ventilator-associated pneumonia (EP) in patients with head trauma.

Patients and methods

Study population

Patients with head trauma admitted to an intensive care unit (ICU) of a university hospital recently intubated in an emergency room or in an ICU.

Inclusion criteria: Glasgow coma score ≤ 12, expectation of mechanical ventilation > 72 h, and no evidence of pulmonary infection on admission. Exclusion criteria: suspicion of gross aspiration, death in the first 48 h of admission, and severe immunosuppression. No selective digestive decontamination was used. The study was approved by the local Ethical Committee.

Data collection

1. Demographic characteristics, Glasgow coma score [4], and Acute Physiology and Chronic Health Evaluation (APACHE) II score [5] were registered.
2. Risk factors analysed were smoking habit, alcohol intake (classified by CAGE test [6]), urgent surgery, cranial pressure catheter, barbiturates, and corticosteroids. We considered prophylactic antibiotic regimen as protective factor: cefuroxime (two doses of 1500 mg/12 h) against ventilator-associated pneumonia (VAP) as has been described [7] in fifty patients, or cefazoline (four doses of 1000 mg/6 h) in twenty patients as prophylaxis of open fractures.
3. Days of mechanical ventilation, ICU, and hospital length of stay and mortality rate were recorded.

Definitions

Colonisation: the presence of potentially pathogenic microorganisms (PPM) in the tracheal aspirate. PPMs were those recognised as causing respiratory infections: *Staph. aureus*, *Strep. pneumoniae*, *H. influenzae*, Enterobacteriaceae, *Pseudomonas aeruginosa*, and *Acinetobacter* spp. The isolation of *Streptococcus viridans*, coagulase-negative staphylococci, *Neisseria* spp., *Corynebacterium* spp., and *Candida* spp in tracheal aspirate was considered non-colonisation. *Staph. aureus*, *Strep. pneumoniae*, and *H. influenzae* were grouped together (early-pneumonia organisms) and Enterobacteriaceae, *Pseudomonas aeruginosa*, and *Acinetobacter* spp., also (gram-negative organisms).

Pneumonia: pneumonia was clinically suspected upon the presence of new and/or progressive pulmonary infiltrates on chest radiograph and two of the following criteria: fever (≥38.5 °C), leukocytosis (≥ 12.000/mm^3), and purulent tracheobronchial secretions. The diagnosis of pneumonia was established by quantitative cultures of the samples obtained by a protected bronchoalveolar mini-lavage (mini-PBAL) growing $\geq 10^4$ colony-forming units (CFU)/ml. We defined EP when the pneumonia was diagnosed within 5 days post-intubation. We studied just the first episode of EP.

Microbiology

During the first 24 h of intubation, a tracheal sample by suction into sterile containers (Mocstrap, Barcelona, Spain) was made. If the patients developed clinical criteria of pneumonia, a non-bronchoscopic mini-PBAL was performed with a special catheter (Combicath, Plastimed, France), as has been described [8]. The samples obtained were plated on the blood, chocolate, McConkey, and Sabouraud media and identified by standard microbiologic procedures.

Statistical analysis

We analysed statistically the risk factors associated with the development of EP. The continuous variables were analysed by a Mann-Whitney or *t*-test and the discrete variables by the chi-squared or Fisher's Exact Test. The variables significantly associated with EP were included in a multivariate stepwise forward logistic regression model. All *P* values were two-sided, and the level of significance was set at 5 %.

Results

We included prospectively 105 patients during the study period. Five of these patients were subsequently excluded from the study because of gross aspiration or death within the first 48 h.

The clinical characteristics and risk factors associated with the development of EP in the 100 patients studied are shown in Tables 1 and 2. The patients who developed EP had higher APACHE II at the time of admission, $P = 0.04$.

Sixty-eight per cent of the patients were colonised in the trachea within 24 h of intubation: 22 patients were colonised by *Staph. aureus*, 20 patients by *H. influenzae*, six by *Strep. pneumoniae* and 20 by gram-negative bacilli. The frequency of microorganisms isolated in the initial tracheal aspirate is presented in Table 3.

EP was diagnosed and microbiologically confirmed by mini-PBAL in 26 patients with an average of 3 ± 1 days after admission. The aetiology of EP was distributed as follows: *Staph. aureus* 44 %, *H. influenzae* 31 %, *Strep. pneumoniae* 12 %, and gram-negative bacilli 13 %. Seventy-seven percent of patients with EP (20/26) showed positive tracheal aspirate samples on admission, being the same as those microorganisms isolated by mini-PBAL in 19 patients. Sixty-nine per cent of patients with EP (18/26) had a positive tracheal colonisation on admission by *Staph. aureus*, *H. influenzae* or *Strep. pneumoniae* and 8 % of patients with EP (2/26) had a positive tracheal colonisation on admission by gram-negative bacilli, $P = 0.01$.

Table 1 Clinical characteristics and statistical analysis for developing early-onset ventilator-associated pneumonia. *SD* Standard deviation, *NS* not significant

Variable	Total ($n = 100$)		Early pneumonia ($n = 26$)		
	Mean	SD	Mean	SD	*P*
Age, years	37	19	39	21	NS
Glasgow coma score	8	2	7	2	NS
APACHE II score	12	5	14	5	0.04

Table 2 Clinical characteristics and statistical analysis for developing early-onset ventilator-associated pneumonia. *NS* not significant

Variable	Total ($n = 100$)		Early pneumonia ($n = 26$)		
	n	%	*n*	%	*P*
Sex, male	74	74	22	84	NS
Smoking habit	52	52	15	57	NS
Alcohol intake	38	38	12	46	NS
Urgent surgery	33	33	10	38	NS
Cranial pressure catheter	41	41	10	38	NS
Barbiturates	19	19	5	19	NS
Corticosteroids	15	15	5	19	NS
Prophylactic antibiotics	70	70	8	31	< 0.01

Table 3 Frequency of microorganisms isolated in the initial tracheal aspirate. *PPM* Potentially pathogenic microorganism

Pathogen	Initial tracheal aspirate ($n = 100$)	
	n	(%)
Early-pneumonia organisms:	48	48
Staphylococcus aureus	22	22
Haemophilus influenzae	20	20
Streptococcus pneumoniae	6	6
Gram-negative organisms:	20	20
Enterobacteriaceae	16	16
Pseudomonas aeruginosa	2	2
Acinetobacter spp.	2	2
No growth	32	32
Polymicrobial (more than one PPM)	2	–

Table 4 Multivariate logistic regression model to evaluate risk factors for developing early-onset ventilator-associated pneumonia. *CI* confidence interval

Risk factor	Odds ratio	95 % CI
Staphylococcus aureus, *Haemophilus influenzae* or *Streptococcus pneumoniae* in tracheal aspirate[a]	28.9	1.59–52.5
Gram-negative bacilli in tracheal aspirate[a]	1.05	0.04–25.98
Prophylactic antibiotics	0.06	0.003–1.32

[a] In tracheal aspirate samples within 24 h of intubation

The 11 % (8/70) of patients with prophylactic antibiotics developed EP versus 60 % (18/30) of the patients without prophylactic antibiotics, $P < 0.01$.

A multivariate stepwise forward logistic regression model was applied – adjusted for APACHE II score – to the significant variables in the univariate analysis. The unique independent risk factor associated with the development of EP was the presence of *Staphylococcus aureus, Haemophilus influenzae* or *Streptococcus pneumoniae* in the tracheal aspirate samples obtained at the time of admission (odds ratio: 28.9; 95 % confidence interval: 1.59–52.5) (Table 4).

The days of mechanical ventilation (15 ± 8 versus 8 ± 5), the length of ICU stay (19 ± 11 versus 11 ± 7), and the length of hospital stay (35 ± 13 versus 25 ± 14) were significantly longer in patients who developed EP ($P < 0.04$). The overall mortality was 17 % and there were no significant differences between both groups.

Discussion

The most important finding on the present study is that the tracheal colonisation by *Staphylococcus aureus, Haemophilus influenzae* or *Streptococcus pneumoniae* within 24 h of intubation is an independent risk factor for developing EP in patients with head trauma.

Korinek et al [9] studied the influence of selective digestive decontamination in a group of neurosurgical patients. They describe a very similar pattern of tracheal colonisation, considering the trachea as the principal reservoir for bacteria causing VAP. Recently, the description of colonisation patterns in 48 head-injured patients has also been reported [10]. However, they have not demonstrated tracheal colonisation as an independent risk factor for EP, probably due to the small size of the studied sample.

Our study shows an early and important bacterial tracheal colonisation, pointing out the state of the healthy carrier in these cases of acute head trauma. Some authors [11] have also described this possibility, attributing to intubation and early resuscitation manoeuvres the passing of the bacterial inoculate to the trachea overcoming the pulmonary defence mechanisms and causing pneumonia. This seems to be the prior mechanism in previously healthy subjects colonised by early-pneumonia organisms *Staphylococcus aureus, Haemophilus influenzae,* and *Streptococcus pneumoniae* in the early admission days that later will cause pneumonia when arriving in large amounts in the pulmonary parenchyma [1, 3]. Another consideration is the role of early endotracheal biofilm with bacteria resistant to the action of antimicrobial therapy and host defences as has been provided by the study of Adair et al [12]. Our work shows that the administration of prophylactic antibiotics at the time of intubation against VAP or as prophylaxis of open fractures probably will decrease the load of micro-organisms in upper airways and tends toward a protective effect in the development of VAP. These results agree with previous studies [7, 13].

In summary, the initial tracheal colonisation is the most important reservoir and risk factor for developing EP in intubated patients with head trauma. Furthermore, our study describes a very important tracheal col-

onisation within 24 h of intubation and confirms the high incidence of EP in this selected population, the main etiologic agents being *Staphylococcus aureus, Haemophilus influenzae* and *Streptococcus pneumoniae.* Finally, continuous subglottic suctioning, parenteral prophylactic antibiotics, and chlorhexidine oral rinses, which can reduce upper airway bacterial colonisation, are efficacious preventive measures [14] and can reduce the incidence of VAP in intubated patients with head trauma.

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