Risk Factors for Nosocomial Infection in Trauma Patients

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Several factors are implicated in the increased vulnerability of multiple trauma victims to infection, especially in intensive care-units (ICU). This cohort study was designed to report the incidence, the topography, the etiology and to identify the risk factors for infection in trauma patients admitted in an ICU. From January 2000 to December 2001, 416 trauma patients were admitted to the ICU for more than 24 hours, the mean length of stay was 9.3 days (range 2-65) and 188 (45%) patients developed a total of 290 NI. The most prevailing infections were pneumonia (49%), bloodstream (19%) and urinary tract infections (12%). The variables studied were: the demographic data, diagnosis on admission, site and mechanism of injury, type and number of surgeries, use of invasive devices, days under mechanical ventilation (MV) and site and number of NI. These variables were analyzed with a univariable and multivariable regression analysis. The NI was associated with injury in more than 1 anatomic segment (OR=1.6; $CI_{95\%}$1.06-2.40); mechanical ventilation for more than 3 days (OR=12; $CI_{95\%}$ 6.87-24.02); more than 1 surgery (OR=3.13;$CI_{95\%}$1.75-5.65) and more than 2 invasive devices (OR=4.7; $CI_{95\%}$2.99-7.37). Deaths over the first 5 days had high association (RR=3.18) with NI. Three significant variables were identified in the logistic regression, which are: more than 3 days under MV, number of invasive devices and number of surgeries.
Key-Words: Trauma, nosocomial infection, intensive care.

The growing complexity of intensive care during recent decades has been accompanied by increased risk of nosocomial infection (NI) [1-9]. Patients with multiple traumas have increased survival, and several factors increased risk of NI too [10-12]. The interaction between victims of trauma and intensive care unit (ICU) is considered additive for morbidity, mortality, hospital days, and economic burden for both patient and hospital [13-22]. The objective of this study was to identify risk factors for NI in ICU.

Materials and Methods

Hospital do Trabalhador is a trauma referral center in Curitiba (Parana-Brazil).The UCI is a 10-bed unit with single-patient rooms. Retrospective data was analysed (historical cohort study) from January 2000 tO December 2001. All 416 trauma patients who stayed for more than 24 hours at the ICU were included. Demographic data (age and gender), diagnosis on admission, sites and mechanism of injuries (blunt or penetrating injury), type and number of surgeries, use of invasive devices, days under mechanical ventilation, site and number of NI were recorded. Centers for Disease Control and Prevention's (CDC) [23,24] definitions of nosocomial infection (NI) were utilized. The data was analyzed using Mann-Whitney U Test. Categorical data was assessed using Chi-Square and Mantel-Haenszel Test and Comparison of 2 Proportions. Odds Ratio (OR) with 95% confidence interval was employed to measure the magnitude of association between the studied variables and NI. Logistic regression with a backward-stepwise approach was used to determine the independent contribution of each variable to the development of NI. Variables with a p value of less than 0.10 were included in the model. ROC curve was utilized to validate the model. This study was approved by the Ethics Committee of the Hospital das Clínicas of Paraná, Federal University, Curitiba, Brazil.

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Results

A total of 460 trauma patients were admitted during this 24-month period, and 416 patients (352 males; 84.6%) stayed for more than 24 hours. The mean age was 32 (range 15-93) years old. The mean length of stay in the ICU was 9.3 days (range 2-65). Head trauma was the most frequent diagnosis in both groups, followed by intracerebral haemorrhage, femur fracture, abdominal trauma and humerus fracture. The most common mechanism of injury was blunt trauma, sustained by 310 (74.5%) patients. A total of 290 infections were diagnosed in 188 (45.2%) patients, representing an infection rate of 74.6/1,000 patient/days and an overall NI rate of 69.7%. Nosocomial infection was diagnosed at a mean of 5.2 days after the admission in ICU (Figure1). One event of NI occurred in 116 patients (61.7%), 50 (26.6%) had 2 infections and 22 (11.7%) had 3 or more.

A total of 122 patients (29.3%) died, 54 (28.7%) with and 68 (29.3%) without NI (p=0.279). The difference in mortality rate between NI and without NI groups was significant (p=0.00002) after exclusion of deaths after the 5th day (OR=3.18;$IC_{95\%}$1.81-5.56), 46 (76.7%) and 14 (23.3%), respectively. The sites of infection are summarized in Table 1. Pneumonia and bloodstream infection together contributed with 68.3% of documented infections (Figure 2). The Table 2 summarizes the organisms isolated from the 290 infections. The most common pathogens found were coagulase-negative *staphylococci* (21%), *Acinetobacter baumanii* (19.7%) and methicillin-resistant *Staphylococcus aureus* (10.2%).

Univariate analysis (Table 3) of the clinical characteristics of patients with and without NI denoted that numerous factors were associated with the occurrence of infection; many of them were related to severity of injury. Patients with NI had a greater number of injured segments (p=0.024) and used more invasive devices (p < 0.00001). The number of surgeries also represented a significant relation to NI and only neurosurgery showed relation to NI (p=0.021).

After exclusion of collinear variables, 5 significant variables of univariate analysis (p<0.10) were submitted to a multiple logistic regression. The variables identified by multiple logistic regression (Table 4) were more than 3 days of mechanical ventilation (p<0.0001), number of surgeries (p=0.0180) and number of invasive devices (p=0.0001).

A calculated receiver operator characteristic (ROC) curve area of 0.856 ($IC_{95\%}$ 0.80-0.91) confirmed the discriminatory power of the logistic regression mode (Figure 3).

Discussion

The nosocomial infection rate in trauma patients is very high, notably in ICU [1-9,21]. In this study almost one half of patients (45.2%) developed at least 1 infection during their hospitalization in ICU. The NI rate was 69.7%, similar to those observed by Papia et al. [19] (76.7%) and Hurr et al. [18](69.0%).

In the current study neither patients' age nor gender was associated to NI. The infection group had a length of stay 3-fold longer than the non-infected patient group (14.7 *versus* 4.9 days). The average of the length of stay in our sample was 9.3 days, resemble to others [14,15,18,19].

The incidence of mortality was similar between infected and non-infected patients. Only when deaths after the 5th day were excluded, there was a significant difference between the groups, probably because the deaths until the 5th day were associated with the severity of the injury.

Tracheotomy, mechanical ventilation, central venous catheter, pleural drainage and indwelling urinary catheter were the 5 invasive devices studied and 97.4% of the 416 studied patients had utilized at least 1 invasive device. Each one of them was demonstrated as an isolated risk factor for NI, except indwelling urinary catheter. It was also observed a significant association between number of invasive devices and NI [25-27]. The risk of NI was 4.6 times higher (IC=2.99-7.3) in patients with more than 2 invasive devices. Mechanical ventilation (MV), recognized as the main risk factor for nosocomial pneumonia in previous studies [10-12,28], was confirmed as an independent risk factor for NI on the multivariate approach. It was the most prevalent invasive device, since 76.4% of the patients required MV. The number of days under MV was dichotomized in equal or less than three days and more than three days, in order to offer an early applicable model. The fact that more than 3 days under MV is an independent risk for NI may be considered as an alert to the need of further efforts in minimizing the length under MV in trauma patients.

The other 2 identified risk factors were the number of surgeries and the number of invasive devices [5,28,29], which may be related to the direct relationship between the complexity of advanced life support procedures and the degree of trauma injuries.

Despite our efforts in identifying early and easily measurable risk factors for NI in trauma patients, such as the number of anatomic sites of injuries, they could not be demonstrated as an independent risk factor to NI. That fact probably occurred because the number of injured segments was a factor that did not modify with the length of stay and the lost importance with prolonged ICU stay.

Figure 1. Nosocomial infection and length of ICU stay.

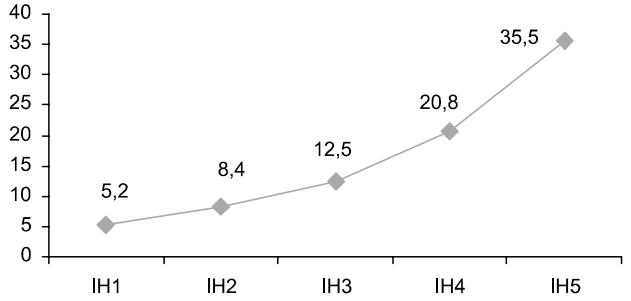
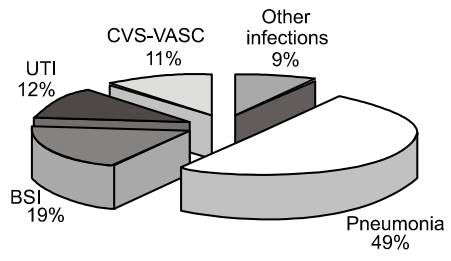


Figure 2. Nosocomial sites of infection.



*BSI=bloodstream infection; UTI=urinary tract infection; CVS-VASC=cardiovascular system infection-vascular. **Other infections=5 (eyes 2; sinusitis 2; skin/soft tissue 1).

Figure 3. ROC curve.

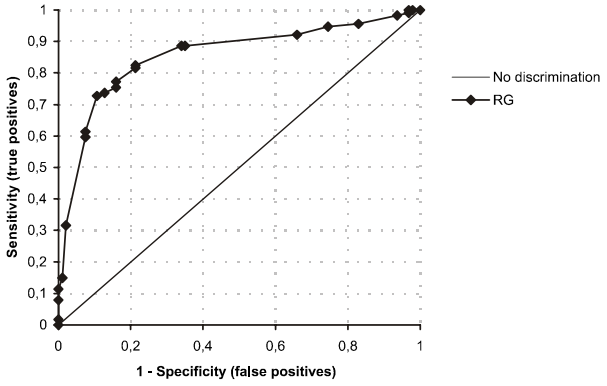


Table 1. More prevalent sites of nosocomial infection and pathogens isolated

Infection sites	N infections (%)	Most common organisms isolated (n)
Pneumonia	143 (49.3)	*Acinetobacter baumanii* (7) *Klebsiella pneumoniae* (3) Methicillin resistant *Staphylococcus aureus* (MRSA) (2) Methicillin sensitive *Staphylococcus aureus* (MSSA) (2) *Staphylococcus coagulase* negative (2) *Others(8)
Primary bloodstream infection	54 (19.0)	*Staphylococcus coagulase* negative (22) *Acinetobacter baumanii* (6) *Klebsiella pneumoniae* (5) *Serratia marcescens* (2) Methicillin resistant *Staphylococcus aureus* (MRSA) (2) Methicillin sensitive *Staphylococcus aureus* (MSSA) (2) *Others (12)
Urinary tract infection	36 (12.4)	*Escherichia coli* (9) *Enterococcus* sp. (9) *Acinetobacter baumanii* (5) *Enterobacter cloacae* (3) *Klebsiella pneumoniae* (3) *Pseudomonas aeruginosa* (2) *Staphylococcus coagulase negative* (2) *Others (3)
Catheter associated infection	32 (11.0)	Methicillin resistant *Staphylococcus aureus* (MRSA) (6) *Staphylococcus coagulase* negative (4) *Acinetobacter baumanii* (3) *Others(3)

Other sites of infection (9.0%) included skin and soft tissue infection (6), sinusitis (2), eye (14), ear (1) urethra infection, (1) peritonitis (1).

Table 2. Organisms isolated from 290 NI in hospitalized trauma patients

Organisms	N	%
Staphylococcus coagulase negative	31	21.8
Acinetobacter baumanii	29	20.4
Methicillin resistant *Staphylococcus aureus* (MRSA)	15	10.5
Enterococcus sp.	13	9.1
Klebsiella pneumoniae	12	8.4
Escherichia coli	11	7.7
Methicillin sensitive *Staphylococcus aureus* (MSSA)	08	5.6
Pseudomonas aeruginosa	05	3.5
Enterobacter cloacae	05	3.5
Serratia marcescens	02	1.4
GNB*	02	1.4
Citrobacter freundii	01	0.7
Enterobacter aglomerans	01	0.7
Enterobacter aerogenes	01	0.7
Enterobacter gergoviae	01	0.7
Klebsiella oxytoca	01	0.7
Serratia rubidae	01	0.7
B hemolytic A group *Streptococcus*	01	0.7
B hemolytic D group *Streptococcus*	01	0.7
Streptococcus viridans	01	0.7
Total	142	100

*GNB=Gram-negative bacillus.

Table 3. Univariate analyses of NI risk factors and NI

Variables	Infected	Non-infected patients (n=188) N (%)	p value[1] patients (n=228) N (%)	Odds Ratio (95% CI)
Age (mean ± SE)	34.7 ± 14.73	5.6 ± 17.0	0.357	
Male	164 (87.2)	188 (82.5)	0.227	
Mean days in ICU (mean ± SE)	14.7 ± 8.5	4.9 ± 3.5	< 0.0001	
Type of injury				
Blunt	145 (77.1)	165 (72.4)	0.319	
Penetrating	43 (22.9)	63 (27.6)		
Site of injury				
Head/Neck	136 (72.3)	142 (62.3)	0.040[2]	
Face	26 (13.8)	25 (11.0)	0.474[2]	
Spinal Cord	13 (6.9)	10 (4.4)	0.371[2]	
Thorax	54 (28.7)	53 (23.2)	0.244[2]	
Abdomen	43 (22.9)	44 (19.3)	0.437[2]	
Pelvis	14 (7.4)	13 (5.7)	0.616[2]	
Arms	33 (17.6)	26 (11.4)	0.097[2]	
Legs	35 (18.6)	54 (23.7)	0.253[2]	
Deaths				
Total	54 (28.7)	68 (29.8)	0.279[2]	
Over 5th day	46 (76.7)	14 (23.3)	0.00002[2]	3.18 (1.81-5.56)
Injured segments (number)				
One	87 (46.3)	132 (57,9)		
More than one	101 (53,7)	96 (42.1)	0.024	1.60 (1.06-2.40)
Invasive devices	188 (100)	217 (95.2)		
Tracheotomy	46 (24.5)	08 (3.7)	< 0.00001[2]	8.46 (3.71-20.05)
Central venous catheter	32 (17.0)	15 (6.9)	0.0026[2]	2.76 (1.39-5.56)
Pleural drainage	69 (36.7)	58 (26.7)	0.0403[2]	1.59 (1.02-2.48)
Mechanical ventilation	180 (95,7)	138 (60,5)		
≤ 3 days	19 (10.6)	83 (60.1)		
> 3 days	161 (89.4)	55 (39.9)	< 0.00001	12.80 (6.87-24.02)
Invasive devices (number)	188 (100)	217 (95.1)		
Until two	77 (41.0)	166 (76.5)		
More than two	111 (59.0)	51 (23.5)	< 0.00001	4.69 (2.99-7.37)
Surgery		0.0002		
Yes	173 (92.0)	178 (78.1)		
No	15 (8.0)	50 (21.9)		
Type of surgery[2]				
Neurosurgery	74 (42.8)	54 (30.4)	0.021[2]	
Ortopedic	69 (39.9)	60 (33.7)	0.274[2]	
General	87 (50.3)	87 (48.9)	0.876[2]	
Surgeries (number)	173 (92.0)	178 (78.1)		
One	120 (69.4)	156 (87.6)		
More than one	53 (30.6)	22 (12.4)	0.00005	3.13 (1.75-5.65)

[1]Chi-square test; [2]Comparison between two proportions.

Conclusion

Trauma patients, who are requested to stay under mechanical ventilation for more than 3 days, should have early intervention for pneumonia prevention [29-31]. Patients submitted to surgical procedures and invasive devices should receive intensified care to have infection minimized or even avoided. In summary, identifying trauma patients who have 1 of these 3 risk factors should warn for strict precocious preventive measures, obtaining consequent decrease in NI incidence.

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Table 4. Predictors factors for nosocomial infection in ICU trauma patients as determined by multivariate analysis

Variable	Coefficient	S.E.	p value	Odds Ratio Value	$IC_{95\%}$
Days of mechanical ventilation					
> 3 days=1	2.41	0.27	< 0.0001	11.23	6.60-19.30
≤ 3 days=0					
Surgery (number)	0.53	0.22	0.0180	1.70	1.10-2.64
Invasive device (number)	0.70	0.17	0.0001	2.013	1.43-2.80
Constant	-3.75	0.47	< 0.0001		
Likelihood Ratio			p < 0.0001		

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