Pneumonia in a Cardiothoracic Intensive Care Unit: Incidence and Risk Factors

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Objective: **The purpose of this study was to determine the incidence, risk factors, and pathogens causing pneumonia in a cardiothoracic intensive care unit (CTICU).**

Design: **A prospective study.**

Setting: **"Civili Hospital," Brescia, Italy.**

Participants: **One hundred forty consecutive patients in the CTICU for more than 24 hours from October 1, 2006, to September 30, 2007.**

Interventions: **None.**

Measurements and Main Results: **Demographic variables and intrinsic and extrinsic risk factors were analyzed with univariate and multivariate analysis. One hundred forty patients were studied, 128 (91.4%) were surgical and 12 (8.5%) were medical. Cumulative incidence of pneumonia was 28.6% (n = 40); 62.5% (n = 25) had ventilator-associated pneumonia (VAP) and 37.5% (n = 15) had non-VAP. The most common isolated pathogens were *Pseudomonas aeruginosa* (n = 15), *Staphylococcus aureus* (n = 5), *Escherichia coli* (n = 4), and *Klebsiella pneumoniae* (n = 3). Mortality was 22.2% (n = 31), with 54.8% (n = 17) of patients with pneumonia leading to mortality during CTICU stay ($p = 0.0006$). On multivariate analysis, independent risk factors for pneumonia were each point of the Sequential Organ Failure Assessment score at CTICU admission ($p = 0.006$, odds ratio [OR] = 1.39, confidence interval [CI] = 1.09-1.76), every day of mechanical ventilation ($p = 0.049$, OR = 1.08, CI = 1.00-1.18), noninvasive mechanical ventilation (NIMV) ($p = 0.014$, OR = 4.83, CI = 1.37-17.03), and bronchoscopy ($p = 0.002$, OR = 8.14, CI = 2.10-31.55).**

Conclusions: **Pneumonia is a common complication in the CTICU, and the authors recommend the following: the removal of the endotracheal tube as soon as possible, the minimal use of a bronchoscope and only in cases of bronchial obstruction, and the use of NIMV.**

KEY WORDS: cardiothoracic intensive care unit, mechanical ventilation, bronchoscopy, Sequential Organ Failure Assessment score, ventilator-associated pneumonia

THE CARDIOTHORACIC INTENSIVE CARE UNIT (CTICU) represents a very specialized setting in the field of intensive care. Many studies have shown that infection is the most frequent noncardiac complication in patients residing in the CTICU for more than 24 hours. Pneumonia increases the mortality of this population by 14%.[1]

Pneumonia is diagnosed in a large percentage of patients requiring mechanical ventilation. Ventilator-associated pneumonia (VAP) is multifactorial, and the factors involved often correlate with each other. First, host defense mechanisms must be compromised. This may be related to advanced age, severity of basic disease, pre-existing pulmonary pathology, immunosuppression, and other concomitant diseases (diabetes, tobacco use, alcoholism, obesity, altered state of consciousness).[2-6]

The microorganisms reach pulmonary tissue by either exogenous or endogenous routes. These can include inhalation of nonsterile gastric contents, aspiration of oropharyngeal secretions colonized by potentially pathogenic microorganisms, hematogenous or lymphatic spread of pathogens, and inhalation of contagious material in aerosol form from the external environment.

The extrinsic factors that most frequently promote the development of pneumonia include increased length of the hospitalization and intensive care unit (ICU) stay, endotracheal intubation,[7] the modality (invasive or not) and duration of mechanical ventilation, reintubation, frequent bronchoscopies,[8] prolonged use of broad-spectrum antibiotics, stress ulcer prophylaxis, dialysis, enteral feeding,[9] and chest or upper abdominal surgery.

Major surgery is a specific risk factor for pneumonia in the CTICU because it reduces local and systemic host defenses. A previous study showed that major surgery reduced neutrophil opsonic capacity in the serum.[10] Cardiac surgery produces major stress on host defenses because of hypothermia, cardiopulmonary bypass (CPB), and relative hypotension.

Thoracic surgery, such as pulmonary surgery, is frequently oncologic; therefore, it often triggers adverse reactions in patients with immunodeficiency, either because of the primary disease or because of frequent treatment with chemotherapeutic drugs in the preoperative period. Multiple researchers[11] also claim that single-lung ventilation, necessary during pulmonary surgery, is frequently the cause of acute lung injury or of acute respiratory distress syndrome, aggravating immunosuppression.

The microorganisms responsible for nosocomial pneumonia are many, and infections are often polymicrobial. Gram-negative bacteria are the most common pathogens. In patients who have undergone cardiac or thoracic surgery, pneumonia is often over- or underdiagnosed because of numerous confounding factors that can simulate or hide it. For example, features of pneumonia, such as fever and leukocytosis, increased bronchial secretions, appearance of new densities in radiographic studies, and gas exchange alteration (such as low PaO_2/F_IO_2 ratio), also may be associated with other etiologies.[12-14] In particular, CPB and one-lung ventilation activate the inflammatory cascade, leading to pulmonary lesions and clinical signs of systemic inflammatory response syndrome.[15-17] In these patients, microbiologic analysis by quantitative tracheal aspirate, bronchoalveolar lavage (BAL), or protected brush specimens becomes fundamental.

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This prospective observational study was designed to determine the incidence of pneumonia in the cardiothoracic ICU, to identify risk factors for pneumonia in order to implement corrective interventions aimed at reducing its incidence, and to identify isolated pathogens and their resistant features.

MATERIALS AND METHODS

This study was conducted in the CTICU of the Civili Hospital, Brescia, Italy, a 2,400-bed, university-affiliated teaching hospital. This CTICU has 6 beds available, including 1 for emergencies. All patients undergoing cardiac and thoracic surgery, and occasionally other medical and surgical patients, are admitted to this CTICU. All the patients included in the study stayed in this CTICU for more than 24 hours between October 1, 2006, and September 30, 2007. Patients discharged from the unit within 24 hours were excluded.

All patients received the same standard of care. The surgical and anesthetic techniques, CPB, and other care received in the CTICU did not differ from standard procedure.

Upon admission to the ICU, all patients received continuous monitoring of the electrocardiogram, invasive arterial blood pressure, central venous pressure with a central venous catheter, hourly diuretic control, body temperature, blood loss through drainage, and blood gas status. All catheters were placed in the operating room using sterile technique so as to eliminate this as a possible venue for infection.

Patients with a regular postoperative course were extubated and transferred to their wards of origin within the first 24 hours. Stress ulcer prophylaxis was routinely administered with esomeprazole (40 mg intravenously). Postoperative analgesia was routinely administered with tramadol intravenously, 100 mg 3 or 4 times per day.

For all the patients studied, the following data were prospectively recorded: age, sex, type of ICU admission (scheduled or urgent), origin (other ICU or hospital ward *v* community), Simplified Acute Physiology Score (SAPS) III, and Sequential Organ Failure Assessment (SOFA) score at ICU admission, worst SOFA score during ICU stay, duration of ICU stay, reason for and diagnosis at ICU admission, outcome (patients transferred or deceased), mode of surgery (elective, urgent, or emergent), class of surgery (clean, clean contaminated, contaminated, or dirty),[18] and pre-existing chronic conditions. Chronic conditions recorded included congestive heart failure and New York Heart Association score, vascular disease, chronic obstructive pulmonary disease (COPD), chronic renal failure, chronic liver failure, malignant neoplasm, diabetes mellitus, alcoholism, immunosuppression, drug addiction, tobacco use, altered state of consciousness, other infections, and obesity. All these data were recorded according to the Centers for Disease Control and Prevention criteria. Other collected data were the following: operating unit, duration of surgery, American Society of Anesthesiologists score, CPB use and duration, hypothermic circulatory arrest, surgical reinterventions, antibiotic prophylaxis or therapy, mechanical ventilation use and duration, reintubation, noninvasive mechanical ventilation (NIMV) use, tracheostomy, continuous venous-venous hemofiltration, bronchoscopy, enteral feeding, hemotransfusion, and antibiotics used during ICU stay.

All data were collected on a flow sheet and then transferred to an electronic database for statistical analysis. The CLINICAL criteria[19] and HELICS criteria[20] were used for the diagnosis of pneumonia (see below).

Pneumonia was attributed to the stay in the cardiothoracic ICU when diagnosed at least 48 hours after cardiothoracic ICU admission. In patients transferring from other wards or other hospitals, pneumonia was attributed to these locations if it was present at the time of admission or if it was diagnosed within the first 48 hours of cardiothoracic ICU stay.

Microbiologic tests were conducted regularly before the extubation of patients intubated for more than 72 hours and at any time at which there was a suspicion of pneumonia. Bronchial samples were withdrawn either by tracheal aspirate or by bronchoalveolar lavage (BAL), at the discretion of the clinician drawing the sample. Qualitative and quantitative microbiologic analyses were performed, and bacterial count was expressed in colony-forming units/mL (cfu/mL). A threshold of more than 10^5 cfu/mL for tracheal aspirate and of more than 10^4 cfu/mL for BAL was used to define a positive result.

Community-acquired pneumonia is defined as pneumonia present at hospital admission or diagnosed within the first 48 hours of hospitalization. Nosocomial pneumonia is pneumonia diagnosed at least 48 hours after the initial hospitalization. Pneumonia was defined, according to CLINICAL criteria, as "probable" if all the following signs appeared: (1) fever higher than 38.3°C, (2) white blood cell count greater than 10,000/mm^3, (3) purulent respiratory secretions, and (4) chest radiography showing a new and persistent lung infiltrate. It was defined as "possible" if at least 3 of the previous signs were present.

VAP is defined as nosocomial pneumonia with onset at least 48 hours after mechanical ventilation, early nosocomial pneumonia as nosocomial pneumonia with onset within 96 hours of hospital admission or of mechanical ventilation, and late nosocomial pneumonia as nosocomial pneumonia with onset at least 96 hours after hospital admission or of mechanical ventilation.

Vascular disease is defined as the occurrence of 1 of the following conditions: occlusive vascular disease, previous bypass surgery or angioplasty (±stent), aortic aneurysm. Chronic obstructive pulmonary disease (COPD) is a history of COPD, COPD diagnosed on the basis of complementary tests, or the use of corticosteroids or bronchodilators. Chronic renal failure is defined as serum creatinine level >2 mg/dL or current need for dialysis, whereas chronic liver failure is defined as serum bilirubin level >2 mg/dL. Diabetes mellitus is a history of diabetes or the use of hypoglycemic agents or insulin.

Alcoholism is defined as illness marked by drinking alcoholic beverages at a level that interferes with physical health; mental health; and social, family, or occupational responsibilities. Immunosuppression is defined as patients undergoing treatment with corticosteroids or immunosuppressants, patients with AIDS, or patients treated recently with chemotherapy or radiotherapy; and obesity is defined as body mass index calculated as the ratio between the weight (in kilograms) and height squared, higher than 30 kg/m^2.

Antibiotic prophylaxis in cardiac surgery was initiated at the beginning of anesthesia induction and ended at the moment of skin suture. Ampicillin/sulbactam was administered in 3-g doses at the induction of anesthesia, the start of CPB, and every 3 hours after the start of CPB, until skin suture. For patients with penicillin allergies, clindamycin (600 mg) was administered at the induction of anesthesia and during CPB. Teicoplanin (12 mg/kg) was administered at the induction of anesthesia in all reinterventions of valve replacement or in cases of emergency. Antibiotic prophylaxis in other types of surgery was managed by the respective wards. For patients who already had antibiotic therapy against a current infection, the therapy was used during surgical intervention until the end of the provided cycle.

For antibiotic therapy, focused treatment was started when patients' clinical conditions required it; in particularly severe cases, empiric antibiotic therapy was initiated, preceded by drawing of respiratory material (quantitative tracheal aspirate or BAL) for quantitative microbiologic examination. On the basis of microbiologic examinations and clinical conditions, antibiotic therapy was re-evaluated and changed after 48 hours, if necessary.

Results are expressed as mean ± standard deviation (SD). Univariate analysis was performed to identify risk factors statistically associated with pneumonia. Dichotomous variables were compared by using a chi-square test or Fisher exact test. Continuous variables that were normally distributed were compared by using a Student *t* test.

Logistic regression analysis was used to model the association of dependent variables with independent variables. The variables for which $p \leq 0.20$ according to univariate analysis were entered into a multivariate model to identify independent risk factors for acquiring pneumonia. Likelihood ratio tests were used to perform an analysis of hierarchical models. Results of the logistic regression analysis are reported as adjusted odd ratios (ORs) with 95% confidence intervals (CI). All statistical tests were 2-tailed, and conventional statistical significance was denoted by $p < 0.05$.

RESULTS

Over a study period of 1 year (from October 2006 to September 2007), 618 patients recovered in the CTICU; out of these, only 140 patients who recovered for more than 24 hours were included in the present study and were prospectively evaluated. Table 1 shows the preoperative and surgical characteristics, including the demographic and descriptive data, of the patients. Of 140 patients, 98 (70%) were male, and the mean age ± standard deviation (SD) was 66.5 ± 12.6 years (range, 23-85 years). ICU admission was scheduled for 92 patients (65.7%) and urgent for 48 patients (34.2%). At the time of ICU admission, 121 patients (86.4%) came from other wards, 9 patients (6.4%) came from other ICU wards, and 4 patients (2.8%) came from other hospitals.

The mean ± SD SAPS III score on admission was 48 ± 14.7, the mean ± SD SOFA score was 5.6 ± 2.2, and the mean ± SD worst SOFA score was 8 ± 3.7. The mean ± SD length of stay in the ICU was 10 ± 14.2 days. Of the 140 patients studied, 128 (91.4%) were surgical; of these, 38 (27.1%) underwent a valve replacement, 42 (30%) coronary artery bypass graft surgery, 9 (6.4%) coronary artery bypass graft surgery with valve replacement, 19 (13.5%) aortic surgery (ascending aortic surgery, aortic arch surgery, or descending thoracic surgery), 8 (5.7%) a pulmonary resection for neoplasm, and 12 (8.5%) a surgery for miscellaneous conditions (chest wall trauma, Maze procedure for chronic atrial fibrillation, or cardiac tamponade). Twelve patients (8.5%) were admitted to the ICU as medical patients for heart failure.

Of 140 patients, the cumulative incidence of pneumonia according to the CLINICAL and HELICS criteria was 28.6% (n = 40). Among cases of pneumonia, 62.5% (n = 25) were VAP, and 37.5% were non-VAP (n = 15). The incidence of VAP in the present population was 52.7 episodes per 1,000 days of mechanical ventilation. Figure 1 shows an algorithm with data on diagnostic criteria, setting characteristics, and the onset of pneumonia.

Five episodes of pneumonia (12.5%) were of polymicrobial origin (Table 2). A total of 35 microorganisms were isolated. The most common pathogens isolated were *Pseudomonas aeruginosa*,[15] *Staphylococcus aureus*,[5] *Escherichia coli*,[4] and *Klebsiella pneumonia*.[3] *P aeruginosa* was the microorganism most frequently isolated in late pneumonia.

Antibiograms of microorganisms are shown in Figures 2-5. In 2 cases (0.5%), *P aeruginosa* was susceptible only to colistin. The majority of staphylococci (80%) were oxacillin-resistant; all methicillin-resistant *S aureus* were susceptible to vancomycin and teicoplanin). *E coli* and *K pneumoniae* were never extended spectrum β-lactamase producers.

Table 1. Baseline and Surgical Characteristics of the Patients

Characteristics	Total Patients, n (%)
Patients observed	140 (100)
Age (y)	66.5 (12.6)
Sex	
Male	98 (70)
Female	42 (30)
ICU admission type	
Scheduled	92 (65.7)
Urgent	48 (34.2)
Provenance	
Community	6 (4.2)
Other hospital	4 (2.8)
Other ward	121 (86.4)
Other ICU	9 (6.4)
Severity score	
SAPS III	
Mean (Ds)	48 (14.7)
Minimum	25
Maximum	93
SOFA at ICU admission	
Mean (Ds)	5.6 (2.2)
Minimum	1
Maximum	12
SOFA worst	
Mean (Ds)	8 (3.7)
Minimum	1
Maximum	18
ICU length of stay	
Mean (Ds)	10 (14.2)
Median	4
Minimum	2
Maximum	83
Diagnosis at ICU admission	
Surgical patients	128 (91.4)
Valve diseases	38 (27.1)
ischemic heart disease	42 (30)
Valve diseases + ischemic heart disease	9 (6.4)
Aortic diseases (aneurysms)	19 (13.5)
Pulmonary neoplasm	8 (5.7)
Miscellaneous surgeries	12 (8.5)
Medical patients	12 (8.5)
Congestive heart failure	12 (8.5)
Total	140 (100)
Died	31 (22.1)

NOTE. Data are shown as mean ± SD or number of patients.

Overall, 109 patients (77.8%) survived and were transferred to another department. Among the 31 deceased patients (22.2%), 17 patients had developed pneumonia during the ICU stay ($p = 0.0006$).

In univariate analysis, the following variables were not significantly associated with pneumonia ($p > 0.05$): age, sex, ICU admission type (ordinary or urgent), origin (community, other department, other ICU, or other hospital), diagnosis at the ICU admission, New York Heart Association score, concomitant vascular disease, chronic renal failure, chronic liver failure, diabetes mellitus, immunosuppression, other infections, altered state of consciousness, obesity, tobacco and narcotic drug use, alcoholism, hemotransfusion, American Society of Anesthesiologists score, prophylactic or perioperative antibiotic use, type

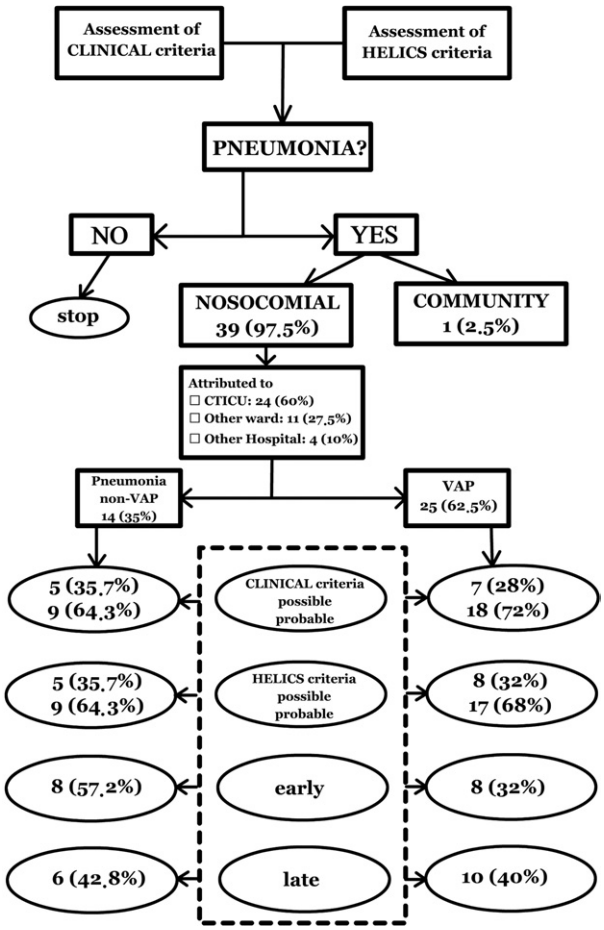


Fig 1. Diagnosis criteria, setting attribution, and onset of pneumonia.

of surgery (elective, urgent, emergent), duration of surgical intervention, CPB use and duration, hypothermic circulatory arrest, and surgical reinterventions.

The following variables were statistically related to the risk of developing pneumonia (Table 3): average and point-to-point SAPS III and SOFA scores (average SAPS III score $p = 0.003$ and each point $p = 0.004$; average SOFA score at ICU admission $p = 0.0002$ and each point $p = 0.001$; worst average SOFA score during ICU stay $p < 0.0001$ and each point $p < 0.0001$), mean duration of ICU stay ($p < 0.0001$) and each day of ICU stay ($p < 0.0001$), pre-existing COPD ($p = 0.03$) and malignant neoplasm ($p = 0.004$), mean duration of mechanical ventilation ($p = 0.002$) and each day of mechanical ventilation ($p < 0.0001$), reintubation ($p = 0.001$), noninvasive mechanical ventilation ($p = 0.007$), tracheostomy ($p < 0.0001$), continuous venous-venous hemofiltration ($p < 0.0001$), bronchoscopy ($p < 0.0001$), enteral feeding ($p < 0.0001$), unclean surgery class ($p = 0.05$), and "ward 3" unit of origin ($p = 0.04$).

Multivariate analysis identified the following significant independent risk factors for pneumonia (Table 4): every point of SOFA score at the time of ICU admission ($p = 0.006$, OR = 1.39, CI = 1.09-1.76), each day of mechanical ventilation ($p = 0.049$, OR = 1.08, CI = 1.00-1.18), noninvasive mechanical ventilation ($p = 0.014$, OR = 4.83, CI = 1.37-17.03), and bronchoscopy ($p = 0.002$, OR = 8.14, CI = 2.10-31.55).

DISCUSSION

The authors have studied the incidence, microbiology, and risk factors associated with pneumonia in a relatively homogenous group of patients in the CTICU. Pneumonia is the most frequently ICU-acquired infection. According to the National Nosocomial Infections Surveillance, it represents 25% of infections in critical care settings; the incidence is estimated to be between 5 and 10 cases every 1,000 admissions and increases 6- to 20-fold in patients on mechanical ventilation.[2] Unlike other organ infections, pneumonia increases the length of both ventilation and ICU stay. Pneumonia is associated with high mortality, ranging from 20% to 50%, but reaching 70% when caused by multiresistant pathogens.[2]

In this study, the cumulative incidence of pneumonia was high (28.6%), partly because of special characteristics of the observed patients. Most patients studied (91.4%) underwent cardiac and thoracic surgery, whereas only 8.5% were medical patients.

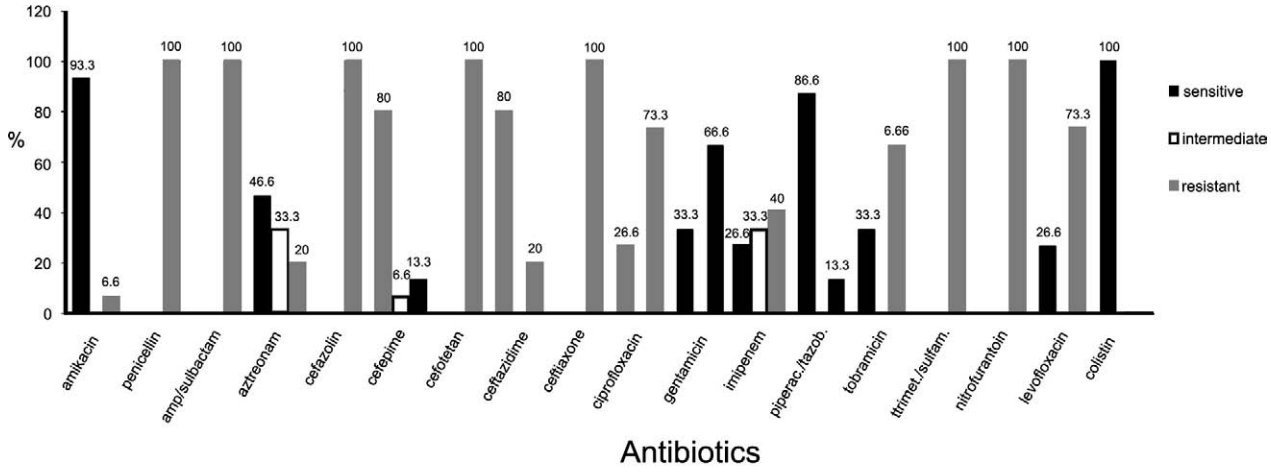
In a study on homogenous subsets of patients, Kollef[21] showed a higher incidence of pneumonia in the CTICU (21.6%) than in other surgical and medical ICUs (14% and 9.3%, respectively). Different populations in various ICUs have specific characteristics predisposing them to certain infections. In the CTICU, cardiac or thoracic surgery alone increases the risk of developing pneumonia. In the current study, all patients coming from thoracic surgery were neoplastic patients who had undergone pulmonary resection. This surgical intervention, of the unclean class, contributed significantly to the elevated incidence of pneumonia. The limited sample of medical patients (8.5%) probably explains the absence of meaningful differences in the incidence of pneumonia between surgical and medical patients.

In the authors' experience of patients who have undergone cardiac surgery with CPB, the criteria used for the diagnosis of pneumonia have not been completely satisfactory because the most common signs of pneumonia (fever and leukocytosis, increased bronchial secretions, appearance of new densities in radiographic imaging, and gas exchange alteration, such as low PaO_2/F_IO_2) also can be caused by pathologic processes other than pneumonia. For instance, systemic inflammatory response

Table 2. Microorganisms Isolated in Patients With Pneumonia

Microorganisms	Microorganisms Isolated, n (%) (Total, n = 35)
P aeruginosa	15 (42.8)
E coli	4 (11.4)
K pneumonia	3 (8.5)
Haemophilus influenzae	3 (8.5)
Moraxella catarrhalis	2 (5.7)
Stenotrophomonas maltophilia	1 (2.8)
Citrobacter	1 (2.8)
Difteroides	1 (2.8)
MSSA	4 (11.4)
MRSA	1 (2.8)

Abbreviations: MSSA, methicillin sensible *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*.



Abbreviation: amp/sulbactam: ampicillin + sulbactam; piperaci./tazob.: piperacllin+tazobactam; trimet/ sulfam: trimetoprim +sulfametoxazol

Fig 2. ***P aeruginosa*** **antibiogram.**

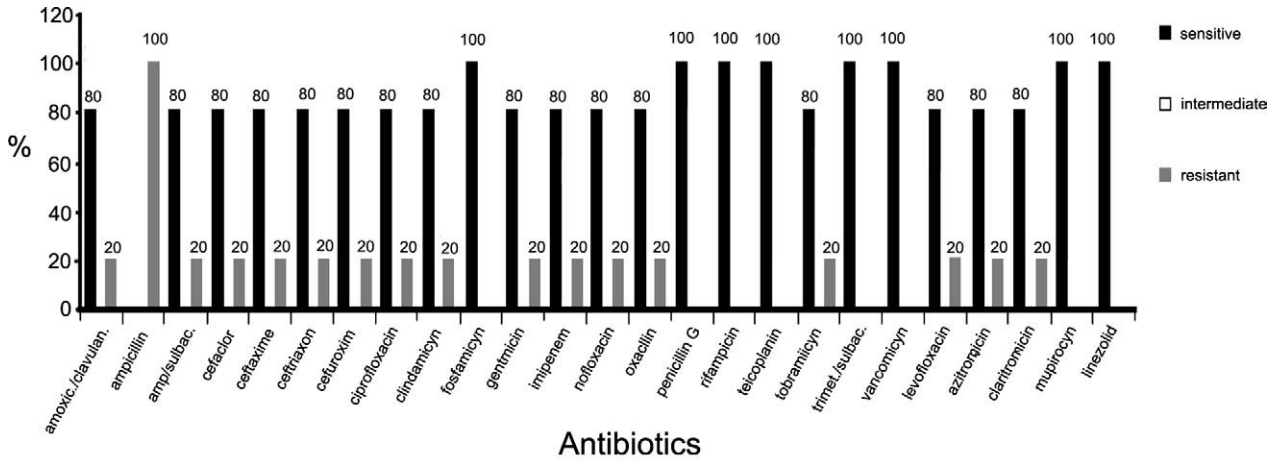
syndrome supported by CPB and heart failure can lead to inflammation and stasis of the lung.

Patients who developed pneumonia had a significantly longer median stay in the ICU than patients without the infection (22.6 and 4.9 days, respectively, $p < 0.0001$). Every day of stay in the ICU has been shown to correlate with an increased risk of developing pneumonia.

The raw mortality of patients with pneumonia also was higher than the mortality of patients without pneumonia (42.5% and 14%, respectively; $p = 0.0006$). However, it is difficult to estimate the independent contribution of pneumonia to mortality and to extension of the median stay in the ICU. For instance, VAP may be only 1 aspect of a much broader medical condition, such as serious cardiac and circulation failure. However, VAP also may be the primary event causing dysfunction of other organs and thus more directly responsible for the course of illness and/or for mortality. In the literature, the nature of this relationship is still unclear.[21] However, in a case-control study, Fagon et al[22] found an association between mortality and multiresistant gram-negative VAP.

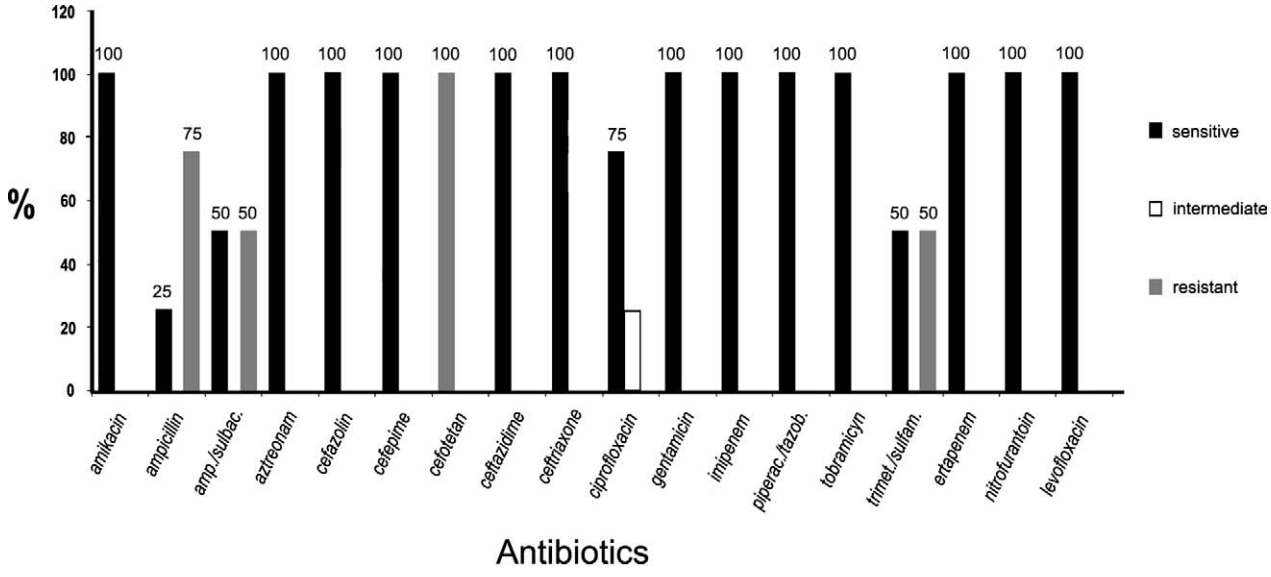
The current study isolated 35 microorganisms from patients with pneumonia. The most frequent were *P aeruginosa*, *S aureus*, *E coli*, and *K pneumonia*. The microorganisms were equally distributed in early pneumonia (57.5%) and in late pneumonia (40%).

Multiresistant microorganisms were isolated in only 3 late pneumonia cases: 2 cases of *P aeruginosa* were sensitive only to colistin, and 1 case of methicillin-resistant *S aureus* was sensitive to both glycopeptides. The low frequency of multiresistant isolates shows that the current approach to antibiotic use is correct and effective for the specific characteristics of patients in this ICU. This conclusion is the result of an extended-length study on the rational use of antibiotics by the sanitary team of this unit in collaboration with infectious diseases



Abbreviation: amoxic./clavulan.: amoxicillin + clavulanic acid; amp./sulbac.: ampicillin + sulbactum; trimet./ sulfam.: trimetoprim +sulfametoxazol

Fig 3. ***S aureus*** **antibiogram.**



Abbreviation: amp./sulbac.: ampicillin + sulbactum; trimet./ sulfam.: trimetoprim +sulfametoxazol

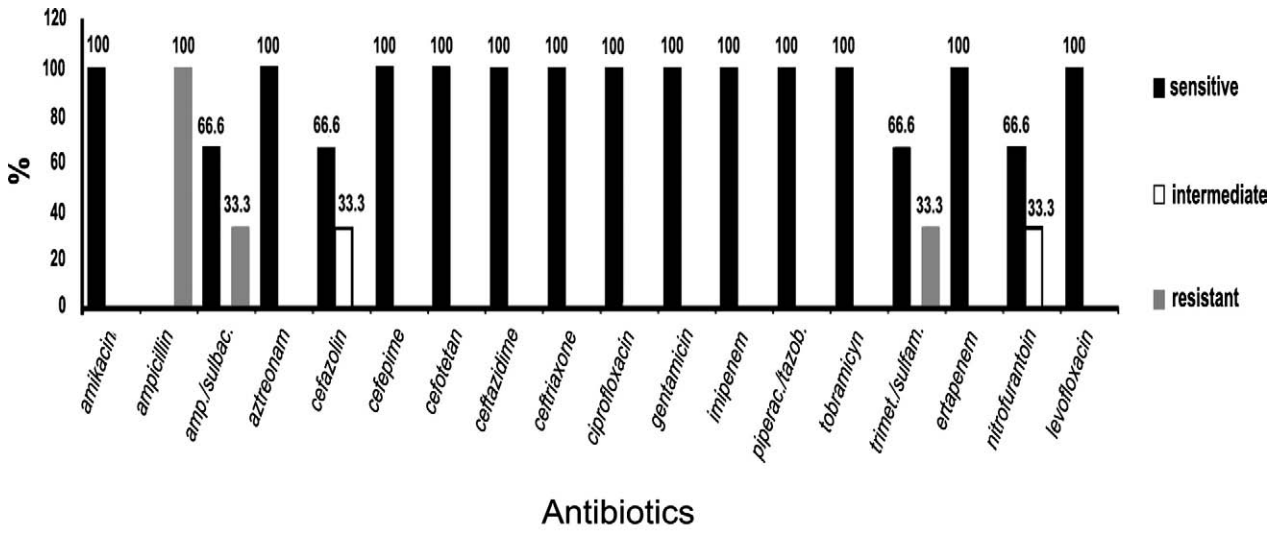
Fig 4. ***E coli*** **antibiogram.**

specialists. The univariate analysis attributed considerable significance to COPD ($p = 0.03$, OR = 2.36, CI = 1.07-5.20) and tracheostomy ($p < 0.0001$, OR = 35.28, CI = 11.63-107).

COPD is a common comorbidity of advanced age. Elderly patients often have colonization of the inferior airways because of reduced mucociliary function, less effective cough reflex, and decreased pulmonary defenses, further aggravated by the use of corticosteroids in the treatment of COPD.[23]

Tracheostomy also contributes to the development of VAP, especially in the first week. This procedure is typically performed in 7.7% to 10.7% of critical patients who receive invasive mechanical ventilation.[24] As opposed to the data reported in the literature, the authors performed tracheostomies in 22% of the patients who underwent mechanical ventilation because the authors prefer to use "early tracheostomy" within 3 weeks. In fact, the authors believe that performing tracheostomy would facilitate weaning from MV and early oral nutrition and would improve overall patient comfort. The decreased physiologic immunocompetence of these patients favors colonization of the airways and, subsequently, the development of pneumonia.

This evidence suggests that tracheostomy procedures should follow a focused prevention protocol, including periprocedural,



Abbreviation: amp./sulbac.: ampicillin + sulbactum; trimet./ sulfam.: trimetoprim +sulfametoxazol

Fig 5. ***K pneumoniae*** **antibiogram.**

Table 3. Significant Variables Associated With Developing Pneumonia on Univariate Analysis

Variable	Pneumonia, n = 40 (28.6%)	Nonpneumonia, n = 100 (71.4)	*p* Value	Odds Ratio	CI (95%)
Severity score					
SAPS III					
1-point increments			0.004	1.03	1.01-1.06
Mean (SD)	53.8 (14.7)	45.7 (14.3)	0.003		
Minimum	32	25			
Maximum	85	93			
SOFA at ICU admission					
1-point increments			0.001	1.39	1.15-1.67
Mean (SD)	6.7 (2.4)	5.2 (2.0)	0.0002		
Minimum	2	1			
Maximum	2	12			
SOFA worst					
1-point increments			<0.0001	1.81	1.49-2.20
Mean (SD)	11.9 (3)	6.4 (2.6)	<0.0001		
Minimum	5	1			
Maximum	18	17			
ICU length of stay					
1-day Increments			<0.0001		
Mean (SD)	22.6 (20)	4.9 (6)	<0.0001	1.19	1.11-1.28
Median	16.5	3			
Minimum	2	2			
Maximum	83	48			
COPD	16 (40)	22 (22)	0.03	2.36	1.07-5.20
Neoplasm	11 (27.5)	8 (8)	0.004	4.36	1.60-11.87
Class of surgery					
Clean	28 (75.6)	86 (95.4)			
Clean-Contaminated	7 (18.9)	1 (1.1)	0.05	5.40	0.98-29.66
Contaminated	0 (0.0)	2 (2.2)			
Dirty	2 (5.4)	2 (2.2)			
Provenance ward					
Ward 1	15 (40.5)	59 (64.8)			
Ward 2	15 (40.5)	28 (30.7)			
Ward 3	7 (18.9)	3 (3.3)	0.04	7	1.06-45.90
Ward 4	0 (0.0)	1 (1.1)			
Mechanical ventilation length					
1-day increments			<0.0001	1.22	1.12-1.32
Mean (SD)	6.6 (12.6)	2.8 (4.9)	0.002		
Reintubation	11 (27.5)	6 (6)	0.001	5.94	2.02-17.46
NIMV	11 (27.5)	9 (9)	0.007	3.83	1.44-10.16
Tracheostomy	26 (65)	5 (5)	<0.0001	35.28	11.63-107
CVVH	14 (35)	8 (8)	<0.0001	6.19	2.34-16.36
Broncoscopy	29 (72.5)	10 (10)	<0.0001	23.72	9.14-61.54
Enteral feeding	34 (85)	41 (41)	<0.0001	8.15	3.13-21.19

NOTE. Data are shown as mean ± SD or number of patients; *p* value indicates comparison between pneumonias and nonpneumonias.
Abbreviation: CVVH, continuous venous-venous hemofiltration.

short-term antibiotic prophylaxis, selective decontamination of the digestive tract, and continuous removal of subglottal secretions. This strategy has not been implemented yet in this ICU. Unfortunately, protocol indications in the current literature do not always agree on these topics.[23,25]

Based on multivariate analysis of logistic regression, the following 4 factors were considered independently significant: the SOFA at ICU admission, mechanical ventilation, the NIMV, and bronchoscopy. The SOFA is derived from the sum of the lowest scores of function in 6 systems: the central nervous, cardiovascular, respiratory, renal, hepatic, and coagulation systems. It is recorded in the first 24 hours of ICU stay and quantifies the severity of illness in patients admitted to the ICU.[26] Because it was concluded in this study that the SOFA score is an independent risk factor for pneumonia ($p = 0.006$, OR = 1.39, CI = 1.09-1.76), this score could lessen the value of the other three variables. Further research should analyze the contribution of every form of organ dysfunction to the development of pneumonia.

Noninvasive ventilation ($p = 0.014$, OR = 4.83, CI = 1.37-17.03) is considered protective in the current literature.[27,28] However, the present study suggested that this factor is actually significant in the development of pneumonia. This may be explained by noting that, for the present patients, NIMV did not represent an alternative to mechanical ventilation; surgical patients (a large percentage of the study popula-

Table 4. Significant Variables Associated With Developing Pneumonia on Multivariate Analysis

Variable	*p* Value	Odds Ratio	CI (95%)
SOFA score at ICU admission, 1-point increments	0.006	1.39	1.09-1.76
Mechanical ventilation, 1-day increments	0.049	1.08	1.00-1.18
NIMV	0.014	4.83	1.37-17.03
Broncoscopy	0.002	8.14	2.10-31.55

tion) had already undergone invasive ventilation and required critical care for severe conditions, such as cardiovascular and respiratory failure. In cases of mechanical ventilation, the present results indicate that each additional day of ventilation is correlated with increased risk of pneumonia ($p = 0.049$, OR = 1.08, CI = 1.00-1.18).

According to American Thoracic Society guidelines, intubation and mechanical ventilation increase the risk of VAP by a factor between 6 and 21 and should be avoided whenever possible. Specific strategies, such as improved methods of sedation and the use of protocols to facilitate and accelerate the weaning process, have been recommended to reduce the duration of mechanical ventilation.[29,30] These interventions rely on adequate ICU staffing. Reintubation also should be avoided, if possible, because it increases the risk of VAP.[29]

Bronchoscopy ($p = 0.002$, OR = 8.14, CI = 2.10-31.55) is used frequently for diagnostic (BAL or protected brush specimen) and therapeutic (respiratory toilet, bronchial cleaning, pulmonary atelectasis) purposes.[31] To the authors' knowledge, there are little data on the infectious complications of bronchoscopy. In a prospective study of 100 fiberoptic bronchoscopies, Pereira et al[32] found parenchymal infiltrates in 6% of patients, but only 1 patient died because of rapidly progressive pneumonia. In the CTICU setting, the common indications for which bronchoscopy is performed may also put these patients at an increased risk of VAP independent of bronchoscopy.

The relationship between bronchoscopy and VAP is worth further investigation. If a causal relationship is confirmed, the risks and benefits of bronchoscopy may need to be re-evaluated because diagnostic bronchoscopies (by BAL) can be replaced adequately by quantitative tracheal aspirate.

In conclusion, the authors have shown a high frequency of pneumonia among patients in the CTICU, and the occurrence rates are comparable to those found among other groups of critically ill patients. Exposing patients with pre-existing clinical illness to invasive devices, such as those used in mechanical ventilation (including NIMV), increased the risk of developing pneumonia. The low recorded incidence of multiresistant microorganisms suggests that knowledge of the local ecology and consideration of patient medical histories have led to rational antimicrobial use for pneumonia in the authors' care setting.

Therefore, the authors recommend the following: (1) removal of the oral tracheal tube as soon as possible, (2) minimal use of bronchoscope and used only in cases of bronchial obstruction, (3) use of weighted NIMV, and (4) submission of short-term antibiotic prophylaxis.

Further studies on more extensive series of patients would be necessary to confirm the present findings, and the authors hope that these data will serve as a useful tool to help reduce pneumonia rates, to improve patient outcomes, and to decrease costs associated with extended ICU stay.

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