World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Bacterial ecology related to healthcare in a Moroccan intensive care unit: A prospective analysis of 53 cases

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World Journal of Advanced Research and Reviews, 2023, 20(03), 805–812

Publication history: Received on 04 November 2023; revised on 12 December 2023; accepted on 15 December 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.3.2543

Abstract

Introduction: This study aims to determine the incidence of healthcare-related infections in our structure, identify the different types of healthcare-related infections in order of frequency, and understand the bacterial ecology.

Materials and methods: We conducted a prospective observational, descriptive study, which included all patients over 16 years of age who were hospitalized in the Intensive Care Unit (ICU) A4 of the Hassan II University Hospital of Fez. The study was performed over a period of 12 months, from May 2021 to May 2022. Patients hospitalized in the ward during this period were all monitored throughout their stay. The study included those who developed a healthcare-related infection, regardless of the site of the infection. We excluded all patients who did not present with a healthcare-related infection and those who were discharged from intensive care or died within the first 48 hours.

Results: Seven hundred and sixty-four patients were admitted to ICU A4 during the study period from May 2021 to May 2022. Out of these, 53 patients developed healthcare-related infections, resulting in an incidence rate of 6.9%. The average age of our patients was 47.42 years, with a significant male predominance. A total of 120 healthcare-related infections were documented during this study period. Bacteremia accounted for the highest percentage at 64.2%, followed by infections related to catheters and pneumopathies acquired under mechanical ventilation, both at 60.4%. Additionally, surgical site infections comprised 22.6%, while urinary tract infections accounted for 18.9%. The average time of infection onset associated with care, compared to hospitalization, was 5.85 days. The evolution was favorable in 13 (24.5%) cases, and unfortunately, there was a significant mortality rate of 40 (75.5%) patients. The isolated germs were mainly *Acinetobacter baumannii*, with a rate of 88 (61.11%) cases, followed by *enterobacteria*, which made up 44 (30.55%) cases. In third place comes *Pseudomonas aeruginosa* with a rate of 13 (9.02%), followed by *enterococci* with a rate of 10 (6.94%), and *Staphylococcus* with a rate of eight (5.55%). four (2.77%).

Conclusion: Healthcare-related infections are frequent in ICUs and can be serious. The severity of these infections is due to both the infection itself and the compromised immune defense mechanisms of the patient, which reflect their overall health condition. Moreover, prevention is still the best weapon.

Keywords: Healthcare-related infection; Bacteremia; Catheter-related infection; Care-related pneumonia

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1. Introduction

An infection is considered to be associated with care if it occurs during or following a patient's treatment (diagnostic, therapeutic, palliative, preventive, or educational) and if it is not present or in the incubation stage at the beginning of management [1].

Nosocomial infections are a type of care-related infection and are defined as "acquired during or after hospitalization" [2]. In intensive care, the rate of nosocomial infection is four times higher than that of medical or surgical services. These differences are largely explained by the fact that resuscitation patients often have a higher body weight, require complex management, and have multiple comorbidities and invasive devices [3]. Urinary tract infections (28.47%) are the most common, followed by surgical site infections (15.92%), pneumonia (15.63%), and bacteremia (11.43%) [4].

Three bacteria account for half of the germs isolated in nosocomial infections: *Escherichia coli* (about a quarter of cases), *Staphylococcus aureus* (1 in 6 cases), of which 15 to 30% of the population are carriers (in the nose, throat, and perineum), and *Pseudomonas aeruginosa* (less than 10%). Other germs that are more rarely isolated include *Enterobacteriaceae* other than *E. coli*, Streptococci, *Clostridium difficile*, or *Acinetobacter baumannii*. Fungi/yeasts, viruses, and parasites are very rarely implicated [5].

In Morocco, although there are currently no national regulations requiring the reporting of all nosocomial infections [6], there has been growing interest in combating these infections in recent years, leading some hospitals to establish their own programs. For example, the first national survey of hospital-acquired infections was conducted in 1994 and found a prevalence rate of 8.1% [7].

The development of an infection associated with care for a resuscitation patient is an element of severity associated with increased mortality, requiring rapid and effective management. The therapeutic management of infections associated with healthcare is based on probabilistic antibiotic therapy, which is mainly guided by knowledge of the bacterial ecology within the hospital structure. Therefore, this study is of great interest.

The objectives of our study were to determine the incidence of healthcare-related infections in our structure, identify the types of healthcare-related infections in order of frequency, and understand the bacterial ecology.

2. Material and methods

2.1. Study design and setting

We conducted a prospective observational, descriptive study of all patients over the age of 16 who were hospitalized in the Intensive Care Unit (ICU) A4 for a period of 12 months, from May 2021 to May 2022. All patients were monitored during their stay, and those who presented with a healthcare-related infection, regardless of the site of infection, were included in the study. We excluded patients who did not present with a healthcare-related infection and those who were discharged from intensive care or died within the first 48 hours. For each included patient, the following criteria were noted: demographic information (age, sex), medical history (diabetes, previous hospitalization, prior antibiotic therapy, etc.), reason for hospitalization, clinical signs, biological signs, invasive procedures performed, and healthcare-related infections experienced by patients, along with their characteristics.

The definitions of healthcare-related infections were based on the recommendations of the French learned societies (SFAR and SRLF) in 2009 [4].

A care-related infection is defined as an infection acquired in a resuscitation unit when it was neither present nor incubated at admission. A minimum period of 48 hours between admission and infection is retained.

2.2. Statistical Analysis

In our study, the information collected on an operating sheet was entered into Excel 2010 and processed using the SPSS software at the Laboratory of Epidemiology at the Faculty of Medicine and Pharmacy in Fez. Quantitative data are presented as the standard mean +/- error (MSB) and were compared using the Student t-test. Qualitative data are presented as percentages with a 95% confidence interval (CI) and were compared using the Chi-square test. The observed differences were considered significant at an alpha level of less than 5% ($p < 0.05$).

3. Results

Seven hundred and sixty-four patients were admitted to the A4 multi-purpose ICU during the study period from May 2021 to May 2022. Out of these, 53 patients had healthcare-related infections, resulting in an incidence rate of 6.9%. The average age of our patients is 47.42 years, ranging from 18 to 85 years. There was a significant male predominance, with 60.4% of patients being men, compared to only 39.6% being women. Patients in the ICU are transferred from either the emergency department, another medical or surgical department, or even another hospital. Six patients (11.3%) had diabetes, four patients (7.5%) had high blood pressure, eight patients (15.1%) were being monitored for tumor pathology, 15 patients (28.3%) had a history of surgery, and 19 patients (35.8%) had been previously hospitalized (Table 1). The majority of patients had normal nutritional status, with 44 (83%) falling into this category. Additionally, six patients (11.3%) were classified as obese, while two patients (3.8%) were cachectic.

Table 1 The background of the participants

Background	Number (%)
High blood pressure	4(7.5%)
Heart disease	4(7.5%)
Diabetes	6(11.3%)
Asthma	2(3.8%)
Tuberculosis	1(1.9%)
Carrying of multi-resistant bacteria	1(1.9%)
HIV	1(1.9%)
Chemotherapy	1(1.9%)
Tumor pathology	8(15.1%)
Ischemic stroke	1(1.9%)
Epilepsy	1(1.9%)
Cirrhosis	1(1.9%)
Myasthenia gravis	1(1.9%)
History of surgery	15(28.3%)
Previous hospitalization	19(35.8%)
Prior antibiotic therapy	9(17%)

Our patients are either hospitalized for medical reasons, such as ketoacidosis decompensation or severe acute pancreatitis, for surgical reasons, such as postoperative abdominal surgery, or for medico-surgical reasons, such as severe trauma that has required trauma surgery or hemostasis splenectomy. A total of 29 patients underwent surgery, with 26 (89.6%) of the interventions being urgent and three (10.3%) being scheduled. The surgery was classified as clean in 10 (18.9%) cases, clean-contaminated in two (3.8%) cases, contaminated in 11 (20.8%) cases, and dirty in six (11.3%) cases. The average preoperative stay was 1.77 days, and the average duration of the operative procedure was 99.06 minutes.

Clinically, fever was the main symptom at the time of reporting a healthcare-related infection and was present in 26 (49.1%) of patients. Hypothermia was present in one patient (1.9%). A comprehensive biological assessment is systematically required for all patients. Thus, leukocytosis with a GB > 15000 elemt/mm^3 was found in 16 (30.2%) cases, thrombocytopenia with platelets < 150000 elemt/mm^3 was present in 14 (26.4%) patients, CRP was higher than 150 mg/l in 35 (66%) patients, and renal failure with creatinine > 12mg/dl was found in 14 (26.4%) patients. Additionally, 42 (79.2%) patients had hypoalbuminemia < 30 g/l, and 21 (39.6%) had metabolic acidosis with alkaline reserves < 20 mEq/l. Procalcitonin was performed in only 17 (32%) of the cases, and it tested positive in 13 (76.4%) of those cases.

Depending on the reason for hospitalization, patients were treated appropriately, with care and monitoring tailored to the patient's clinical condition. Thus, 51 (96.2%) patients benefited from a bladder survey, 52 (98.1%) required the placement of a central venous catheter, four (7.5%) needed a hemodialysis catheter, and 18 (34%) required an arterial catheter. Orotracheal intubation was necessary for 45 (84.9%) of the patients, of whom five (9.4%) were subsequently tracheotomized. Thoracic drainage was achieved in seven (13.2%) patients, postoperative drainage in 19 (35.8%), and four (7.5%) patients underwent guided echo drainage **(Table 2).** In 48 (90.6%) of the cases, the patient benefited from more than two interventions.

Table 2 Actions taken

Gesture performed	**Number (%)**
Bladder catheterization	51(96.2%)
Pubic catheter	1(1.9%)
Central venous catheter:	52(98.1%)
Femoral	16(30.2%)
Jugular	21(39.6%)
Femoral + jugular	13(24.5%)
Femoral + jugular + under keyboard	2(3.8%)
Femoral hemodialysis catheter	4(7.5%)
Arterial catheter:	18(34%)
Radial	6(11.3%)
Femoral	12(22.6%)
Intubation	45(84.9%)
Tracheotomy	5(9.4%)
Thoracic drainage	7(13.2%)
Postoperative drainage	19(35.8%)
Guided echo drainage	4(7.5%)

The average time of infection onset associated with care, compared to hospitalization, was 5.85 days. Fifteen patients (28.3%) had a single healthcare-related infection, while 14 (26.4%) had two healthcare-related infections, 19 (35.8%) had three healthcare-related infections, and five (9.4%) had four healthcare-related infections.

A total of 120 healthcare-related infections were documented during the study period. Bacteremia accounted for the highest percentage at 64.2%, followed by catheter-related infections and pneumonia acquired under mechanical ventilation, both at 60.4%. Additionally, surgical site infections comprised 22.6%, while urinary tract infections accounted for 18.9% (Table 3).

Table 3 Types of healthcare-related infections

Type of healthcare-related infection	**Percentage (%)**
Bacteremia	64.2%
Catheter-related infection	60.4%
Pneumonia acquired under mechanical ventilation	60.4%
Surgical site infection	22.6%
Urinary tract infection	18.9%

As part of the prevention of healthcare-related infections, several preventive measures must be followed, particularly when inserting central venous catheters. Thus, the wearing of masks was obligatory in our study, as was the use of a hydroalcoholic solution. However, the wearing of overcoats was only respected in 10 (18.9%) cases. Further, to limit the spread of healthcare-related infections in the structure, the infected patient was isolated in 30 (56.6%) of the cases, while in 23 (43.4%) of the cases, infected patients were grouped together. After the declaration of the infection, a comprehensive infectious assessment was conducted in our series: 53 (100%) of the patients underwent hemoculture, 42 (79.2%) patients had infected material replaced, and 13 (24.5%) patients benefited from pus drainage. After carrying out the infectious assessment, and depending on the suspected site of infection, probabilistic antibiotic therapy was initiated in 52 (98.1%) of the cases. After obtaining the results of bacteriology, therapeutic de-escalation was only possible in a single patient (1.9%). This was either due to the use of a probabilistic antibiotic adapted to the specific germ found or because the patient had a multi-resistant germ, requiring a broader spectrum of antibiotic therapy. The average length of hospitalization was 19.47 days, with a range of four to 100 days. The evolution was favorable in 13 (24.5%) of the cases, and unfortunately, there was a significant mortality rate of 40 (75.5%) patients.

During the study period, out of the 764 patients hospitalized in our ICU, 53 patients presented with a healthcare-related infection. In this study population, among all the bacteriological samples taken, 144 tested positive. This includes 41 (28.47%) positive blood cultures, 41 (28.47%) positive protected distal samples, 40 (27.77%) positive catheter bacteriological studies, 12 (8.33%) positive pus samples, and 10 (6.9%) positive cytobacteriological examinations of urine (Table 4).

Table 4 Breakdown of bacteriological examinations performed

Type of bacteriological examination	Percentage (%)
Blood culture	28.4%
Protected distal sampling (PDS)	28.47%
Catheter study (KT)	27.77%
Pus study	8.33%
Cytobacteriological examination of urine (CBEU)	6.90%

Of the 144 samples, the isolated germs were mainly *A. baumannii*, accounting for 88 (61.11%) cases. This was followed by *Enterobacteriaceae*, with a rate of 44 (30.55%), including 26 *Klebsiella pneumoniae*, 17 *E. coli*, and one *Enterobacter cloacae*. In third place comes *P. aeruginosa* with a rate of 13 (9.02%), followed by enterococci with a rate of 10 (6.94%), and Staphylococcus with a rate of eight (5.55%). Four (2.77%) samples were positive for an unidentified gram-negative bacterium (GNB), and two (1.38%) samples were isolated from *Stenotrophomonas maltophilia*. One *Haemophilus influenzae* was isolated on a protected distal sampling (PDS). Three (2.08%) yeasts were identified, including one Candida.

K. pneumoniae was sensitive in 10 (38.46%) cases, beta-lactamase extended-spectrum (BLES) in 13 (50%) cases, and carbapenemase in three (11.58%) cases. Additionally, *E. coli* was sensitive in six (35.29%) cases, BLES in nine (52.94%) cases, and carbapenemase in two (11.76%) cases. Out of the eight samples identifying Staphylococcus, five (62.5%) cases were coagulase-negative, and three (37.5%) cases were aureus. Enterococci were resistant in six (60%) cases and sensitive in four (40%) cases (Table 5).

Table 5 Distribution of isolated germs on bacteriological examinations

Germ (N)	Prelevelment type				
	Blood culture	KT	PDS	Pus	CBEU
Acinetobacter baumannii (88)	27	27	29	0	5
Klepsiella pneumoniae (26)	5	10	5	6	0
Sensitive (10)	1	6	2	1	
BLES (13)	3	3	2	5	
Carbapenemase (3)	1	1	1	0	

E. coli (17)	3	0	7	5	2
Sensitive (6)	0		4	1	1
BLES (9)	2		2	4	1
Carbapenemase (2)	1		1	0	0
Staphylococcus (8)	4	2	2	0	0
Coagulase negative (5)	4	1	0		
aureus (3)		1	2		
Pseudomonas aeruginosa (13)	1	2	8	2	0
Enterococci (10)	4	0	0	4	2
faecium (6)	1			3	2
faecalis (4)	3			1	0
Unidentified *GNB* (4)	0	3	1	0	0
Sensitive (3)		2	1		
BLES (1)		1	0		
Enterobacter cloacae (1)	0	0	0	1	0
Stenotrophomonas maltophilia (2)	0	0	1	1	0
Haemophilus influenza (1)	0	0	1	0	0
Yeasts (3)	0	2	0	0	1

4. Discussion

Healthcare-related infection is the first frequent adverse event in ICUs [8], affecting 7% of hospitalized patients every year [9]. In our study, the incidence of healthcare-related infections was 6.9%. A study on the prevalence of nosocomial infections, conducted under the auspices of the WHO in 55 hospitals across 14 countries in four of the six regions (Southeast Asia, Europe, Eastern Mediterranean, and Western Pacific), revealed that, on average, 8.7% of hospitalized patients had acquired a nosocomial infection [10]. In the United States, the National Nosocomial Surveillance System (NNIS) reports a median incidence of nosocomial infections in 196 ICUs, affecting 9.2% of patients [11].

Concerning the bacteriological profile of our study, out of 144 samples taken, the predominant isolated germs were *A. baumannii* with a rate of 88 (61.11%), followed by *enterobacteria* with a rate of 44 (30.55%), including 26 *K. pneumoniae*, 17 *E. coli*, and one *E. cloacae*, which are predominantly multidrug-resistant. In third place comes *P. aeruginosa* with a rate of 13 (9.02%), followed by enterococci with a rate of 10 (6.94%), and Staphylococcus with a rate of 8 (5.55%). Additionally, two samples (1.38%) were found to be isolated with *S. maltophilia*. One *H. influenzae* was isolated from a single sample, and three (2.08%) yeasts were identified, including one Candida.

A. baumannii is the predominant pathogen in our series, accounting for 61.11% of cases. In the literature, it is the second non-feeling organism isolated from care-related infections after *P. aeruginosa* [12]. As well as in our series, this germ was responsible for a wide range of infections, including care-related pneumonia, bacteremia, urinary tract infections, and wound superinfection [13]. The risk factors that increase the likelihood of acquiring an infection related to the care of *A. baumannii* are well-documented and commonly found in serious resuscitation patients, which explains its frequency in our facility. These factors can be attributed to the host, such as undergoing major surgery, experiencing severe trauma (especially extensive burns), being exposed to prolonged stays in ICUs, and being hospitalized in a department where *A. baumannii* is endemic or comes into contact with contaminated medical equipment [14,15]. They can also be related to medical management, such as receiving assisted ventilation, having implanted devices (such as catheters, urinary catheters, and drains), undergoing repeated invasive procedures, or having a history of previous antibiotic use or broad-spectrum antibiotic treatment [16,17]. Until the early 2000s, extended-spectrum beta-lactamases enterobacteria (ESBLE) were sporadic or responsible for localized hospital epidemics [18,19]. Currently, they pose a significant public health problem worldwide. In France, for example, 5–10% of the general population [20,21] would be asymptomatic carriers of ESBLE. Our facility is not an exception, as enterobacteria is the second most

commonly isolated pathogen in our study, with a rate of 30.55%. Among these cases, 50% were found to be ESBL-positive cases, and 11.3% were carbapenemase-positive.

P. aeruginosa is the third pathogen encountered in our facility, with a prevalence rate of 9.02%. It is a saprophytic bacterium that is naturally resistant to antibiotics. Under favorable conditions, it can become an opportunistic pathogen, causing serious infections in both the community and hospital settings [22]. In some series, it is involved in 15.7% to 17% of ICU infections, surpassing *E. coli* (13.9%) and *S. aureus* (12.2%) [23]. The prevalence survey of nosocomial infections conducted in France in 2006 found that *P. aeruginosa* accounted for 10% of the 15,800 microorganisms isolated in 13,504 nosocomial infections. This placed it behind *E. coli* (24.7%) and *S. aureus* (18.9%) in terms of prevalence. *P. aeruginosa* was responsible for 20.6% of bronchopneumopathies (ranking first), 15.4% of skin and soft tissue infections (ranking second), 9% of surgical site infections (ranking third), 7.8% of urinary tract infections (ranking fourth), and 6.4% of bacteremia (ranking fifth) [24]. In our series, pneumonia associated with care accounted for 61.5% of cases, catheter-related infections and surgical site infections for 15.38%, and bacteremia for 7.7%.

Enterococci are less frequent in our facility, ranking fourth with a rate of 6.94%. In 60% of cases, an *Enterococcus faecium* strain sensitive to vancomycin was isolated, while in 40% of cases, an *Enterococcus faecalis* strain sensitive to penicillin was found. In contrast, in other countries around the world, such as the United States, enterococci are the second most commonly isolated bacteria in care-related infections [25,26]. There has been a shift in the resistance profile of enterococci since the late 1970s, when *E. faecalis* was the most prevalent strain [27]. However, since the early 1990s, *E. faecium* has become the most common strain and has shown increasing resistance to vancomycin [26,28]. Staphylococcus occupies the last place with a rate of 5.55%, but it remains sensitive in all cases.

5. Conclusion

Resuscitation-healthcare-related infections are frequent and can be severe. The severity of these infections is due to both the infection itself and the compromised immune defense mechanisms of the patient, which reflect their overall health condition. While there are many factors that contribute to the occurrence of such infections, prevention, although partial, can be achieved through the implementation of simple measures, such as maintaining aseptic conditions and regularly evaluating the relevance of medical devices. A regular update of knowledge about care-related infections seems essential to ensure the most adequate prevention possible, especially since eradication is still impossible.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicts of interest.

Statement of ethical approval

Our study is purely descriptive, non-interventional, and it has been oppressed by the ethics committee of our institute.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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