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Bacteremia in Burned Patients at the Chu Mohammed VI in Marrakech

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Abstract **Original Research Article**

This study conducted at CHU Mohammed VI in Marrakech over six years examined bacteremia in burn patients, finding a prevalence of 13.04% among 2,230 blood cultures. The predominant pathogens were gram-positive cocci (49.5%) and gram-negative bacilli (47.1%), with coagulase-negative staphylococci (25.1%), Staphylococcus aureus (17.5%), and Klebsiella pneumoniae (13.1%) being the most frequent isolates. Notably, 9.6% of Staphylococcus aureus strains were methicillin-resistant, and 74.7% of Enterobacteriaceae were resistant to third-generation cephalosporins. Acinetobacter baumannii exhibited high resistance, with 93.1% resistant to both ceftazidime and imipenem. The overall rate of multidrug-resistant bacteria was 35.7%, dominated by gram-negative bacilli. These findings highlight the critical need for improved infection control and judicious use of antibiotics to prevent the emergence of resistant strains, emphasizing the importance of close collaboration between clinicians and microbiologists to enhance patient outcomes.

Keywords: Bacteremia, Burn Patients, Antibiotic Resistance, Multidrug-Resistant Bacteria (MRB).

INTRODUCTION

Burns are defined as more or less extensive and more or less deep destruction of the skin caused by thermal, electrical, chemical, or radioactive agents [1]. After surviving the acute phase of a burn, septic complications become the leading cause of mortality in severely burned patients [2], particularly bacteremia resulting from wound infection, the use of invasive devices, and translocation of gastrointestinal flora [3]. This remains the primary cause of death, accounting for up to 60% of deaths in burn patients [4].

The responsible pathogens often exhibit high antibiotic resistance, frequently putting clinicians in a therapeutic dilemma. A good understanding of the bacterial species involved in bacteremia, their susceptibility profiles, and their resistance mechanisms guides empirical antibiotic therapy and allows the implementation of infection prevention programs. This could lead to an overall improvement in patient prognosis.

The objective of this study is to describe the microbiological characteristics of bacteremia in burn patients and determine the antibiotic resistance profiles of the isolated germs [5].

PATIENTS AND METHODS

This is a retrospective study conducted over a period of 6 years, from January 1, 2018, to December 31, 2023. The study collected all documented bacteremia's from patients hospitalized in the Plastic Surgery and Burn Unit at Mohammed VI University Hospital in Marrakech. The identification of isolated germs was based on morphological, cultural, and biochemical characteristics (API20E® galleries) and mass spectrometry (MALDI-TOF MS: matrix-assisted laser desorption/ionization-time of flight mass spectrometry). Antibiotic susceptibility testing was performed using an automated method (BD PHOENIX Automated Microbiology System).

RESULTS

Epidemiological Characteristics

During the study period, 291 of the 2,230 blood cultures taken were positive. The prevalence of bacteremia in burn patients was 13.04%. The average age of our patients was 35 years, with extremes ranging from 6 to 93 years.

The working population (aged between 16 and 45) was the most represented (52.2%). The sex ratio (M/F) was 1.8/1 (188/103).

Microbiological Profiles

The microbiological profile of bacteremia showed a predominance of gram-positive cocci (GPC) in 49.5% of patients, followed by gram-negative bacilli (GNB) in 47.1%. Fungemia was found in 1% of patients.

The most frequently isolated species were coagulase-negative staphylococci (SCN) with 25.1% (n=73), followed by Staphylococcus aureus (SA) with 17.5% (n=51), Klebsiella pneumoniae with 13.1% (n=38), Enterobacter cloacae with 10.0% (n=29), and Acinetobacter baumannii with 10.0% (n=29). (Table I)

Table I: Distribution of germs isolated in bacteremia in burn victims over 6 years at Marrakech University Hospital (n=291)

	Count	**%**
Gram-positive cocci (GPC)	144	49,5%
SCN	73	25,1%
Staphylococcus aureus	51	17,5%
Streptococcus spp	5	1,7%
Enterococcus faecalis	10	3,4%
Enterococcus faecium	5	1,7%
Gram-negative bacilli (GNB)	137	47,1%
Enterobacteria's *(EB)*	99	34,0%
Klebsiella pneumoniae	38	13,1%
Enterobacter cloacae	29	10,0%
E. col*i*	15	5,2%
Providencia spp	4	1,4%
Raoutella terrigena	3	1,0%
Proteus mirabilis	3	1,0%
Serratia spp	3	1,0%
Morganella morganii	2	0,7%
Citrobacter frendeii	1	0,3%
Klebsiella oxytoca	1	0,3%
Non-fermentative gram-negative bacilli (NFGNB)	38	13,1%
Acinetobacter baumanii	29	10,0%
Pseudomonas aeruginosa	7	2,4%
Pseudomonas putida	1	0,3%
Aeromonas hydrophilia	1	0,3%
Gram-positive bacilli (GPB)	7	2,4%
Corynebacterium spp	5	1,7%
Bacillus pumillus	1	0,3%
Aerococcus viridans	1	0,3%
Yeast	3	1,0%
Non-albicans candida	2	0,7%
Candida albicans	1	0,3%
TOTAL	291	100,0%

Resistance Profiles of Germs Isolated

Resistance to methicillin in Staphylococcus aureus was 9.6%; resistance to aminoglycosides was reported in 12.3%; 4.1% for fluoroquinolones; and 8.2% for sulfamethoxazole-trimethoprim. No glycopeptide-resistant strains were reported in this study.

Resistance to third generation cephalosporins affected 74.7% of Enterobacteria's, mainly affecting Klebsiella pneumoniae (32.3%), and 15.2% showed reduced sensitivity to carbapenems. Resistance to gentamicin and amikacin was 55.6% and 15.2% respectively, and 50.5% for fluoroquinolones. (Table II)

Tableau II: Antibiotic resistance profile of Enterobacteria's isolated in burn victims over 6 years at Marrakech University Hospital (n=99)

	C3G (%)	**IMP (%)**	**CIP (%)**	**AK (%)**	**GM (%)**	**SXT (%)**	**CS (%)**
K. pneumoniae(n=38)	32 (32,3%)	15 (15,2%)	27 (27,3%)	4 (4,0%)	25 (25,3%)	30 (30,3%)	1 (1,0%)
E. cloacae(n=29)	21 (21,2%)	14 (14,1%)	5 (5,1%)	0 (0,0%)	13 (13,1%)	26 (26,3%)	0 (0,0%)
E. coli(n=15)	8	7	7	4	3	10	0

	C3G (%)	IMP (%)	CIP (%)	AK (%)	GM (%)	SXT (%)	CS (%)
	(8,1%)	(7,1%)	(7,1%)	(4,0%)	(3,0%)	10,1%	(0,0%)
Providencia spp(n=4)	4 (4,0%)	4 (4,0%)	3 (3,0%)	0 (0,0%)	4 (4,0%)	2 (2,0%)	NR*
P. mirabilis(n=3)	2 (2,0%)	1 (1,0%)	3 (3,0%)	2 (2,0%)	3 (3,0%)	2 (2,0%)	NR*
Serratia spp(n=3)	0 (0,0%)	0 (0,0%)	1 (1,0%)	1 (1,0%)	1 (1,0%)	1 (1,0%)	NR*
R. terrigena(n=3)	3 (3,0%)	3 (3,0%)	3 (3,0%)	3 (3,0%)	3 (3,0%)	3 (3,0%)	0 (0,0%)
M.morganii(n=2)	2 (2,0%)	0 (0,0%)	0 (0,0%)	0 (0,0%)	1 (1,0%)	2 (2,0%)	NR*
C.frendeii(n=1)	1 (1,0%)	1 (1,0%)	1 (1,0%)	1 (1,0%)	1 (1,0%)	1 (1,0%)	0 (0,0%)
K. oxytoca(n=1)	1 (1,0%)	0 (0,0%)	0 (0,0%)	0 (0,0%)	1 (1,0%)	0 (0,0%)	0 (0,0%)
Total	74 (74,7%)	45 (45,5%)	50 (50,5%)	15 (15,2%)	55 (55,6%)	77 (77,8%)	1 (1,0%)

***NR: Natural resistance**

Acinetobacter baumannii strains (n=29) showed high resistance to ceftazidime (CAZ), piperacillin/tazobactam (TZP) and imipenem (IMP), with resistance rates of 93.1%. Resistance to fluoroquinolones was 89.7%, while 82.2% of strains were resistant to trimethoprim/sulfamethoxazole (SXT). One strain showed resistance to colistin, confirmed by determination of the MIC by microdilution.

Pseudomonas aeruginosa (n=6), resistance to ceftazidime (CAZ) was noted in 83.3% of strains, and to imipenem (IPM) in 50.0%. Resistance to aminoglycosides was 16.7% for amikacin (AMK) and 33.3% for gentamicin (GEN) and 50.0% for fluoroquinolones (CIP).

Profile of Multi Resistant Bacteria

The rate of multi-resistant bacteria was 35.7%. Enterobacteriaceae accounted for 64.4%, followed by ABMR (26%) and PAMR (2.9%). MRSA accounted for 6.7% of all MRB. (Table III)

Table III: Distribution of MRB isolated in bacteremia in burn patients over 6 years at Marrakech University Hospital (n=104)

	2018	2019	2020	2021	2022	2023	TOTAL	%
Gram-negative bacilli (GNB)	**24**	**15**	**21**	**5**	**17**	**15**	**97**	*93,3%*
Enterobacteria*'s*	**21**	**10**	**15**	**3**	**10**	**8**	**67**	*64,4%*
Klebsiella pneumoniae (n=38)	11	2	3	3	9	4	32	*30,8%*
Enterobacter cloacae (n=22)	8	6	2	0	0	2	18	*17,3%*
E. col*i* (n=15)	1	1	2	0	1	2	7	*6,7%*
Providencia spp (n=4)	0	0	4	0	0	0	4	*3,7%*
Raoutella terrigena (n=3)	0	0	3	0	0	0	3	*2,9%*
Morganella morganii (n=2)	0	1	0	0	0	0	1	*1,0%*
Proteus mirabilis (n=3)	0	0	1	0	0	0	1	*1,0%*
Citrobacter frendeii (n=1)	1	0	0	0	0	0	1	*1,0%*
Non-fermentative gram-negative bacilli (NFGNB)	**3**	**5**	**6**	**2**	**7**	**7**	**30**	*28,8%*
Acinetobacter baumanii (n=29)	2	4	6	2	7	6	27	*26,0%*
Pseudomonas aeruginosa (n=3)	1	1	0	0	0	1	3	*2,9%*
Gram-positive cocci (GPC)	**2**	**0**	**2**	**0**	**2**	**1**	**7**	*6,7%*
SA(n=51)	2	0	2	0	2	1	7	*6,7%*
TOTAL	**26**	**15**	**23**	**5**	**19**	**16**	**104**	**100%**

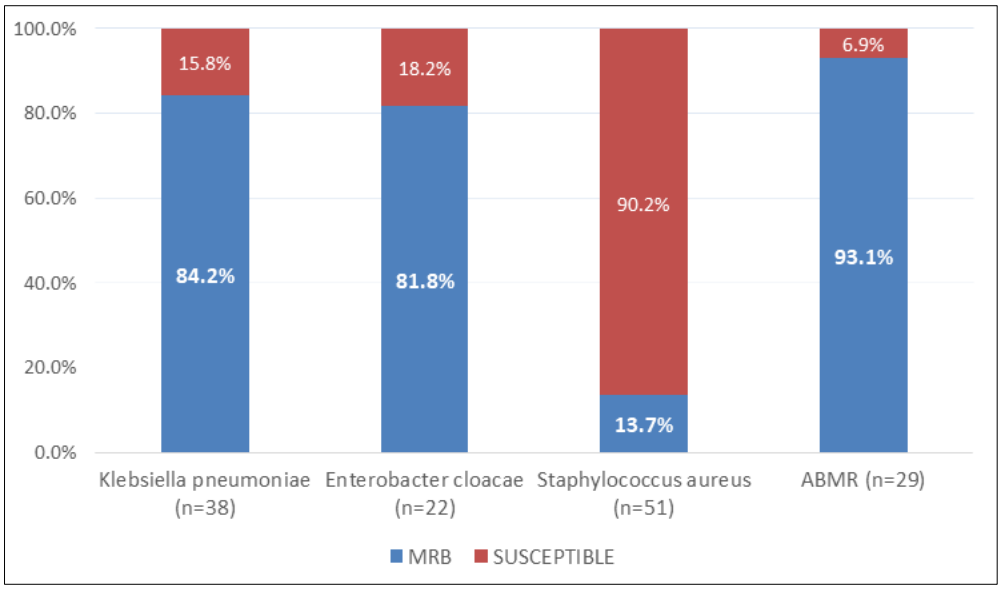

Figure I: Percentage of multidrug resistance within species in bacteremia in burn victims over 6 years at Marrakech University Hospital (%)

DISCUSSION

The occurrence of bacteremia in burn patients is a diagnostically and therapeutically emergency, given the unpredictable evolution of the susceptibility of the bacteria involved. To ensure effective antibiotic therapy from the outset, it is crucial to have a precise and constantly updated understanding of bacterial epidemiology and the antibiotic susceptibility of the strains responsible for bacteremia [6] . This study had the advantage of studying bacteremia in burn patients from both an epidemiological and biological perspective.

In burn patients, bacteremia may occur without any clinically detectable route of entry: either by direct inoculation of bacteria into the bloodstream following destruction of the skin by the burn, or by bacterial translocation following intestinal hypoperfusion, often observed during states of shock [7].

The prevalence of bacteremia in this study was 13.04%, a significantly lower figure than that reported in the Meknes hospital (69.25%) [8], and in Tunisia (25,7%) [7]. A study conducted in Spain reported a prevalence of bacteremia of just 2.96% [9].

Except for coagulase-negative staphylococci, the main bacterial species isolated in our study were Staphylococcus aureus (17.5%) and Klebsiella pneumoniae (13.1%).

The distribution of germs shows slight similarities with that observed in a survey in Meknes [8], where Staphylococcus aureus was the most prevalent germ (33.8%), followed by Enterobacteriaceae (28.22%). However, this predominance differs considerably from that reported in Rabat [10], in 2018, where Acinetobacter baumanii was the most prevalent (26.3%), followed by Pseudomonas aeruginosa (19.44%). In Spain [9], Pseudomonas aeruginosa was the most prevalent germ (17.5%), followed by Staphylococcus aureus (16.5%).

This distribution can be explained that the bacteria located deep down are at least partially respected. The burn, sterile in the first few hours, is therefore rapidly colonized, initially (within 48 hours) by skin bacteria (mainly Gram-positive cocci) and then (at the end of the first week) by bacteria of digestive, ENT or environmental origin [11].

The study of antibiotic sensitivity showed elevated levels of resistance to the various antibiotics usually prescribed.

Methicillin-resistant staphylococcus aureus (MRSA) accounted for 9.6% of bacteremia's, a much lower figure than that reported nationally in Meknes in 2018 (56.8%) [8], and in Tunisia [7], in 2021 (64.0%). This rate was close to that reported in Spain [9], in 2014 (11.8%). Resistance to aminoglycosides concerned 9.6% of strains, while in Tunisia [7], this figure was higher (57.9%). No resistance to glycopeptides was observed.

The reservoir of staphylococcus aureus is mainly human, and it is mainly transmitted by hand, often via healthcare workers [12]. The new anti-staphylococcal antibiotics, such as daptomycin, tigecycline, linezolid and ceftaroline (C5G), have demonstrated their efficacy against MRSA and remain important alternatives in the treatment of strains resistant or with reduced sensitivity to glycopeptides [13].

For the Enterobacteriaceae family, resistance to C3G was 74.7%, a higher rate than those found in Meknes hospital [8], (68.18%) and Tunisia [7], (69.5%). Strains with reduced susceptibility to carbapenems

represented 15.2%, a high figure compared with that reported in Tunisia [7], (9.1%), and in Rabat (14.0%) [10], but much lower than that reported at Mohammed 5 Hospital in Meknes [8], (43.24%). For aminoglycosides, 55.6% of strains were resistant to gentamicin, a lower figure than that found in Meknes [8], (78.5%). Resistance to fluoroquinolones concerned 50.5% of strains, a much higher rate than that found at Mohammed 5 Hospital in Rabat [10] (21.0%).

Acinetobacter baumannii resistance to ceftazidime (CAZ) affected 93.1% of isolates, a higher rate than that observed at Mohammed 5 Hospital in Meknes [8] (65.0%). In Tunisia, the reported rates were 84.0% in 2021 [7]. Resistance to imipenem (IMP) was also 93.1%, a rate similar to that found in Meknes [8], in 2020 (90.0%) and in Tunisia in 2021 [7], (90.0%). Only one colistin-resistant strain was isolated in our series, which is encouraging. This indicates a virtual absence of Acinetobacter baumannii strains resistant to colistin, which remains the last molecule active against multi-resistant strains [14].

For Pseudomonas aeruginosa, the results showed 83.3% resistance to CAZ, a high rate compared with that reported in Rabat [10] (43.0%) and Meknes [8], (40.0%). Imipenem resistance was described in half of the cases (50.0%), a figure similar to that reported in Rabat [10], but higher than that reported in Meknes [8], (30%). No resistance to colistin was reported during our study period. Colistin remains an effective drug with very low resistance rates in the treatment of multi-resistant Pseudomonas aeruginosa [15].

Non-fermentative gram-negative bacilli (NFGNB) are widespread in the hospital environment, and their frequency is encouraged by the considerable number of invasive procedures performed on immunocompromised patients, and also by the selection pressure of third generation cephalosporins and imipenem. These are formidable bacteria, with the capacity to acquire and accumulate several resistance mechanisms easily [6].

The proportion of BMR was 35.7%, a rate very close to that reported in 2021 in Tunisia [7], (44%). Multi-resistant Enterobacteriaceae dominated (64.4.1%), followed by multi-resistant Acinetobacter baumanii (26%), MRSA (6.7%) and Pseudomonas aeruginosa (2.9%). This rate and distribution varies considerably from one study to another, probably due to the heterogeneity of the populations studied, the study methodology and the germs isolated [16].

Long hospital stays are the major risk factor for MRB bacteremia, as are previous exposure to antibiotics and the use of invasive medical devices such as endotracheal tubes and urinary catheters [17].

The treatment of infections caused by multi-resistant bacteria is often complicated by their limited sensitivity to the usual antibacterial drugs and the spread of resistance to other antibiotics during treatment [18].

Secondary hyperparathyroidism is an inevitable complication of chronic kidney disease that results from a cascade of phosphocalcic metabolic alterations, which jeopardizes the vital and functional prognosis of hemodialysis patients. The diagnosis of SHPT is essentially biological, based on the measurement of PTH, which is associated with phosphocalcic assessment, vitamin D measurement, and ALP.

Treatment is primarily preventive, aiming to maintain calcium, phosphorus, and 25-OH Vitamin D levels within recommended ranges and to reduce parathyroid response to phosphocalcic disorders.

Our work has allowed us to highlight the following characteristics:

- The average time for SHPT development within the first four years of dialysis.
- The initial predominance of vitamin D deficiencies is concurrent with the increase in PTH beyond recommended levels.
- A significant decrease in SHPT prevalence following therapeutic intervention.
- Therapeutic control is more effective for calcium and phosphorus levels compared to PTH in the absence of calcimimetic therapy in Morocco.
- A high percentage of our patients responded better to KDIGO criteria than to KDOQI criteria because they are more comprehensive

CONCLUSION

The high prevalence (13.04%) of bacteremia in burn patients in our hospital, with an overall rate of MRB of 35.7%, largely dominated by gram-negative Bacilli, should encourage us to make a greater effort to prevent nosocomial infections, especially during long hospital stays, and reconsider the modalities of probabilistic antibiotic treatment on admission, in order to avoid the emergence of multi-resistant strains which put the clinician in a therapeutic impasse.

Good collaboration between the biologist and the clinician is the key to improving the patient's vital prognosis.

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