



Burn wound bacterial profile and antibiotic sensitivity results in Turkey's southeast region of Anatolia

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Abstract

Introduction: The conducted study was done to reveal the profile of bacteria isolated from wound sites of patients hospitalized in our burn center. We also aimed to find the appropriate sensitive antibiotics for use in the treatment.

Methods: In the study, we examined 394 patients with (+) wound cultures reports from the 1,415 patients hospitalized at the Gazi Yaşargil Training and Research Hospital Burn Center between January 2010 and January 2020.

Results: From 394 patients, 217 (55%) were male and 177 (45%) were female. The average age of patients was 12.86 ± 17.34 (min 1 - max: 94 years). In the wound culture results, bacteria were 70.55% gram-positive and 28.68% gram-negative. *Candida albicans* was found in wound culture growth at a rate of 0.07%. The most common gram (+) pathogen was *Staphylococcus aureus* at 23.09% (n = 91). The most common gram (-) pathogens were *Escherichia coli* at 9.13% (n = 36) and *Pseudomonas aeruginosa* at 9.13% (n = 36).

Conclusion: As a result of our study, we found that the most common causes of burn infections in our region were due to *S. aureus*, *E. coli*, and *P. aeruginosa*. We hope that the use of broad spectrum antibiotics can be effective against these bacteria and will contribute to clinical treatments until culture reports are available.

Keywords: Burn, Wound, Microbiological culture results, Antibiotics

Highlights

- The reasons that increase the infection rate of burn wound sites in our region
- The common results of burn wound culture report in our region.
- The results of susceptibility rate of bacteria to antibiotics in our region
- The results of resistant rate of bacteria to antibiotics in our region

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Türkiye'nin Güneydoğu Anadolu Bölgesinde Yanık Yarası Bakteri Profili ve Antibiyotik Duyarlılık Sonuçları

Öz

Giriş: Yapılan çalışmada, bölgemizin tek yanık merkezi olan yanık merkezimizde yatan hastaların yara yerlerinden izole edilen bakteri profilini ortaya çıkarmak ve ayrıca tedavide kullanılmak üzere uygun duyarlı antibiyotikleri bulmayı amaçladık.

Yöntemler: Çalışmada Ocak 2010-Ocak 2020 tarihleri arasında Gazi Yaşargil Training and Research Hastanesi Yanık Merkezi'nde yatan 1.415 hastadan (+) yara kültürü raporu alınan 394 hasta incelendi.

Bulgular: 394 hastanın 217'si (%55) erkek, 177'si (%45) kadındı. Hastaların ortalama yaşı $12,86 \pm 17,34$ (min 1 - max: 94 yıl) idi. Yara kültürü sonuçlarında %70,55 bakteri gram (+) ve %28,68 gram (-) olarak bulundu. Yara kültüründe %0,07 oranında *Candida albicans* üremesi saptandı. En yaygın gram (+) patojen %23,09 (n=91) ile *Staphylococcus aureus* idi. En sık görülen gram (-) patojenler %9,13 (n=36) ile *Escherichia coli* ve %9,13 (n=36) ile *Pseudomonas aeruginosa* idi.

Sonuç: Çalışmamız sonucunda bölgemizde yanık enfeksiyonlarının en sık nedenlerinin *S. aureus*, *E. coli* ve *P. aeruginosa*'ya bağlı olduğunu tespit ettik. Bu bakterilere karşı etkili geniş spektrumlu antibiyotik kullanımının kültür raporları gelene kadar klinik tedavilere katkı sağlayacağını umuyoruz.

Anahtar Kelimeler: Yanık, Yara, Mikrobiyolojik kültür sonuçları, Antibiyotikler

Öne Çıkanlar

- Bölgemizde yanık yara yeri enfeksiyon oranını arttıran nedenler
- Yanık yara kültürü raporunun bölgemizde yaygın olarak görülen sonuçları
- Bölgemizdeki bakterilerin antibiyotiklere duyarlılık sonuçları
- Bölgemizde bakterilerin antibiyotiklere direnç sonuçları

INTRODUCTION

Burn is a type of injury to the skin and other tissues caused by heat, electricity, chemicals, friction or radiation¹. About 180,000 deaths a year are caused by burns, and most of these deaths occur in less developed countries¹. Children and women are the most affected groups from burn injuries. Non-fatal burn wounds result in significant morbidity, prolonged hospital stays, cosmetic impairments, and often stigmatization and rejection¹. In 2015, 67 million people were affected by burns².

Burn wound sites are a sensitive region for the growth of opportunistic organisms³. Infection is an important cause of morbidity and mortality in burn patients and creates difficulties in burn treatment⁴. The risk of infection, which can lead to sepsis, is increased due to changes in a patient's immunity after burn trauma⁵. After the initial care, complications due to infections in burn patients constitute 50%-75% of the

mortality⁶⁻⁸. There are many factors that cause wound infection in burn injuries, including being in an immunocompromised state, invasive procedures performed in healthcare facilities, and prolonged hospitalization. Patient age, total body surface area (TBSA) and the degree of burn wounds are factors that affect the morbidity and mortality of patients. In addition, the factors affecting morbidity and mortality related to microbiological organisms are the type and number of infections, enzyme / toxin production, and the mobility of organisms.

Superficial bacterial contamination can cause sepsis in burn patients and both are directly linked to each other⁸⁻¹⁰. There are three characteristic areas of a burn wound. The first is the coagulation site closest to the heat source, which forms a scab. The second area is adjacent to this zone and called the stasis zone, An increased risk of ischemia depending on decreased blood perfusion. The third zone is the hyperemia zone which, relative to normal skin,

increased blood flow with vasodilation bypasses with minimal cellular damage. The most important, it is the region containing the most protein-rich eschar, which supports microbial growth as result of its dead and avascular structure. Moreover, these properties prevent the accessing of immune cells and systemic antibiotics⁶. Burn wound remains sterile for a certain period of time after a thermal injury³, but is then enriched by organisms that are carried by healthcare and other personnel¹¹.

Gastrointestinal system is an important source of infection in burn patients. Endogenous organisms may contaminate the burn wound site via feces¹¹.

The increasing patient number in public hospitals causes delay of several days between taking patient cultures and receiving the reports of culture result. At this critical time, Empirical antibiotic therapy can be administered to burn patients to control infections. However, antibiotic resistance increases as result of inappropriate antibiotic prescriptions and unnecessary use¹²⁻¹⁴.

Therefore, in this study, we carried out to identify the burn wound bacterial profile and their antibiotic sensitivity of inpatients in our region. Until the wound culture reports are finalized, they were made to find suitable sensitive antibiotics for use in their treatments.

METHODS

The study was conducted between January 2010 and January 2020 in accordance with the principles of the 2008 revision of the Declaration of Helsinki, and approval was obtained prior to the study from the local ethics committee for retrospective research (Gazi Yaşargil Training and Research Hospital Ethics Committee/02.07.2021/E-810). The patients hospitalized in Gazi Yaşargil Training and Research Hospital Burn Center were scanned using retrospective clinical records and computer

records. We have included patients admitted to our hospital burn center. Patients who were re-admitted for follow up or outpatient clinic control after one time were excluded from the study. Culture reports of 395 (+) from a total of 1,415 patients were included. Wound cultures were taken from all patients at admission. Age, sex, admission time, place of application, burn degree, burn type, TBSA, burn type, and length of hospital stay were recorded from the patient's records.

Data were analyzed using Statistical Package for Social Sciences (SPSS), v23.0 (IBM SPSS Statistics, Armonk, NY). Descriptive statistics were applied to find frequencies, percentages, means and standard deviations. Quantitative variables such as age and TBSA are expressed as means and standard deviations. Qualitative variables such as bacterial type and burn type are expressed in frequencies and percentages. Normality of quantitative variables was checked by applying Kolmogorov-Smirnov and Shapiro-Wilk tests. Mann-Whitney U tests and Kruskal-Wallis tests were used to find significant differences between the means of nonparametric variables with two or more categories, respectively. The chi-square test was used to compare the percentages of the two categorical variables. The significance level of $p < 0.05$, respectively.

RESULTS

The culture-positive reports of 394 patients from the initial 1,415 patients were included. There were 194 patients (49.2%) who were hospitalized from the emergency room. Another 200 of these (50.8%) were hospitalized from the polyclinic. We had 201 (51.0%) patients from rural and 193 (49.0%) patients from the city center who applied to our hospital. There were 284 (72.1%) patients who arrived on the day of the burn injury, while 110 (27.9%) applied one day or more after the burn injury. There were 394 patients including 217 (55%) male and 177 (45%) female. The mean age of the patients was 12.86 ± 17.34 (min: 1 - max: 94) years. With regard to the types of burns, 317 (80.45%) patients were scalded, 45 (11.42%) had

flame burns, 22 (5.58%) had electrical burns, 3 (0.76%) were burned from embers, 2 (0.05%) had frostbite, 2 (0.05%) had hot object contact burns, and 1 patient (0.02%) each had burns due to tandoori, grape leaves, or green walnuts (Table 1).

Burn injuries were seen mostly in the right lower extremity of 209 (53.04%) patients and in the left lower extremity of 194 (49.23%) patients (Table 1).

Table I: General information About the Patients

Patient		number	percent	all patients %	p value
sex	man	217	55%	56.4%	0.387
	women	177	45%	43.6%	
age group	0-4 ages	224	5,8%	53.2%	0.012
	5-9 ages	39	9.9%	12.5%	
	10-14 ages	14	3.5%	5.0%	
	15-24 ages	37	9.4%	8.9%	
	25-34 ages	30	7.6%	7.7%	
	35-44 ages	17	4.3%	4.8%	
	45-64ages	23	5.8%	5.5%	
	65+	10	2.5%	2.4%	
Application Place	emergency	194	49.2%	49.75%	
	policlinic	200	50.8%	50.25%	
	1 or more day delay	110	27.9%	23.1%	
place of residence	rural	201	51.0%	47.85%	0.065
	urban	193	49.0%	52.15%	
season	winter (December, January, February)	105	26.64%	24.02%	
	spring (March, April, May)	87	22.08%	25.72%	
	summer (June, July, August)	84	21.32%	24.17%	
	autumn (September, October, November)	118	29.95%	26.09%	
Cause of burns	scalding burns	317	80.45%	76.60%	
	flame burns	45	11.42%	9.18%	
	electrical burns	22	5.58%	3.67%	
	embers burns	3	0.76%		
	asphalt burns	2	0.05%		
	frostbite	2	0.05%	0.03%	
	hot object conract burns	2	0.05%		
	tandoori	1	0.02%		
	grape leaf burn	1	0.02%		
	green walnut	1	0.02%		
Location of burns	head-neck	76	19.28%	21.41%	p:0.14
	upper right extremity	133	33.75%	32.08%	p:0.40
	upper left extremity	132	33.5%	32.79%	p:0.159
	front chest + abdomen	112	28.42%	27.85%	0.202
	posterior chest + lumbar region	35	8.88%	7.63%	0.197
	Perineum	29	7.36%	5.30%	0.36
	Lower right extremity	209	53.04%	42.54%	0.152
	lower left extremity	194	49.23%	40.56%	0.52
Burn degree			2.67(min:2-max:4)	2.64(min:2-max:4)	0.04
% burned			14.18(min:2-max:50%)	9.22(min:1-max:50) %	0.083
length of stay in hospital			12.88(min:1-max:39)	6.0 gün(min:1-max:39)	

The average burn degree was 2.67 (min: 2–max: 4). The burn percentage average was 14.18% (min: 2–max: 50). Laboratory test results of the white blood cells (WBC) and C-reactive protein

(CRP) were 13.6 ± 7.13 and 29.49 ± 21.25 respectively.

In the wound culture results, 70.55% were gram (+) and 28.68% were gram (-) bacteria. *C. albicans* was found in wound culture growths at a rate of 0.07%. *S. aureus* was the most common gram (+) bacteria with 23.09% (n = 91). The most common gram (-) bacteria were *E. coli* with 9.13% (n = 36) and *P. aeruginosa* with 9.13% (n = 36) (Table 2).

Table II: Wound Site Culture Results

Bacteria genus	Species	NUMBER	PERCENT
GRAM(-)		113	28.68%
Escherichia	coli	36	9.13%
Enterobacter	aerogenes	4	1.01%
	cloacae	6	1.52%
Pseudomonas	aeruginosa	36	9.13%
	fluorescens	1	0.02%
	putida	2	0.50%
Acinetobacter	Baumannii	8	2.03%
Proteus	mirabilis	6	1.52%
Klebsiella	pneumoniae	5	1.26%
Pantoea	agglomerans	3	0.07%
Serratia	marcescens	2	0.50%
Sphingomonas	paucimobilis	2	0.50%
Aeromonas	Hydrophila	1	0.02%
Burkholderia	cepacia	1	0.02%
GRAM (+)		278	70.55%
Staphylococcus	aureus	91	23.09%
	capitis	3	0.07%
	epidermidis	76	19.28%
	haemolyticus	27	6.85%
	hominis	33	8.37%
	lugdunensis	1	0.02%
	pseudintermedius	1	0.02%
	saprophyticus	2	0.50%
	simulans	1	0.02%
	warneri	2	0.50%
	xylosuse	5	1.26%
Streptococcus	spp	4	1.01%
	pyogenes	3	0.07%
	agalactiae	1	0.02%
Enterococcus	avium	1	0.02%
	faecalis	18	4.56%
Kocuria	kristinae	3	0.07%
	rosea	1	0.02%
Lactococcus	garvieae	1	0.02%
Micrococcus	lylae	1	0.02%
YEAST		3	0.07%
Candida	albicans	3	0.07%
TOTAL		394	100

In the wound culture results of the patients who arrived late (≥ 1 day following their burn), the most gram (+) results were 65.14%. Among these, the most common was *S. aureus* with 20.18% (Table 3).

Table III: Cultural Results in Patients Arriving Late For 1 Day or Mo

Bacteria genus	Species	NUMBER	PERCENT
Gram(-)		38	34.86%
Acinetobacter	baumannii	2	1.83%
Escherichia	coli	10	9.17%
	faecalis	7	6.42%
Klebsiella	pneumoniae	2	1.83%
Pantoea	agglomerans	1	0.91%
Proteus	mirabilis	3	2.75%
pseudomonas	aeruginosa	10	9.17%
	putida	2	1.83%
serratia	marcescens	1	0.91%
Gram(+)		71	65.14%
enterococcus	avium	1	0.91%
kocuria	kristinae	1	0.91%
lactococcus	garvieae	1	0.91%
staphylococcus	aureus	22	20.18%
	epidermidis	17	15.59%
	haemolyticus	9	8.25%
	hominis	12	11.0%
	lugdunensis	1	0.91%
	xylosus	2	1.83%
streptococcus	Spp.	2	1.83%
	agalactiae	1	0.91%
	mutis	1	0.91%
	pyogenes	1	0.91%
Total		109	100%

We had 19 patients who had to be followed up in the intensive care center because of the infection clinic. The mean length of stay in the intensive care unit was 11 days (min: 2-max: 36). Gram (+) organisms were isolated with the highest rate of 78.95% in the culture results of patients in need of intensive care. *S. aureus* was the most common organism with 21.05% (Table 4).

Table IV: Pathogens Insulated in Cultural Results in Patients in Intensive Care

Bacteria genus	Species	NUMBER	PERCENT
Gram(-)		4	21.05%
acinetobacter	baumannii	1	5.26%
escherichia	coli	2	10.52%
proteus	mirabilis	1	5.26%
Gram(+)		15	78.95%
enterococcus	faecilis	1	5.26%
staphylococcus	aerous	4	21.05%
	epidermidis	8	42.10%
	heamolyticus	1	5.26%
	hominis	1	5.26%
Total		19	100%

In the antibiogram of Staphylococcus, which was the most common bacterium in our culture results, the antibiotics to which it was most resistant were cefazoline, tobramycin, and cefoxitin. Antibiotics to which it was most sensitive included moxifloxacin, teicoplanin, imipenem, and colistin (Figure 1).

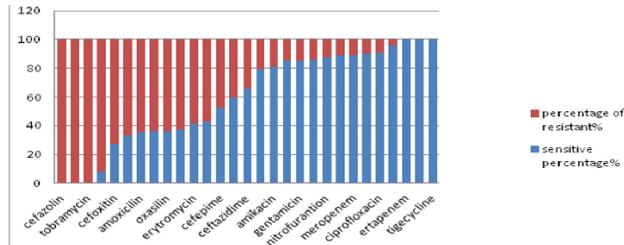


Figure 1: Staphylococcus antibiotic sensitivity

E. coli was one of the most common gram (-) bacteria in our culture results, it was the most resistant to cefturoxime, amoxicillin, oxacillin, and ampicillin. Antibiotics to which it was most sensitive to were ertapenem, meropenem, netilmicin, and teicoplanin (Figure 2).

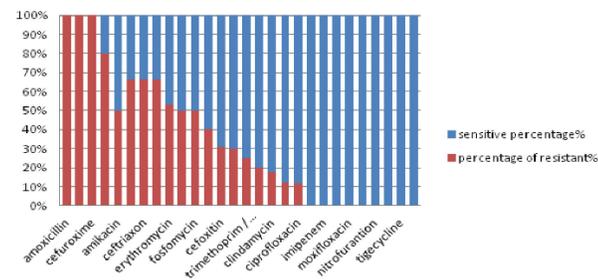


Figure 2: Escherichia coli antibiotic sensitivity

The resistance rate of all Staphylococcus to methicillin was 24.80%, and the resistance rate of S. aureus to methicillin was 20.31%. Our rate of extended spectrum beta-lactamase (ESBL) (+) E. coli was 36.11%.

Percentages of resistance to methicillin-resistant Staphylococcus aureus (MRSA) and ESBL (+) E. coli microorganisms included the penicillin and cephalosporin group of antibiotics. This resistance showed rates of almost 100%. This group of bacteria was more sensitive to antibiotics like piperacillin/tazobactam and trimethoprim/sulfamethoxazole (Figure 3).

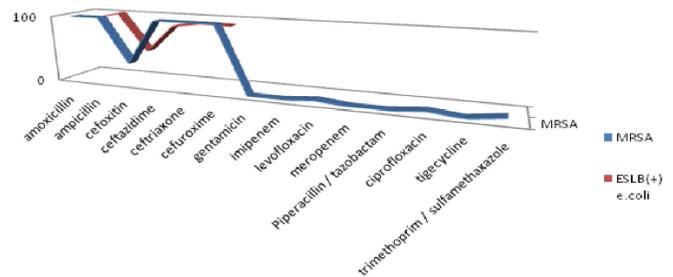


Figure 3: MRSA and ESBL (+) E.coli resistance percentages

The antibiotics to which Pseudomonas, which was the most prominent of the gram (-) pathogens, were most resistant to in the antibiogram were penicillin G, erythromycin, and ampicillin. Antibiotics to which it was most sensitive to included tigecycline, moxifloxacin, levofloxacin (Figure 4).

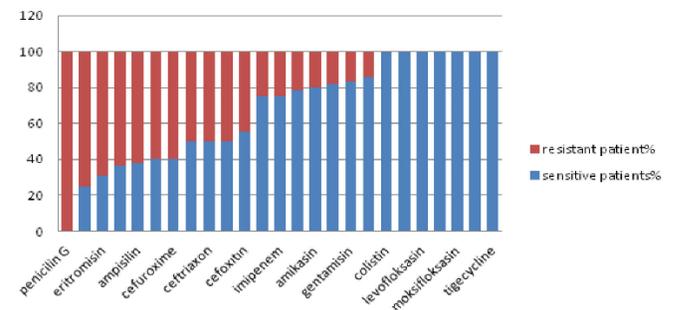


Figure 4: Pseudomonas antibiotic sensitivity

The average antibiotic sensitivity rate of Staphylococcus, which was the most common gram (+) bacteria, was 62.6% and the resistance

rate to antibiotics was 37.4%. The average antibiotic sensitivity rates of *Escherichia* and *Pseudomonas*, which were among the most common gram (-) bacteria, were 64.9% and 68.1%, respectively. Moreover, their resistance rates to antibiotics were 35.1% and 31.9%, respectively (Figure 5).

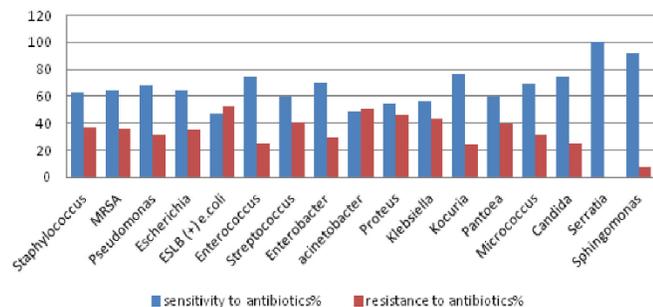


Figure 5: Susceptibility and resistance percentages to microorganism

The average length of stay was 12.86 ± 17.34 (range: 1–39) days. Of the total number of patients, 21 (1.48%) died, two from insufficient fluid replacement in the first 24 hours and the 19 from wound site infections.

DISCUSSION

Wound infection treatment is important in burns. Because wound infection in burns causes prolongation length of hospital stay, sepsis, and even mortality. Wound site infectious diseases are the diseases caused by the proliferation and the invasion of microorganisms on wound sites. It is essential to know the risk factors and treatment of wound infections, which continues to be one of the most important problems of modern burn treatment. With the antibiotic resistance developing in the world, it is important to know the effective antibiotic to be used against microorganisms in the burn wounds.

Datta S.¹⁶ and Meroj A. et al.¹⁷, more women than men affected by the burn injury. However, in our study, it was observed that males (55%) were affected more than females (45%) from burn injuries. This result is consistent with studies by Saaq M.¹⁸ and Chaudhary N.

Ave¹⁹. The reason for this may be more exposure to occupational hazards of the men; Therefore, the risk of burns is higher than women.

Our study involved patients of all ages. The most common cause of burn injuries varied by age groups. While scalding burns and hot object contact burns are mostly seen in children in our region, scald burns, electrical burns, flame burns, chemical burns were observed in mostly adult groups. The age group with the most wound culture (+) was the 0–4 age group, consistent with the study by Tekin Recep et al.²⁰. The reason for this is the most active years occur in the 0–5 age group who generally do not recognize the dangers of their environment. While the burned TBSA was 2%–50% in patients hospitalized in our study, Saaq M. et al. reported 5–40%¹⁸, and 3–93% in the study by Chaudhary N. A. et al.¹⁹.

In our study, the most common cause of burns was scalding, followed by flame and electrical burns. Saaq M.¹⁸. and Chaudhary N.A¹⁹. et al. Reported that the most common cause of burns was flame burns. The reason for the higher rate of scalding burns in our study was because families with many children have more unprotected contact with hot liquids in the kitchen. Therefore, we think scalding burns occurred more frequently due to this environment.

Based on data from the Central Asian and Eastern Europe Antimicrobial Resistance Surveillance (CAESAR) study, *S. aureus* ranks third among the most frequently isolated microorganisms from invasive samples in our country^{21,22}. In the 2017 CAESAR study, the rate of MRSA in our country was 26%²¹.

S. aureus was the most common (23.09%) cause of wound culture (+) results in our study. *S. aureus* was resistant to 20.31% methicillin. Our methicillin resistance rate was close to the that of the CAESAR study. We attribute the lower

level in our study to the use of antibiotics that were dependent on the culture results.

According to the results of the antibiotic sensitivity tests in our study, the antibiotics most sensitive to MRSA were ciprofloxacin, piperacillin/tazobactam, and trimethoprim/sulfamethoxazole.

In our study, the most common microorganism isolated from burn wounds was *S. aureus*, followed by gram (-) pathogens *P. aeruginosa* and *E. coli*. Mehta M., Tekin Recep et al.^{23,24} and its results are inconsistent with our results. Mehta M. et al. The rates of *P. aeruginosa* and *E. coli* were 52% and 10.0%, respectively. According to research conducted by Al Laham et al, *P. aeruginosa* and *E. coli* rates were 52.0% and 9.0 %, respectively. In our study, the rates of *P. aeruginosa* and *E. coli* were 9.13% and 9.13%, respectively. In studies carried out by Mehta M et al., the *P. aeruginosa* resistances to gentamicin amikacin and ciprofloxacin were high (40%–75%). In our study, this rate was lower (16%–19%). In the study by Rahman M. et al., The rate of ESBL (+) *E. coli* found in burn wound cultures is 45.5%²⁵. In our study, this rate was lower by 36.11%.

Various potential risk factors have been investigated for their role in burn wound colonization in burn centers²⁶. When we compared the positive culture results of male patients to all male patients admitted to our burn center (56.4% vs. 55.0%, respectively), the positive culture results of female patients to all female patients admitted to our burn center (43.6% vs. 43.0%, respectively) were not in agreement. We think that the male sex plays a (+) role in the outcome of the culture, however this was not statistically significant ($p = 0.387$).

The percentage of patients coming from rural and city centers was 47.85% and 52.15%, respectively. This ratio was 51.0% and 49.9% in those who had (+) wound culture results. We think that residing in rural areas increases the rate of wound infection. However, this was not statistically significant ($p = 0.065$).

We found that the upper and lower extremities were more commonly contaminated than other areas. In particular, the percentage of perineal infections increased more than the general patient rate. The perineal burn rate in all patients vs. the perineal burn rate in infected patients was 5.3% vs. 7.36%, respectively. This was not a statistically significant difference ($p = 0.36$).

The risk of a (+) wound culture increases as the TBSA increases, with an average of 14.18% (min: 2–max: 50) and 9.22% (min: 1–max: 50) in all patients with culture results. But this difference was not significant ($p = 0.083$).

CONCLUSION

This study is the first large-scale study conducted in our region to compare the results of organisms that cause burn wound infections. Recently, due to increased antibiotic resistance, duration of stay in hospital of patients with increasing morbidity and mortality rates. As a result of our study, we found that the most common causes of burn infections in our region were caused by *S. aureus*, *P. aeruginosa* and *E. coli*. We hope that the use of broad-spectrum antibiotics that can be effective against these bacteria will contribute to clinical treatments until culture results are obtained. Thus, it avoids the unnecessary use of antibiotics we hope to reduce the rate of resistance to antibiotics in southeast of turkey.

Study limitations

The most important factors limiting our study are the retrospective nature of our study.

Ethics Committee Approval: The study was conducted between January 2010 and January 2020 in accordance with the principles of the 2008 revision of the Declaration of Helsinki, and approval was obtained prior to the study from the local ethics committee for retrospective research (Gazi Yaşargil Training and Research Hospital Ethics Committee/02.07.2021/E-810).

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