Internal and Emergency Medicine (2019) 14:259–264
https://doi.org/10.1007/s11739-018-1973-0

IM - ORIGINAL

Risk factors associated with bacteremia correlated with mortality in patients with acute bacterial skin and skin structure infection

Chia-Peng Chang[1] · Cheng-Ting Hsiao[1,2] · Wen-Chih Fann[1]

Received: 17 June 2018 / Accepted: 17 October 2018 / Published online: 25 October 2018
© Società Italiana di Medicina Interna 2018

Abstract
Acute bacterial skin and skin structure infections (ABSSSI) is a common cause of acute admissions worldwide, but the disease is not well understood epidemiologically with respect to factors that determine positive blood cultures or patient mortality. To understand the utility of blood cultures and the association between bacteremia and mortality in patients with ABSSSI, we conducted a retrospective study to investigate factors associated with positive blood cultures and mortality in patients with ABSSSI. A retrospective cohort study of hospitalized adult patients with ABSSSI was conducted in a tertiary hospital in Taiwan between March 2015 and December 2016. A total of 1322 hospitalized patients with ABSSSI are included. The overall mortality rate is 2.1% (28/1322), and 122 patients had positive blood culture results. Comorbidities that are significant risk factors for a positive blood culture include diabetes mellitus and chronic kidney disease. Significant risk factors evident in laboratory evaluations include high C-reactive protein (CRP) level (> 20 mg/dL), hyperglycemia, and hypoalbuminemia. Bacteremia is also a significant factor associated with mortality. A blood culture should be considered for patients with ABSSSI with diabetes mellitus or chronic kidney disease or those exhibiting abnormal CRP, glucose, or albumin levels because of the positive correlation between bacteremia and mortality.

Keywords ABSSSI · Bacteremia · Blood culture · Mortality

Introduction

Acute bacterial skin and skin structure infection (ABSSSI) is defined as a bacterial infection of the skin with a lesion area size of at least 75 cm^2 (lesion size measured by the area of redness, edema, or induration). ABSSSI include cellulitis/erysipelas (A diffuse skin infection characterized by spreading areas of redness, edema, and induration), wound infection (an infection characterized by purulent drainage from a wound with surrounding redness, edema, and induration), and major cutaneous abscess (an infection characterized by a collection of pus within the dermis or deeper that is accompanied by redness, edema, and induration). Common bacterial pathogens causing ABSSSI are *Streptococcus pyogenes* and *Staphylococcus aureus* including methicillin-resistant *S. aureus*. Less common causes include other *Streptococcus* species, *Enterococcus faecalis*, or Gram-negative bacteria [1]. Typically, this infection has a relatively benign course [2]. Treating infectious diseases often emphasize the need to determine microbiology to plan the most effective treatment. However, in cases of cellulitis and acute bacterial skin and skin structure infections (ABSSSI), diagnosis and management mostly depend on the morphological features of the lesion and the clinical setting; the causal pathogen is relatively less important [3]. The role of blood culture in the management of ABSSSI remains controversial. This relates to the incidence of bacteremia in ABSSSI being relatively low, and contamination rates relatively high, which devalues the clinical significance of blood culture [4–8]. Infectious Diseases Society of America (IDSA) guidelines for the management of skin and soft-tissue infections state that blood cultures are recommended only for patients with

✉ Wen-Chih Fann
dr5853@cgmh.org.tw

Chia-Peng Chang
giovanni850730@yahoo.com.tw

Cheng-Ting Hsiao
cth3160@gmail.com

[1] Department of Emergency Medicine, Chang Gung Memorial Hospital, No. 6, Sec. W., Jiapu Rd., Puzi, Chiayi 613, Taiwan, ROC

[2] Department of Medicine, Chang Gung University, Taoyuan, Taiwan, ROC

deleterious conditions, such as malignancy, sepsis, immersion injury, animal bites, neutropenia, and severe cell-mediated immunodeficiency [3]. However, evidence to support these recommendations is limited. Several reported factors for positive blood cultures in cellulitis cases include: age > 65 years, nonlower extremity involvement, liver cirrhosis, and systemic inflammatory response syndrome [9]. Factors associated with a positive blood culture in patients with ABSSSI remain controversial, and findings vary among studies because of sample sizes or study designs. This study investigates factors associated with positive blood cultures, and correlation between bacteremia and mortality in patients with ABSSSI on the basis of clinical conditions including comorbidities and initial laboratory evaluations. This study has a large sample size, which provides a high statistical power of the results. On the basis of our findings, when presented with a case of ABSSSI, clinicians should be able to effectively differentiate between patients in whom blood culturing should be performed, and patients who should be treated more carefully because of the presence of high-risk factors for mortality.

Materials and methods

Patient selection

The Institutional Review Board of Chang Gung Memorial Hospital, Chiayi, Taiwan, approved this retrospective study. We collected retrospective data on patients who had a discharge diagnosis of ABSSSI, identified according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 528.3 (cellulitis and abscess of oral soft tissues), 681.00–681.9 (cellulitis and abscess of the finger and toe), and 682.0–682.9 (other cellulitis and abscess), and who were admitted via our emergency department (ED) from March 2015 to December 2016. Each patient's medical record was reviewed for documentation of ABSSSI or a related diagnosis, clinical characteristics, final diagnosis, hospitalization duration, comorbidities, and mortality. Some of the results have been published (age > 65 years, liver cirrhosis, lymphedema, systemic inflammatory response syndrome, chronic kidney disease, and leukocytosis of $> 13.5 \times 10^3$/μL are shown to be associated with higher risk of bacteremia) [9, 13]. In the current study, we use data collected from these studies for further analysis to evaluate the association between laboratory data and clinical condition recorded in the ED, comorbidities, and bacteremia in ABSSSI patients. All blood cultures were drawn in ED at the same time. Patients aged ≤ 18 years, those found not to have ABSSSI on chart review, and those having a discharge diagnosis of another infectious disease were excluded from the study.

Data analysis

All patients who visited our ED between March 2015 to December 2016, who had a discharge diagnosis of ABSSSI, and who did not meet the exclusion criteria were enrolled in our study. We reviewed the patients' charts and recorded the following variables: age, gender, clinical condition, site of infection, laboratory data, comorbidities, hospital stay, blood culture result, and survival status on discharge. We defined these variables as follows: anemia, hemoglobin < 10 mg/dL in ED; thrombocytopenia, platelet counts $< 100 \times 10^3$ μL in ED; hyperglycemia, serum glucose level of > 200 mg/dL in ED; hypoalbuminemia, albumin < 3.0 g/dL in ED; hyperthermia, body temperature > 38 °C in ED; hypothermia, and body temperature < 35 °C in ED. The WBC counts, CRP, hemoglobin, platelet count, serum glucose, albumin, and creatinine were assessed in the first laboratory analyses in the ED.

Differences between the bacteremia and nonbacteremia groups were assessed using the Chi-square test for all the categorical variables (Table 1). To identify possible effects on bacteremia, a multivariate analysis was applied for variables with a p value of < 0.05 for differences between the bacteremia and nonbacteremia groups (Table 2). Differences between mortality and survival were also assessed using the Chi-square test (Table 3). Factors with a p value of < 0.05 for differences between mortality and survival were also included in multivariate analysis (Table 4). Because bacteremia is the primary factor evaluated in this study, it was included in the logistic regression model.

Results

Of 1322 patients, 122 patients had positive blood cultures, and 28 patients died. Therefore, the positivity rate of blood cultures is 9.2%, and the mortality rate is 2.1%. The analysis of variables between bacteremia and nonbacteremia groups is summarized in Table 1. Compared with the nonbacteremia group, the bacteremia group has a higher incidence of diabetes mellitus (58.2% vs. 37.1%; $p = 0.047$) and chronic kidney disease (39.3% vs. 22.8%; $p = 0.008$). Significant differences are observed in the WBC count $> 10 \times 10^3$/μL, CRP > 20 mg/dL, anemia, hyperglycemia, hypoalbuminemia, creatinine > 1.5 mg/dL, and hyperthermia. In addition, the bacteremia groups have longer hospital stays and a higher mortality rate.

Multivariate analysis reveals major contributing factors to bacteremia including: diabetes mellitus ($p = 0.001$, OR 4.18, 95% CI 2.03–14.85), chronic kidney disease ($p = 0.003$, OR 3.69, 95% CI 0.64–8.73), CRP > 20 mg/

Table 1 Clinical characteristics of the bacteremia and nonbacteremia groups

Variable	Bacteremia group ($n=122$)	Nonbacteremia group ($n=1200$)	p value
Age ≥ 65, no. (%)	68 (55.7%)	712(59.3)	.671
Sex, no. (%)			.958
Male	74 (60.7%)	728 (60.7%)	
Female	48 (39.3%)	472 (39.3%)	
Clinical condition, no. (%)			
Wound	68 (55.7%)	607 (50.6%)	.313
Swelling	113 (92.6%)	934 (77.8%)	.058
Comorbidity, no. (%)			
Diabetes mellitus	71 (58.2%)	453 (37.1%)	.047*
CKD	48 (39.3%)	273 (22.8%)	.008*
Liver cirrhosis	19 (15.6%)	105 (8.8%)	.129
Adrenal insufficiency	6 (4.9%)	49 (4.1%)	.996
PAD	9 (7.4%)	63 (5.3%)	.650
Admission data, no. (%)			
WBC count > 10×10^3/μL	52 (42.3%)	398 (33.2%)	<.001*
WBC count < 4×10^3/μL	19 (15.5%)	304 (25.3%)	.732
CRP > 20 mg/dL	65 (53.3%)	433 (36.1%)	<.001*
Anemia	43 (35.2%)	347 (29.8%)	.033*
Thrombocytopenia	37 (30.3%)	307 (25.6%)	.576
Hyperglycemia	70 (57.4%)	478 (39.8%)	<.001*
Hypoalbuminemia	77 (63.1%)	502 (41.8%)	<.001*
Creatinine > 1.5 mg/dL	66 (54.1%)	426 (35.5%)	.001*
Hyperthermia (BT ≥ 38 °C)	47 (38.5%)	283 (23.6%)	<.001*
Hypothermia (BT < 35 °C)	19 (15.6%)	226 (18.8%)	.509
Hospital stay (day)	14.4 (± 11.3)	10.3 (± 8.7)	<.001*
Mortality, n (%)	12 (9.8%)	16 (1.3%)	.016*

Values are presented as mean ± standard deviation or number (%). Anemia, hemoglobin < 10 mg/dL. Thrombocytopenia, platelet counts < 100×10^3 μL. Hyperglycemia, serum glucose > 200 mg/dL. Hypoalbuminemia, albumin < 3.0 g/dL

PAD peripheral artery disease, *CKD* chronic kidney disease, *WBC* white blood cell, *CRP* C-reactive protein

*$p<0.05$

dL ($p<0.001$, OR 2.55, 95% CI 1.68–9.26), hyperglycemia ($p=0.016$, OR 1.95, 95% CI 1.09–4.15), and hypoalbuminemia ($p=0.001$, OR 3.43, 95% CI 2.25–9.58) (Table 2).

The analysis of variables between the patients who survived and those who did not is summarized in Table 3. Significant differences are observed in the age subgroup of > 65 years; and percentage of patients with chronic kidney disease, liver cirrhosis, WBC count > 10×10^3/μL, CRP > 20 mg/dL, thrombocytopenia, hypoalbuminemia, and hyperthermia (Table 3). After controlling for factors that are

Table 2 Multivariable analysis to identify independent risk factors for bacteremia in patients with ABSSSI

Variables	OR	95% CI	p value
Diabetes mellitus	4.18	2.03–14.85	.001*
Chronic kidney disease	3.69	0.64–8.73	.003*
WBC count > 10×10^3/μL	1.18	0.98–5.78	.069
CRP > 20 mg/dL	2.55	1.68–9.26	<.001*
Anemia	1.96	0.87–3.84	.448
Hyperglycemia	1.95	1.09–4.15	.016*
Hypoalbuminemia	3.43	2.25–9.58	.001*
Creatinine > 1.5 mg/dL	1.22	0.88–3.65	.767
Hyperthermia (BT ≥ 38 °C)	2.65	1.54–7.81	.853

Anemia, hemoglobin < 10 mg/dL. Hyperglycemia, serum glucose > 200 mg/dL. Hypoalbuminemia, albumin < 3.0 g/dL

WBC white blood cell, *CRP* C-reactive protein

*$p<0.05$

significantly related to mortality, we find that age ≥ 65 years (odds ratio [OR]: 4.37, Table 4), liver cirrhosis (OR: 1.06), hypoalbuminemia (OR: 7.12), and bacteremia (OR: 1.97) significantly affect mortality. A power analysis was conducted for a logistic regression. It is determined that, for a sample size of 1322 participants, with an alpha of 0.05, OR 1.97 (bacteremia), the statistic power is nearly 1.0.

An extremity area was the most common (70.7%) site of cellulitis. No significant difference in bacteremia or mortality is found according to the site of infection (Tables 5, 6).

Staphylococcus and *Streptococcus* species are the most frequent causative organisms. Polymicrobial infections and anaerobic organisms account for 13.1% and 6.6% of infections, respectively. However, no difference in mortality is found according to the isolated organisms ($p=0.412$, Table 7).

Discussion

Our study examines the factors of clinical conditions, comorbidities, and laboratory data associated with bacteremia, which include diabetes mellitus and chronic kidney disease, high CRP level, hypoalbuminemia, and hyperglycemia. High CRP levels may indicate severe infection or inflammation caused by ABSSSI. Low albumin and high serum glucose levels are correlated with chronic kidney disease, diabetes mellitus, which are often associated with chronic illness and poor nutrition status. An association between comorbidity and positivity rates of blood culture has been described before, especially for malignancy, immunodeficiency, or diabetes mellitus [3, 10]. Diabetes mellitus is a comorbidity with a high prevalence, and the relationship between diabetes mellitus and positive blood

Table 3 Clinical characteristics of the mortality and survival groups

Variable	Mortality group ($n=28$)	Survival group ($n=1294$)	p value
Age ≥ 65, no. (%)	22 (78.6%)	798 (61.7%)	.004*
Sex, no. (%)			.697
Male	16 (57.1%)	790 (61.1%)	
Female	12 (42.9%)	504 (38.9%)	
Clinical condition, no. (%)			
Wound	21 (75%)	654 (50.6%)	.198
Swelling	25 (89.3%)	1027 (79.4%)	.235
Comorbidity, no. (%)			
Diabetes mellitus	12 (42.9%)	513 (37.1%)	.907
CKD	12 (42.9%)	309 (22.8%)	.017*
Liver cirrhosis	6 (21.4%)	118 (9.1%)	.024*
Adrenal insufficiency	1 (3.6%)	54 (4.2%)	.886
PAD	3 (10.7%)	69 (5.3%)	.205
Admission data, no. (%)			
WBC count > 10×10^3/μL	15 (53.6%)	516 (39.9%)	< .001*
WBC count < 4×10^3/μL	4 (14.3%)	253 (19.6%)	.086
CRP > 20 mg/dL	19 (67.9%)	533 (41.2%)	< .001*
Anemia	10 (35.7%)	395 (30.5%)	.964
Thrombocytopenia	8 (28.6%)	278 (21.5%)	.03*
Hyperglycemia	11 (39.3%)	316 (25.4%)	.10
Hypoalbuminemia	17 (60.7%)	401 (31.0%)	< .001*
Creatinine > 1.5 mg/dL	10 (35.7%)	254 (19.6%)	.054
Hyperthermia (BT ≥ 38 °C)	10 (35.7%)	295 (22.8%)	.04*
Hypothermia (BT < 35 °C)	4 (14.3%)	148 (11.5%)	.708
Hospital stay (day)	16.3 (±7.5)	10.3 (±6.1)	.003*
Bacteremia, *n* (%)	12 (42.9%)	110 (8.5%)	< .001*

Values are presented as mean ± standard deviation or number (%). Anemia, hemoglobin < 10 mg/dL. Thrombocytopenia, platelet counts < 100×10^3μL. Hyperglycemia, serum glucose > 200 mg/dL. Hypoalbuminemia, albumin < 3.0 g/dL

PAD peripheral artery disease, *CKD* chronic kidney disease, *WBC* white blood cell, *CRP* C-reactive protein

*$p < 0.05$

Table 4 Multivariable analysis to identify independent risk factors for mortality in patients with ABSSSI

Variables	OR	95% CI	p value
Age ≥ 65	4.37	2.34–8.16	< .01*
Chronic kidney disease	1.89	0.94–3.81	.12
Liver cirrhosis	1.06	1.03–1.09	.02*
WBC count > 10×10^3/μL	1.13	0.43–2.95	.87
CRP > 20 mg/dL	2.73	2.69–2.78	.06
Thrombocytopenia	1.49	0.41–5.48	.44
Hypoalbuminemia	7.12	1.61–31.56	< .01*
Hyperthermia (BT ≥ 38 °C)	1.21	1.05–3.48	.32
Bacteremia	1.97	1.04–3.74	< .01*

Thrombocytopenia, platelet counts < 100×10^3 μL. Hypoalbuminemia, albumin < 3.0 g/dL

WBC white blood cell, *CRP* C-reactive protein

*$p < 0.05$

Table 5 Mortality according to the site of infection

Site of infection	No. (%)	Mortality, *n* (%)	p value
Extremities	934 (70.7%)	19 (67.9%)	.549
Head and neck	108 (8.2%)	3 (10.7%)	–
Chest	46 (3.5%)	0 (0%)	–
Back	32 (2.4%)	2 (7.1%)	–
Genital area	202 (15.2%)	4 (14.3%)	–
Total	1322 (100%)	28 (100%)	–

cultures has been described [11]. In our study, the positivity rate for patients with diabetes is also higher than in patients without diabetes. A study addressing hypoalbuminemia (< 3 g/dL) and bacteremia as factors independently associated with prolonged hospitalization and mortality gives results similar with our findings [12]. In the logistic regression model for factors associated with

Table 6 Bacteremia according to the site of infection

Site of infection	No. (%)	Bacteremia, *n* (%)	*p* value
Extremities	934 (70.7%)	65 (53.3%)	.071
Head and neck	108 (8.2%)	17 (13.9%)	–
Chest	46 (3.5%)	9 (7.4%)	–
Back	32 (2.4%)	10 (8.2%)	–
Genital area	202 (15.2%)	21 (17.2%)	–
Total	1322 (100%)	122 (100%)	–

mortality, bacteremia is identified as an independent risk factor for mortality (OR: 1.97) in ABSSSI. Therefore, a blood culture should be considered for patients with ABSSSI with diabetes mellitus or chronic kidney disease or those exhibiting abnormal CRP, glucose, or albumin levels because of the positive correlation between bacteremia and mortality. The causative organism has no significant association with mortality. The site of infection also demonstrates no clinical correlation with mortality.

A Swedish study shows that blood cultures are more frequently performed in patients who fulfill the severe inflammatory response syndrome (SIRS) criteria [13]. However, they did not compare the positivity rates of blood cultures between patients who did or did not fulfill the SIRS criteria. An American retrospective chart review compares the positivity rates of blood cultures in patients with cellulitis with or without fever [8]. Unexpectedly, patients without fever have positive blood cultures significantly more frequently than patients with fever, which supports our findings that hyperthermia is not associated with a higher positivity rate of blood cultures in ABSSSI. The results of this study may have clinical implication for the clinical choice to send blood cultures or not in patients with ABSSSI.

The most common cause of cellulitis is beta-hemolytic S*treptococci* (groups A, B, C, G, and F); most commonly, group A *Streptococci* or *Streptococcus pyogenes* are observed. *S. aureus* (including methicillin-resistant strains) is a notable but less common cause [14–16]. We contend that the increasing incidence rate of cellulitis caused by *S. aureus* (including methicillin-resistant strains) should be a global health concern. Gram-negative aerobic bacilli are identified in a minority of cases. In immunocompromised patients, the spectrum of potential pathogens is much broader, and infectious disease consultation is warranted, because a weakened immune system is a risk factor for mortality [14].

Our study has several limitations. Its study design (we used the initial laboratory data in the ED) may result in small populations of some factors (e.g., hyperthermia, thrombocytopenia, and leukocytosis), which might represent a significant impact on mortality in ABSSSI patients. This may limit the evaluation of these factors and other possible significant predictors. Furthermore, because of this retrospective setup, we selected patients based on the diagnosis documented in the patient files, and we were dependent on the documentation of health care providers. Moreover, we used all-cause mortality as an end-point, which may have overestimated the number of deaths due strictly to ABSSSI admissions.

There are several strengths to this study. Several characteristics and variables that have not previously been associated with bacteremia in cellulitis, which have positive

Table 7 Micro-organisms of patients with ABSSSI with positive blood culture

Pathogens	Nonsurvival group (*n* = 28)	Survival group (*n* = 1294)	Total, no. (%) (*n* = 122)	*p* value
MSSA	1	19	20 (16.4)	.412
MRSA	2	5	7 (5.7)	
Streptococcus species	0	28	28 (22.9)	
Klebsiella pneumoniae	1	5	6 (4.9)	
Escherichia coli	1	4	5 (4.1)	
Enterococcus species	0	4	4 (3.3)	
Pseudomonas aeruginosa	2	3	5 (4.1)	
Anaerobes	1	7	8 (6.6)	
Acinetobacter baumannii	0	3	3 (2.5)	
Hemophilus influenzae	0	3	3 (2.5)	
Fungi	0	4	4 (3.3)	
Other Gram-positive	0	6	6 (4.9)	
Other Gram-negative	1	6	7 (5.7)	
Polymicrobial	3	13	16 (13.1)	

MSSA methicillin-susceptible *Staphylococcus aureus*, *MRSA* methicillin-resistant *Staphylococcus aureus*, *Polymicrobial* more than one species

correlations with mortality, are examined. The large number of patients that we studied provides a high power for estimates in the model that we used.

Conclusion

These findings can be used to stratify patients with ABSSSI according to the degree of risk for bacteremia, and may be helpful for deciding the most appropriate means of care—outpatient treatment or hospitalization.

Acknowledgements The authors thank all the participants who participated in this study. This manuscript was edited by Wallace Academic Editing.

Funding This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Statement of human and animal rights The institutional review board of our hospital approved this retrospective study (100-4178B).

Informed consent Consent to participate was not applicable.

References

1. Guidance for industry acute bacterial skin and skin structure infections: developing drugs for treatment. U.S. Department of Health and Human Services Food and Drug Administration Center for Drug Evaluation and Research (CDER) October 2013. http://www.fda.gov/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/default.htm
2. Bisno AL, Stevens DL (1996) Streptococcal infections of skin and soft tissues. N Engl J Med 334:240–245
3. Stevens DL, Bisno AL, Chambers HF, Dellinger EP, Goldstein EJ, Gorbach SL et al (2014) Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014 update by the infectious diseases society of America. Clin Infect Dis 59:e10–e52
4. Perl B, Gottehrer NP, Raveh D, Schlesinger Y, Rudensky B, Yinnon AM (1999) Costeffectiveness of blood cultures for adult patients with cellulitis. Clin Infect Dis 29:1483–1488
5. Swartz MN (2004) Clinical practice. Cellulitis. N Engl J Med. 350:904–912
6. Peralta G, Padrón E, Roiz MP, De Benito I, Garrido JC, Talledo F et al (2006) Risk factors for bacteremia in patients with limb cellulitis. Eur J Clin Microbiol Infect Dis 25:619–626
7. Gunderson CG, Martinello RA (2012) A systematic review of bacteremias in cellulitis and erysipelas. J Infect 64:148–155
8. Paolo WF, Poreda AR, Grant W, Scordino D, Wojcik S (2013) Blood culture results do not affect treatment in complicated cellulitis. J Emerg Med 45:163–167
9. Lee CY, Kunin CM, Chang C et al (2016) Development of a prediction model for bacteremia in hospitalized adults with cellulitis to aid in the efficient use of blood cultures: a retrospective cohort study. BMC Infect Dis 16:581
10. Perl B, Gottehrer NP, Raveh D, Schlesinger Y, Rudensky B, Yinnon AM (1999) Cost-effectiveness of blood cultures for adult patients with cellulitis. Clin Infect Dis. 29(6):1483–1488
11. Kielhofner MA, Brown B, Dall L (1998) Influence of underlying disease process on the utility of cellulitis needle aspirates. Arch Intern Med 148(11):2451–2452
12. Figtree M, Konecny P, Jennings Z, Goh C, Krilis SA, Miyakis S (2010) Risk stratification and outcome of cellulitis admitted to hospital. J Infect 60(6):431–439
13. Blackberg A, Trell K, Rasmussen M (2015) Erysipelas, a large retrospective study of aetiology and clinical presentation. BMC Infect Dis 15:402
14. Semel JD, Goldin H (1996) Association of athlete's foot with cellulitis of the lower extremities: diagnostic value of bacterial cultures of ipsilateral interdigital space samples. Clin Infect Dis 23:1162–1164
15. Bruun T, Oppegaard O, Kittang BR, Mylvaganam H, Langeland N, Skrede S (2016) Etiology of cellulitis and clinical prediction of streptococcal disease: a prospective study. Open Forum Infect Dis. 3:181
16. Baibergenova A, Drucker AM, Shear NH (2014) Hospitalizations for cellulitis in Canada: a database study. J Cutan Med Surg. 18:33–37