Epidemiology of burns

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Chapter 5

Bacteriological cultures on admission of the burn patient: To do or not to do, that's the question

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ABSTRACT

Introduction: In many burn centers, routine bacteriological swabs are taken from the nose, throat, perineum, and the burn wound on admission, to check for the presence of microorganisms that require specific measures in terms of isolation or initial treatment. According to the Dutch policy of "search and destroy," for example, patients infected by multiresistant bacteria have to be strictly isolated, and patients colonized with *β-haemolytic Streptococcus pyogenes* must receive antibiotic therapy to prevent failed primary closure or loss of skin grafts. In this respect, the role of bacteria cultured on admission in later infectious complications is investigated. The aim of this study is to assess systematic initial bacteriological surveillance, based on an extensive Dutch data collection.

***Materials and methods*:** A total of 3271 patients primarily admitted to the Rotterdam Burn Centre between January 1987 and August 2010 with complete bacteriological swabs from nose, throat, perineum, and the burn wounds were included. For this study, microbiological surveillance was aimed at identifying resistant microorganisms such as methicillin-resistant *Staphylococcus aureus (MRSA)*, multiresistant *Acinetobacter*, and multiresistant *Pseudomonas*, as well as Lancefield A β-hemolytic streptococci (HSA), in any surveillance culture.
The cultures were labelled as "normal flora or non-suspicious" in the case of no growth or a typical low level of bacterial colonization in the nose, throat, and perineum and no overgrowth of one type of microorganism.
Further, the blood cultures of 195 patients (6.0%) who became septic in a later phase were compared with cultures taken on admission to identify the role of the initially present microorganisms. Statistical analysis was performed using SPSS 20.0.

Results: Almost 61% of the wound cultures are "non-suspicious" on admission. MRSA was cultured in 0.4% (14/3271) on admission; 12 out of these 14 patients (85.7%) were repatriated. Overall, 9.3% (12/129) of the repatriated patients were colonized with *MRSA*. Multiresistant *Acinetobacter* or *Pseudomonas* was detected in 0.3% (11/3271 and 10/3271, respectively). In total, 18 of the 129 repatriated patients (14%) had one or more resistant bacteria in cultures taken within the first 24 h after admission in our burn center. On admission, *S. pyogenes* was found in 3.6% of patients (117/3271), predominantly in children up to 10 years of age (81/1065 = 7.6%).

Conclusions: Resistant bacteria or microorganisms that impede wound healing and cause major infections are found only in few bacteriological specimens obtained on admission of patients with burn wounds. However, the consequences in terms of isolation and therapy are of great importance, justifying the rationale of a systematic bacteriological surveillance on admission.

Patients who have been hospitalized for several days in a hospital abroad and are repatriated show more colonization at admission in our burn center. The microorganisms identified are not only (multi)resistant bacteria, showing that a hospital environment can quickly become a source of contamination. These patients require special attention for resistant bacteria. HSA contamination is observed more frequently in younger children. Bacteria present at admission do not seem to play a predominant role in predicting later sepsis.

1. INTRODUCTION

Infections remain one of the major complications after severe burns. They are facilitated by the suppressed innate immune response of the patient and the skin barrier defect, covered with debris and necrotic tissue [1,2]. The human body is host to a number of microbes occurring in various forms of host–microbe associations, such as commensals, mutualists, pathogens, and opportunistic symbionts [3]. Potentially pathogenic microorganisms can be present on the skin as commensal flora, or they may be transferred acutely (e.g., by cooling with contaminated water) or during hospitalization (hospital acquired). The amount and type of microorganisms on and in the burned tissue do influence wound healing, the frequency of invasive infections, and the clinical characteristics of such infections [4]. Therefore, knowledge of the colonization status at any time is important in the treatment of burn patients [4].

For this reason, as in other intensive care units, most burn centers (BCs) use routine surveillance, based on cultures taken on admission and routinely afterwards (e.g., weekly) [2,4]. Apart from the burn wounds, the body sites cultured most often are the nose, throat, and perineum [2,5,6]. Positive surveillance cultures may lead to more infection prevention measures, for example, methicillin-resistant *Staphylococcus aureus (MRSA)*, which can guide antimicrobial therapy and may identify and control outbreaks (source determination) [7–11]. Surprisingly, little is known about the initial colonization status of burn patients at admission, as most studies have included few patients or only studied specific microorganisms (e.g., Pseudomonas spp.) [20,21]. It might be assumed that deep burn wounds are initially sterile, as they are exposed to the heat source. But is this still the case when the patient arrives in the BC a few hours later? Therefore, the objective of this study was to assess the frequency of colonization on admission, and to identify the microorganisms involved and their potential role in later septic complications in a large cohort of burn patients over a 24-year time period.

2. METHODS

2.1. Bacteriological survey in our hospital

In the BC of the Maasstad Hospital in Rotterdam, the Netherlands, routine bacteriological swabs are taken from the burn wounds as well as from the nose, throat, and perineum on admission. Other cultures such as blood, urine, and sputum were only taken when clinically indicated on admission. In the case of exceptional microorganisms, necessary measures such as quarantining patients can be taken. When the cultures of these patients reveal Lancefield group A *β-hemolytic streptococci (HSA),* antibiotics are started to prevent failure in primary closure or loss of skin grafts. Furthermore, the Dutch medical system uses a "search-and-destroy" policy with respect to resistant microorganisms, especially for repatriated patients, with a time difference between accident and secondary BC admission. This study focuses on the bacteriological cultures sampled within the first 24 h of BC admission and the follow-up cultures of septic patients.

2.2. Study design and population

This retrospective cohort study involved all patients admitted to the Rotterdam Burn Centre (RBC) in the Netherlands between January 1987 and September 2010. Data were gathered by merging a database used for epidemiological purposes and a microbiology database. The standard treatment protocols of the BC are described elsewhere [16].

2.3. Routine surveillance

On admission, surveillance cultures were taken from the following four body sites: burn wounds (B), nose (N), throat (T), and perineum (P). The swabs were analyzed in the hospital's microbiological laboratory. Pathogens were identified and
their susceptibility to antimicrobial agents was tested using routine microbiological methods. Cultures were labelled as "normal flora or non-suspicious" in the case of no growth or a typical low level of bacterial colonization in the nose, throat,
and perineum and no overgrowth of one type of microorganism. Based on his or her interpretation, the laboratory technician decided on further analyzing the grown cultures or not. The normal flora for the nose was considered to be *Staphylococcus epidermidis* and diphtheroids. The flora of the nose included *S. epidermidis*, diphtheroids, *Streptococcus viridans* (except for *Streptococcus pneumoniae*), *Neisseria* (except for *Neisseria meningitidis*), whereas that of the perineum included *S. epidermidis* and few Gram-negative bacteria (except for nonfermentatives). Few colonies of *S. epidermidis* or diphtheroids were regarded as the normal flora of burn wounds. Apart from the abovementioned normal flora at various body sites, in the present study, positivity was defined as the presence of the following

potentially pathogenic microorganisms:

- *Staphylococcus aureus* (SA) including *MRSA*
- *S. epidermidis* (coagulase-negative *Staphylococcus (CNS)*)
- *Streptococcus pyogenes*
- *Enterobacte*r species
- Other coliforms (*Escherichia coli, Klebsiella,* etc.)
- *Pseudomonas aeruginosa* (*PsA*)
- *Acinetobacter baumannii*
- Fungi including yeast

A large number of antibiotics were tested and reported. Because of their varying sensitivities , only gentamicin resistance was recorded, but not for the remaining antibiotics (tobramycin, ciprofloxacin, etc.). Furthermore, the known existing microorganism was determined by the once-weekly antibiogram, whereas this was always done with the first isolates.

2.4. Relation between bacteria cultured on admission and blood cultures

In septic patients with symptoms such as high fever and hemodynamic instability, blood cultures were performed and compared with the cultures taken on admission.

2.5. Statistical analysis and definitions

For analysis, only the data of patients with complete sets of admission cultures (burn wounds, nose, throat, and perineum) were used. Data expression and statistical analyses were performed using SPSS 20.0 (SPSS Inc., Chicago, IL, USA).

The role of routine surveillance cultures on admission to predict pathogens in blood cultures of patients who developed sepsis later was expressed by the following operating characteristics: sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) with respective 95% confidence intervals (CI).

Sensitivity was defined as the proportion of patients with a positive admission culture and also the related positive blood culture (true-positive rate).

Specificity was defined as the proportion of patients with a negative admission culture and also a negative blood culture (true-negative rate).

Microorganisms found either in the surveillance cultures on admission or in the blood cultures were respectively defined as 'false positive' and 'false negative'.

The PPV is the probability of positive blood cultures with the same microorganisms cultured on admission, and the NPV is the probability that both blood cultures and surveillance cultures on admission are negative. Sensitivity, specificity, PPV, and NPV are expressed as percentages.

3. RESULTS

3.1. Enrolment

In the period from January 1987 until August 2010, 5342 patients were admitted to the RBC. Of these patients, 251 were readmitted for the same burns and 434 for secondary corrections, and 111 patients did not suffer from burns but, for example, were diagnosed with toxic epidermal necrolysis and other non-burn skin defects.
Of the remaining 4546 patients, we were able to match 4219 patients (93%) from the two different databases. Not all cultures (nose, throat, perineum, and wound) were taken from 948 patients within 24 h after admission, leaving 3271 (72%) with complete cultures for analysis (Fig. 1).

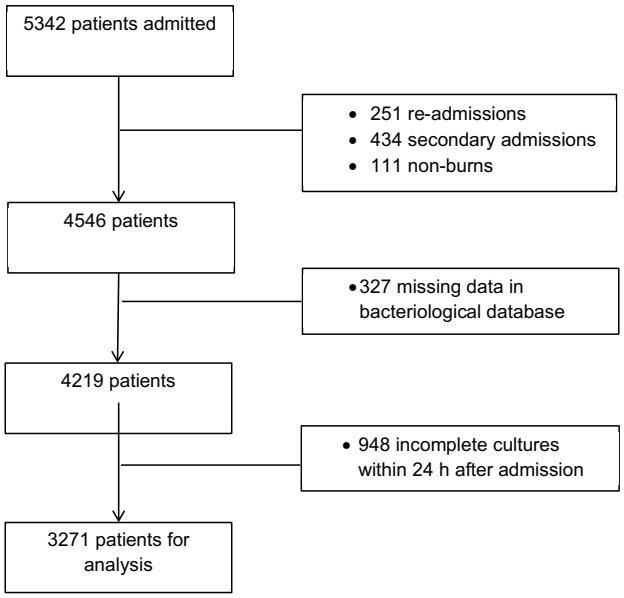

Figure 1. Enrollment of the cohort.

3.2. Demographics

Most patients were younger men (median age 26.0 years,) with limited burned total body surface area (TBSA) (median 6.0%). The study population included 129 repatriated patients, whose interval between the accident and admission to our BC was on average 6.5 days (0–67). The main characteristics of the analyzed cohort of patients are reported in Table 1.
Values are described as median (interquartile range) and mean (range) or n (%). On average, the repatriated patients are 5 years older and have larger burns.

Table 1 – Main characteristics of the analyzed cohort of patients ($n = 3271$).

	All patients ($n = 3271$)	Patients from NL ($n = 3142$)	Repatriated ($n = 129$)
Age (years)			
Median (IQR)	26.0 (3.0–45.0)	25.0 (3.0–44.0)	34.0 (12.5–51.5)
Mean (range)	28.1 (0–98)	27.8 (0–98)*	32.8 (0–83)*
TBSA (%)			
Median (IQR)	6.0 (4.0–12.0)	6.0 (4.0–12.0)	8.0 (5.0–15.5)
Mean (range)	10.4 (0–85)	10.2 (0–85)**	13.9 (1–85)**
Male gender (%)	2221/3271 (67.9)	2130/3142 (67.8)	91/129 (70.5%)
Repatriated from abroad (%)	129/3271 (3.9)	0/3142 (0.0)	129/129 (100)

IQR, interquartile range.
* $p < 0.05$.
** $p < 0.001$.

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3.3. Microorganisms cultured on admission

The results of the microbiological examination on admission are reported in Table 2.
Here, a distinction is made between the patients admitted directly from the Netherlands and those from abroad. The majority of inventory cultures in the throat and perineum proved to be non-suspicious (75.9/68.2% and 79.1/77.5% respectively). However, the nose (45.2/46.5%) and burn wound (38.6/51.9.2%) were frequently colonized.
Positive cultures included a wide range of Gram-positive and Gram-negative microorganisms, predominantly SA (40.4/48.8%) and streptococci (29.8/20.2%).

Table 2 – Microorganisms found on admission.

	Nose NL/repat	Throat NL/repat	Perineum NL/repat	Wound NL/repat	Found on admission NL/repat
Non-suspicious or sterile	1721/69 (54.8/53.5%)	2386/88 (75.9/68.2%)	2485/100 (79.1/77.5%)	1928/62 (61.4/48.1%)**	
Staphylococcus aureus (including MRSA)	743/41 (23.6/31.8%)*	287/19 (9.1/14.7%)*	301/17 (9.6/13.2%)	558/47 (17.8/36.4%)**	1269/63 (40.4/48.8%)
E. coli	23/1 (0.7/0.8%)	33/0 (1.0/0.0%)	31/1 (1.1/0.8%)	82/1 (2.6/0.8%)	160/3 (5.1/2.3%)
Enterobacter	32/4 (1.0/3.1%)	27/3 (0.9/2.3%)	3/1 (0.1/0.8%)	137/13 (4.4/10.1%)*	181/17 (5.8/13.2%)*
Serratia, Proteus, Citrobacter	59/2 (1.9/1.6%)	18/3 (0.6/2.3%)*	7/0 (0.2/0.0%)	84/10 (2.7/7.8%)**	149/12 (4.7/9.3%)*
Klebsiella	37/1 (1.2/0.8%)	55/4 (1.8/3.1%)	6/1 (0.2/0.8%)	65/7 (2.1/5.4%)*	144/9 (4.6/7.0%)
Streptococci (including β-Hemolytic Streptococci)	258/2 (8.2/1.6%)**	358/10 (11.4/7.8%)	323/10 (10.3/7.8%)	245/7 (7.8/5.4%)	937/26 (29.8/20.2%)*
β-Hemolytic Streptococci	13/0 (0.4/0.0%)	78/0 (2.4/0.0%)	9/0 (0.3/0.0%)	43/2 (1.4/1.6%)	115/2 (3.7/1.6%)
Acinetobacter baumanii	37/5 (1.2/3.9%)*	23/4 (0.7/3.1%)*	5/3 (0.2/2.3%)**	232/12 (7.4/9.3%)	265/14 (8.4/10.9%)
Pseudomonas and other non-fermentatives (exl.*Acinetobacter*)	50/4 (1.6/3.1%)	32/5 (1.0/3.9%)*	32/6 (1.0/4.7%)**	249/12 (7.9/9.3%)	319/18 (10.2/14.0%)
Yeast and fungi	19/0 (0.6/0.0%)	38/6 (1.2/4.7%)**	3/0 (0.1/0.0%)	17/2 (0.5/1.6%)	72/8 (2.3/6.2%)*

NL = from The Netherlands; repat = repatriated from abroad.
* $p < 0.05$
** $p < 0.01$.

3.4. Multiresistant microorganisms on admission in the BC

In 27 of 3271 patients (0.8%), resistant microorganism(s) were cultured within the first 24 h of admission. Three different resistant bacteria were found in two of these patients and two resistant species in four of them (Fig. 2).
MRSA was cultured in 0.4% (14/3271) on admission; 12 of these 14 patients (85.7%) were repatriated from abroad. Overall, 9.3% (12/129) of repatriated patients were colonized with MRSA. Multiresistant Acinetobacter or Pseudomonas was detected in 0.3% (11/3271 and 10/3271, respectively). Overall, in 18 of the 129 (14%) repatriated patients, one or more resistant bacteria were observed in the culture within the first 24 h from admission in our BC. Due to the "search-and-destroy" policy, the incidence of MRSA was low in the Netherlands.

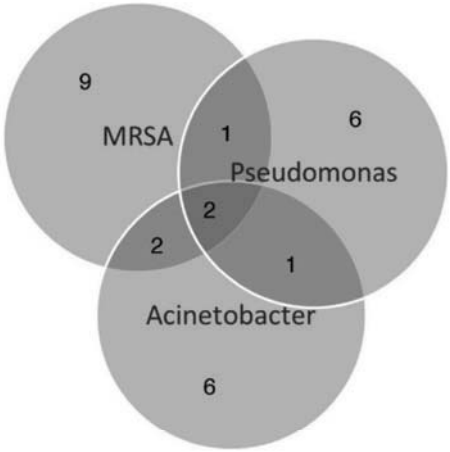

Fig. 2 – Distribution in 27 patients presenting with resistant microorganisms in the admission cultures.

3.5. HSA on admission

On admission, *S. pyogenes* was found in 3.6% of patients (117/3271), predominantly in children up to 10 years of age (81/1065 = 7.6%; Fig. 3).

3.6. Relation between bacteria cultured on admission and in later infectious complications

Six percent (195/3271) of the patients developed infectious complications, and a total of 402 blood cultures were performed. The microorganisms found in these blood cultures are listed in Table 3.

Fig. 3 – Presence of *Streptococcus pyogenes* (%) in relation to age.

Table 3 – Species found in 402 blood cultures of 195 patients with clinical signs of sepsis.

	Positive blood cultures
Staphylococcus.epidermidis (CNS)	122/195 = 62.6%
Pseudomonas species and other non-fermentatives species (exl.*Acinetobacter*)	36/195 = 18.5%
Staphylococcus aureus including MRSA	34/195 = 17.4%
Streptococci	33/195 = 16.9%
Escherichia coli	16/195 = 8.2%
Acinetobacter species	16/195 = 8.2%
Klebsiella species	13/195 = 6.7%
Enterobacter species	11/195 = 5.6%
Yeast and fungi	10/195 = 5.1%
Serratia, *Proteus*, *Citrobacter* species	2/195 = 1.0%

In order to identify the role of microorganisms present on admission and in later septic complications, positive cultures on admission were compared with blood cultures in patients who developed sepsis later.

SA, not detected on admission, was found in blood cultures of 0.9% of patients who developed sepsis later. In patients with SA in initial cultures, 1.2% showed later SA in positive blood cultures, with a non-significant difference (p=0.45). In addition, there was no difference in the percentages of *streptococci* and in Gram-negative enterobacteria such

as *Enterobacter*, *Serratia*, and *Proteus* cultured on admission and in later blood cultures of septic patients.

PsA showed up in 0.9% of later blood cultures of septic patients when negative on admission and in 3.3% when cultured on admission, indicating a significant difference ($p<0.01$). *Klebsiella* (0.3% vs. 2.6% ($p<0.01$)) and *Acinetobacter* (0.4% vs. 1.8%, $p<0.01$) showed a similar trend. However, the PPV and NPV did not differ significantly between the microorganisms involved (Table 4). Therefore, the difference in sensitivity does not seem to be of great clinical importance.

Table 4 – Value of surveillance cultures on admission to predict these microorganisms later in blood cultures.

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Staphylococcus aureus	47.1% (29.8–64.9)	59.3% (57.6–61.0)	1.2% (0.7–1.9)	99.1% (98.5–99.4)
E. coli	0% (0–20.8)	95.0% (94.2–95.7)	0% (0–2.3)	99.5% (99.2–99.7)
Enterobacter	18.2% (2.8–51.8)	94.0% (93.1–94.8)	1.0% (0.2–3.6)	99.7% (99.4–99.9)
Serratia, Proteus, Citrobacter	50% (8.2–91.8)	90.8% (89.7–91.7)	0.33% (0.1–1.8)	99.8% (99.8–99.9)
Streptococci	24.2% (11.1–42.3)	70.5% (68.9–72.1)	0.8% (0.4–1.6)	98.9% (98.4–99.3)
Klebsiella	30.8% (9.3–61.4)	95.4% (94.7–96.1)	2.6% (0.7–6.6)	99.7% (99.5–99-9)
Acinetobacter	31.3% (11.1–58.6)	91.6% (90.6–92.5)	1.8% (0.6–4.1)	99.6% (99.3–99.8)
Pseudomonas	30.6% (16.3–48.1)	89.9% (88.8–90.9)	3.3% (1.6–5.8)	99.2% (98.7–99.5)
Yeast and Fungi	30.0% (7.0–65.2)	97.6% (97.1–98.1)	3.8% (0.8–10.6)	99.8% (99.6–99.9)

Values are presented as percentages and 95% confidence intervals.

4. DISCUSSION

Although many BCs perform bacteriological swabs on admission of the patient, what is their value? The aim of the study was to assess the bacteriological cultures on admission and to identify the microorganisms.

In our study population, the patient age and gender reflect the normal distribution of burn patients, and the median TBSA burned is comparable to data from the American Burn Association National Burn Repository.

The data of 327 patients in the bacteriological database (7%) were missing, possibly due to a selection bias. However, we have no reason to assume that they differ from the remaining 93% and a part of the missing data are of patients admitted for day surgery, so the potential for selection bias is very limited.

Many clinicians believe that burns are sterile at admission because of the heat of the skin at the time of the accident. In this study, 61.4% of the burns were found to be non-suspicious on admission. Furthermore, part of it will indeed show no bacterial growth, but, as previously described, the results of the wound cultures also depend on the interpretation of the technician. This can be a subjective bias. After plating the swab and incubating, the

art is to distinguish the clinically relevant colonies from the nonrelevant growth. Notoriously pathogenic microorganisms or a dense growth of a microorganism with respect to the other existing microorganisms is clinically relevant.
On average, the interval between the accident and admission to the BC in repatriated patients was 6.5 days (median 3 days). In these patients, 48.1% of the wound cultures are non-suspicious or sterile, which is significantly different from patients admitted directly from the Netherlands. As seen in Table 2, these wounds are more colonized on admission in terms of *SA* (including *MRSA*), *Enterobacter*, *Serratia*, *Proteus*, *Citrobacter*, and *Klebsiella*. The burn wound is susceptible to microbial colonization from the hospital environment, even if the patient does not use antibiotics. All of the non-suspicious cultures will certainly not be sterile. A culture was further investigated only in cases of a clear overgrowth of one or more bacteria. This implies that nearly 40% of the wounds at admission within 24 h are colonized with one or more potentially pathogenic microorganisms.
Although SA, including MRSA, is a highly common microorganism, MRSA was cultured in only 14 of 3271 patients (0.4%) on admission, explained by the "search-and-destroy" policy in The Netherlands. The chance of detecting resistant bacteria at admission is <1% (27/3271 = 0.8%). In this respect, the necessity of performing several cultures at admission is questionable. However, cultures are clinically relevant in terms of isolation and control of infection. This is especially relevant for patients who are repatriated from abroad, where resistant microorganisms are found nearly 15 times more frequently (18/129 = 14%).

We are of the opinion that the presence of HAS is an indication of antibiotic therapy. This bacterium is found in 3.6% (117/3271) of the patients and nearly twice as much in children (81/1065 = 7.6%). In particular, children with sore throat could be at a risk of developing *S. pyogenes* infection.
Although *PsA* is often hospital acquired, 10.2% of the patients are already colonized with these bacteria at admission. Patients who develop sepsis are generally treated with broad-spectrum antibiotics adjusted on blood cultures. In 122 out of 195 septic patients (62.6%), blood cultures revealed *S.epidermidis* (CNS), predominantly suggesting a central venous catheter-related infection. In recent years, the Netherlands has been confronted with a rise in specific resistant microorganisms, such that the policy of obtaining inventory cultures at admission must be continued.

5. CONCLUSION

About 60% of burn wound cultures on admission within 24 h are considered non-suspicious, which indicates that about 40% are colonized with one or more potentially pathogenic microorganisms.

Patients who have been hospitalized for several days abroad show more colonization at admission in our BC of (multi)resistant bacteria, indicating that a hospital environment can quickly become a source of contamination.
Resistant bacteria or microorganisms that impede wound healing and cause major infections are found in <1% of bacteriological specimens obtained on admission of patients with burn wounds. However, consequences in terms of isolation and therapy are highly significant, justifying the rationale of a systematic bacteriological surveillance on admission. This is important especially in patients repatriated from abroad, because 14% of these patients are colonized with resistant microorganisms. The search-and-destroy policy has ensured a low prevalence of MRSA in the population and health facilities of The Netherlands.
HSA are found especially in children up to 10 years of age (7.8%). Bacteria present at admission do not seem to play a predominant role in predicting later sepsis. However, various reasons are attributed to the importance of surveillance, as previously described, which can be applied with great enthusiasm.

REFERENCES

[1] Church D, Elsayed S, Reid O, Winston B, Lindsay R. Burn wound infections. Clin Microbiol Rev 2006;19:403–34.
[2] Erol S, Altoparlak U, Akcay MN, Celebi F, Parlak M. Changes of microbial flora and wound colonization in burned patients. Burns 2004;30:357–61.
[3] Appraisal of microbial evolution to commensalism and pathogenicity in humans. Clin Med Insights Gastroenterol 2013;6:1–12.
[4] Vindenes H, Bjerknes R. Microbial colonization of large wounds. Burns 1995;21:575–9.
[5] Altoparlak U, Erol S, Akcay MN, Celebi F, Kadanali A. The time-related changes of antimicrobial resistance patterns and predominant bacterial profiles of burn wounds and body flora of burned patients. Burns 2004;30:660–4.
[6] Lawrence JC. The bacteriology of burns. J Hosp Infect 1985;6(Suppl. B):3–17.
[7] Croft CA, Mejia VA, Barker DE, Maxwell RA, Dart BW, Smith PW, et al. Methicillin-resistant Staphylococcus aureus in a trauma population: does colonization predict infection? Am Surg 2009;75:458–61. discussion 461-452.
[8] Hendriks WD, Cech M, Kooy P. Isolation efficiency and its clinical importance in patients with burns. Antonie Van Leeuwenhoek 1981;47:247–54.
[9] Brusselaers N, Logie D, Vogelaers D, Monstrey S, Blot S. Burns, inhalation injury and ventilator-associated pneumonia: value of routine surveillance cultures. Burns 2012;38:364–70.
[10] Kaiser ML, Thompson DJ, Malinoski D, Lane C, Cinat ME. Epidemiology and risk factors for hospital-acquired methicillin-resistant Staphylococcus aureus among burn patients. J Burn Care Res 2011;32:429–34.
[11] Wibbenmeyer L, Appelgate D, Williams I, Light T,Latenser B, Lewis R, et al. Effectiveness of universal screening for vancomycin-resistant enterococcus and methicillin-resistant Staphylococcus aureus on admission to a burn-trauma step-down unit. J Burn Care Res 2009;30:648–56.
[12] Keen 3rd EF, Robinson BJ, Hospenthal DR, Aldous WK, Wolf SE, Chung KK, et al. Incidence and bacteriology of burn infections at a military burn center. Burns 2010;36:461–8.
[13] Atoyebi OA, Sowemimo GO, Odugbemi T. Bacterial flora of burn wounds in Lagos, Nigeria: a prospective study. Burns 1992;18:448–51.
[14] Chong SJ, Ahmed S, Tay JM, Song C, Tan TT. 5 year analysis of bacteriology culture in a tropical burns ICU. Burns 2011;37:1349–53.
[15] Manson WL, Pernot PC, Fidler V, Sauer EW, Klasen HJ. Colonization of burns and the duration of hospital stay of severely burned patients. J Hosp Infect 1992;22:55–63.
[16] Bloemsma GC, Dokter J, Boxma H, Oen IM. Mortality and causes of death in a burn centre. Burns 2008;34:1103–7.
[17] Brusselaers N, Monstrey S, Snoeij T, Vandijck D, Lizy C, Hoste E, et al. Morbidity and mortality of bloodstream infections in patients with severe burn injury. Am J Crit Care 2010;19:e81–7.
[18] Rezaei E, Safari H, Naderinasab M, Aliakbarian H. Common pathogens in burn wound and changes in their drug sensitivity. Burns 2011;37:805–7.
[19] Miller PL, Matthey FC. A cost-benefit analysis of initial burn cultures in the management of acute burns. J Burn Care Rehabil 2000;21:300–3.
[20] Mahar P, Padiglione AA, Cleland H, Paul E, Hinrichs M, Wasiak J. Pseudomonas aeruginosa bacteraemia in burns patients: risk factors and outcomes. Burns 2010;36:1228–33.
[21] Tredget EE, Shankowsky HA, Rennie R, Burrell RE, Logsetty S. Pseudomonas infections in the thermally injured patient. Burns 2004;30:3–26.