

## Reducing hospital infection rates in the burn unit by adherence to infection control measures: a six-year experience

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**Aim:** To show the effect of infection control measures (ICMs) on nosocomial infections (NIs) in a burn unit.

**Materials and methods:** This study was conducted retrospectively at a 15-bed pediatric and adult burn unit, and 1329 hospitalized patients from 2003 to 2008 were enrolled. Detection and surveillance of NIs was performed by the infection control team (ICT), actively and prospectively, and was patient and laboratory based. Pan-resistant *P. aeruginosa* strains were seen in the unit in 2003. A periodical education program was applied by the ICT, and some changes were recommended. The hydrotherapy tank was abandoned, antimicrobials were used by the ICT, and new burn wound nursing techniques were applied by the surgeons.

**Results:** During the study period, compliance to ICMs increased. Wet dressing, early debridement, and grafting were performed. The NI rate decreased from 28.3% to 4.5%, the mortality rates declined from 2.2% to 1.2%, and the mean hospital stay of the patients with NI was reduced from 45.4 to 34.0 days. The numbers of burn wound infection (BWI) and bacteremia were decreased, as were sepsis and mortality attributed to infection. The antibiotic resistance of gram-negative microorganisms declined and pan-resistant *P. aeruginosa* strains disappeared.

**Conclusion:** NIs can be decreased by ICMs in burn units. Antibiotic usage should be rational. The hydrotherapy tank should not be used if possible. Wet dressing, early debridement, and grafting are the mainstays of the therapy.

**Key words:** Burn wound infection, nosocomial infection, infection control measures

### Yanık ünitesinde hastane enfeksiyonlarının enfeksiyon kontrol önlemlerine uyum sayesinde azaltılması: Altı yıllık deneyim

**Amaç:** Enfeksiyon kontrol önlemlerine uyumun yanık ünitesinde hastane enfeksiyonlarının azalması üzerine etkisini göstermektir.

**Yöntem ve gereç:** Bu çalışma 15 yataklı çocuk ve erişkin yanık ünitesinde geriye dönük olarak yürütüldü ve 2003-2008 yılları arasında yatan 1329 hasta çalışmaya dahil edildi. Hastane enfeksiyonlarının saptanması ve sürveyansı enfeksiyon kontrol ekibi tarafından aktif, prospektif olarak hastaya ve laboratuvara dayalı olarak yapıldı. 2003 yılında ünite tam dirençli *P. aeruginosa* suşları ortaya çıktı. Enfeksiyon kontrol ekibi tarafından enfeksiyon kontrol önlemleri konusunda periyodik eğitim programı uygulandı ve bazı değişiklikler önerildi. Hidroterapi tankının kullanımı bırakıldı. Antimikrobialler enfeksiyon kontrol ekibi tarafından kullanıldı. Yanık yarası bakımında cerrahlar tarafından yeni teknikler uygulandı.

**Bulgular:** Çalışma süresince enfeksiyon kontrol önlemlerine uyum arttı. Islak pansuman, erken debritleme ve greftleme uygulandı. Hastane enfeksiyonu oranı % 28,3'den % 4,5'e düşürüldü. Mortalite oranları % 2,2'den 1,2'ye düştü.

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Nozokomiyal enfeksiyonlu hastaların ortalama hastanede kalış süresi 45,5 günden 34,0'a geriledi. Yanık enfeksiyonu ve bakteriyemiler azaldı. Sepsis ve enfeksiyona atfedilebilir ölümler azaldı. Gram negatif mikroorganizmalarda antibiyotik direnci azaldı ve tam dirençli *P. aeruginosa* suşları kayboldu.

**Sonuç:** Yanık ünitesinde hastane enfeksiyonları enfeksiyon kontrol önlemlerine uyum ile azaltılabilir. Antibiyotik kullanımı akılcı olmalıdır. Hidroterapi tankı mümkünse kullanılmamalıdır. Islak pansuman, erken debridman ve greftleme tedavinin esasıdır.

**Anahtar sözcükler:** Yanık yarası enfeksiyonları, nosokomial enfeksiyon, enfeksiyon kontrol önlemleri

## Introduction

Nosocomial infection (NI) is a serious complication in burn units (1,2). In patients with severe burns, sepsis is the main cause of death (1).

Burn wound infection (BWI) is the most frequent nosocomial infection in burn units. A burn wound (BW) can easily be infected, because the surface of a BW is protein-rich, avascular, and necrotic (1). Necrotic tissue provides culture medium; additionally, host immune cells cannot migrate enough due to avascularity; thus, both innate and adaptive immune responses are suppressed. Colonizing microorganisms are mainly derived from the patient's skin flora, which is a time-related change (within the first 48 h), and arise from the hospital environment (1,3,4). Gram-positive microorganisms are predominant at the early phase and turn into a gram-negative species after the 7th day of burn (1,3,4). Therefore, NI rates are usually high in burn units (5,6).

The aim of the present study was to show the effect of infection control measures (ICMs) on decreasing NI in burn units.

## Materials and methods

This study was conducted retrospectively at a 15-bed pediatric and adult burn unit located in a 1200-bed university hospital, during a 6-year period from 2003 to 2009, and 1329 hospitalized patients were enrolled in the study. In total, 5 nurses, 3 doctors, and 10 other staff members (5 of them were cleaning staff) were working in the burn unit; 1 physician, 1 or 2 nurses and 2 staff (1 was for cleaning) were working in the unit during each shift. The unit is the reference burn center in the Eastern Anatolia region, and

thus severe burn patients are referred to this center. Debridement of burn wounds was performed in the surgical room, where there was a hydrotherapy tank.

Detection and surveillance of hospital infections were performed by an infection control team (ICT) actively, prospectively, and in a patient-based fashion. Patients with NIs were regularly consulted by the infection control specialists (ICs), 3 times per week. Diagnosis of NI was made according to the Centers for Disease Control and Prevention (CDC) criteria (7).

In 2003, the rate of carbapenem-resistant *P. aeruginosa* strains increased and 5 pan-resistant strains were observed (8). Closure of the unit was considered unless the pan-resistant strains were eradicated. Environmental surveillance cultures were performed. The ICT and surgeons agreed on decreasing NI rates and antibiotic resistance. An infection control program was applied by the ICT in May 2003:

1. First, health-care staff were trained periodically about ICMs (such as hand hygiene and contact isolation precautions), BWI, catheter nursing and aseptic techniques, and environmental cleaning and disinfection. All of the unit staff (n: 18) were lectured 5 times per month. Problems and recommended solutions were discussed. During visits, face to face practical education was given. Alcohol-based hand antiseptic dispensers were installed in all of the rooms and usage of these increased before and after contact with a patient. Adherence to hand hygiene was improved. Glove use was increased. The frequency of environmental cleaning and disinfection was increased, and sodium hypochlorite was used for disinfection.

2. There were 7 rooms in the unit (3 with single beds, 4 with 3 beds). Previously, 3 patients could stay in the same room. Afterwards, no more than 2 patients were hospitalized in the same room and 2 additional rooms were opened in the unit. Now, the unit has 3 rooms with single beds and 6 rooms with 2 beds. A maximum of 2 patients were hospitalized in each room. Colonized and/or infected patients with multidrug-resistant (MDR) microorganisms were isolated in single-bed rooms and surgical debridement of infected patients with MDR microorganisms was conducted in a separate operation room.
  3. Previously, extended-spectra antibiotics were frequently used and ampicillin/sulbactam was routinely given to patients, starting from admission, for a long time (weeks). Later, empirical antibiotic usage was abandoned. Antibiotic usage was limited to short periods in light of recommendations by the ICT (according to the results of cultures and antibiotic susceptibility tests). The ICS used only ampicillin/sulbactam empirically, in the early period if necessary. Other antibiotics were used according to culture results (evidence based).
  4. Environmental culture results showed that the major sources of multidrug/pan-resistant *P. aeruginosa* strains were the operating room and hydrotherapy tank. *P. aeruginosa* was isolated from different regions (wall, tap, or drain) of the tank many times. In spite of proper disinfection, some regions of the tank remained a source of the microorganisms for months. The hydrotherapy tank was not used after July 2004.
  5. The tank was located in the operating room and the room's air was very humid. There were no air conditioners. The moist environment was providing suitable conditions for growth of *P. aeruginosa*. To reduce humidity, an air conditioner was installed in the operating room, and a better air conditioner was provided at the end of 2004.
  6. Of the burn unit staff, 3 members (the head of the burn unit, a responsible nurse, and a cleaner) were sent for a training program in an advanced clinic for a week to observe surgical methods and all other applications in a burn unit. When they returned, some surgical procedures were changed:
    - a. Dressing and debridement: Debridement was not routine in the unit, but it can be necessary in deep burn wounds (from a tandoor [a clay oven], electricity, and flames). Early debridement was applied if necessary, and some local dressing agents, which facilitate debridement, were used. Previously, the dry dressing technique was applied, and silver sulfadiazine was used for wounds. Before the debridement, the patient was kept in the hydrotherapy tank. Since the end of 2004, a very wet dressing with sterile water has been used, and boric acid antibacterial pomade has been applied to the wound. Before debridement, the wound is cleansed with warm sterile saline solution. Additionally, since 2005, hydrogel with alginate, which can provide autolytic debridement, rehydrate necrotic and sloughy wounds, and provide a moist wound healing environment for granulating and epithelizing wounds, has been used in our burn unit.
    - b. Grafting: Graft operations were more frequent and in the early period.
      1. Experienced residents were employed in the burn unit for better nursing and more efficient surgical debridement.
      2. The same personnel (trained for ICMs in burn units) were employed in the unit when possible.
      3. Visitors were not allowed to see the patients.
      4. Finally, instructions were prepared for patients' companions about the rules of ICMs.
- Some of the changes took place immediately (such as the use of alcohol-based hand antiseptics, hand washing, and the use of gloves) but some others (such as abandoning use of the hydrotherapy tank, air ventilator, additional room, rotation to developed center, and new surgical applications) were applied later.

## Results

In the study period, 1329 patients were observed in the burn unit. The characteristics of the patients are shown in Table 1. In this 6-year period, the burn wound infection rate sharply decreased. A total of 238 NI (171 BWI, 26 bloodstream infections, 11 pneumonia, 8 sepsis, 8 urinary tract infections, 5 upper respiratory infections, and 6 surgical site infections) were detected. NI rates were reduced by 23.8%. The rate was 28.3% in 2003, 16.8% in 2004, 9.8% in 2005, 6.6% in 2006, 5.4% in 2007, and 4.5% in 2008 (Figure 1).

The mortality rate decreased. The rate was 2.2% in 2003, 5% in 2004, 1.9% in 2005, 1.7% in 2006, and 1.2% in 2008. The mean hospital stay of the patients with NI was reduced from 45.4 days to 34.0 days. The distribution of nosocomial infections is shown in Table 2.

*P. aeruginosa* was the most frequently isolated bacterium in our burn unit at the end of 2006, followed by *Staphylococcus* spp. Previously, antibiotic

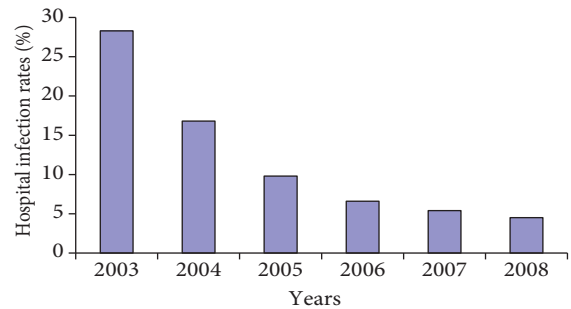


Figure. Hospital infection rates.

resistance rates were high in our burn unit (4,8,9). Carbapenem-resistant *P. aeruginosa* strains and metallo-beta-lactamase-positive *Acinetobacter* spp. were encountered (8,9). After terminal cleaning and disinfections, abandoning use of the hydrotherapy tank, and improving surgical room ventilation, pan-resistant *P. aeruginosa* strains were not seen any more. Specifically, carbapenem-resistance decreased and disappeared in 2006 and 2008 (Table 3).

## Discussion

NI rates can be reduced by compliance with ICMs. The CDC has shown that about 36% of NIs are preventable by adherence to strict guidelines.

The environmental surface, hands of health care workers (HCWs), contaminated equipment, hydrotherapy tank, and colonized and/or infected patients are the most important sources of microorganisms for hospitalized patients in burn units (1,10). The hands of HCWs are the most important source of cross contamination, and hand washing is the cheapest and easiest method for preventing NI. Alcohol-based hand rubs may be better than traditional hand washing in labor intensive wards such as burn units because they waste less time, act faster, are less irritating, and contribute to sustained compliance with hand hygiene. It was shown that, after use of alcohol-based hand rub, infection rates decreased by 36% in an orthopedic surgery unit (11).

Previously, we showed that the presence of colonized/infected patients with imipenem-resistant *P. aeruginosa* was a risk factor for acquisition of this strain in burn units (8). An isolation unit is recommended for colonized/or infected patients to reduce the infection rates in burn units (1,2).

Table 1. Characteristics of the patients.

	N = 1329 n (%)
<b>Gender</b>	
Male	785 (59.1)
Female	544 (40.9)
<b>Age</b>	
0-5	811 (61.0)
6-14	173 (13.0)
15-50	254 (19.2)
>50	91 (6.8)
<b>TSBA*</b>	
0-20	985 (74.1)
21-40	261 (19.6)
41-60	54 (4.1)
61-80	21 (1.6)
81-100	8 (0.6)
<b>Type of burns suffered</b>	
Hot fluid	871 (65.5)
Tandoor	121 (9.1)
Electric	139 (10.5)
Flame	181 (13.6)
Chemical	12 (0.9)
Other	5 (0.4)

\*Total surface burn area.

Table 2. Nosocomial infections.

Type of NI	2003	2004	2005	2006	2007	2008	Total
	n (%)						
BWI	60 (81)	43(63.2)	19 (74)	18 (85)	21 (52.5)	10(90.9)	171(71.8)
BWI + bloodstream infection	5 (6.8)	8 (11.8)	1 (3.7)	2 (9.5)	9 (22.5)	1 (9.0)	26 (10.9)
BWI + pneumonia	-	8 (11.8)	1 (3.7)	-	2 (5)		11 (4.6)
BWI + sepsis	5 (6.8)	3 (4.4)	-	-	-	-	8 (3.4)
UTI	4 (5.4)	1 (1.5)	1 (3.7)		2 (5)	-	8 (3.4)
SSI	-	-	-	-	6 (15)	-	6 (2.5)
URI	-	3 (4.4)	2 (7.4)	-	-	-	5 (2.1)
BWI + catheter inf.	-	2 (2.9)	-	1 (4.8)	-	-	3 (1.3)
Total number of NI	74	68	24	21	40	11	238

BWI: Burn wound infection, UTI: urinary tract infection, SSI: surgical site infection, and URI: upper respiratory infection.

Table 3. Antimicrobial susceptibility rates of *P. aeruginosa* strains isolated from burn unit.

Tested antibiotics	Group 1%			Group 2%			P
	2003	2004	2005	2006	2007	2008	
	n = 82	n = 54	n = 34	n = 13	n = 5	n = 5	
Ceftazidime	25.7	3.8	0	-	0	20	0.75
Ciprofloxacin	52.4	68.5	58.3	84.6	100	40	0.109
Aminoglycoside	80.5	77.5	67.5	100	80	100	<b>0.032</b>
Cefoperazone/sulbactam	36.5	17.6	20.0	-	80	60	<b>0.008</b>
Piperacillin/tazobactam	42.6	37.2	58.9	84.6	60	60	<b>0.008</b>
Carbapenem	82.9	33	67.7	100	80	100	<b>0.001</b>

P accounted between Group 1 and Group 2.

The hydrotherapy tank may remain a source of bacteria, especially *P. aeruginosa*, and cause cross-contamination between patients because it is difficult to clean microbial contamination of the tank water, aerators, and agitators in hydrotherapy tubes (1,12-14). Other studies showed that mortality rates and antimicrobial resistance were reduced when the hydrotherapy tank was not used, in line with our study (13,15,16).

While 35.3% of the burn wounds were found to be sterile on admission, microbial colonization reached 86.3% within the first week (3). Coagulase-negative staphylococci (CNS, 63.0%) and *S. aureus* (19.7%) were the most prevalent isolates in admission cultures, but sharp increases in the numbers of *S. aureus* and *P. aeruginosa* were detected from admission to day 21 (3). In the last 50 years, *P. aeruginosa* and *S. aureus* have been continuously predominant in burn infections

(17). The moist environment is suitable for viability of *P. aeruginosa*. Similar to our study, *P. aeruginosa* from the patient's endogenous gastrointestinal flora and/or an environmental source is generally the most important cause of BWI, followed by staphylococci, and BWI is the most frequent NI in other burn units (5,6,12,13,15-18).

In our study, *Candida* spp. were isolated as a causative microorganism from BWI. The average time for candidal colonization of the burn wound and diagnosis of candidal infections at other sites was reported for postburn day 30 and 41, respectively (19). The emergence of fungi as the predominant organisms causing invasive BWI reflects the success of current techniques of burn wound care. Yeast and fungal burn wound infections commonly occur in patients with burns of 50% or more of the total body surface of the eschar that has been removed by early surgical excision. Candidemia was found to be associated with more extensive burns and a longer duration of hospital stay (20). Basil et al. (19) have suggested that invasive burn wound sepsis is now most commonly caused by fungi (19). Additionally, wound colonization by yeasts and fungi usually occurs later due to the use of broad-spectrum antibiotic therapy (19).

Drug resistance of pathogenic bacteria is a very serious condition in a burn unit (21). Between admission and day 21, the rates of methicillin-resistance of staphylococci strains increased steadily, and nasal carriage of methicillin-resistant staphylococcus aureus (MRSA) reached from 3.9% to 62.7% in our burn unit (3,4). The size of the burn was in correlation with colonization. Burn patients colonized with MRSA represent an institutional reservoir for the spread of MRSA to the rest of the hospital. Moreover, dressing changes in the MRSA-infected burned patients generate infectious aerosols (22). The rate of methicillin-resistance has been reported to be 82.5% in burn patients (21).

*P. aeruginosa* strains are probably able to maintain vitality for a long time and acquire a resistance to environmental conditions and chemicals. Thus, *P. aeruginosa* isolated from the blood stream of burn patients are usually MDR strains. In one study, 90% were found to be resistant to amikacin and ceftazidime, 45% to ciprofloxacin, and 25% to piperacillin; 43%

of *S. aureus* were MRSA (16). In another study, *P. aeruginosa* resistance was reported to be 35.6% and 35.4%, respectively, for ceftazidime and imipenem (18). The previous study was conducted in our burn unit; extended-spectrum beta-lactamases (ESBL) and inducible beta-lactamases (IBL) producing rates of colonized gram-negative microorganisms were 57.1% and 79.6%, respectively (4).

An effective infection control policy is required to reduce or eliminate endemic MDR organisms, which is the predominant nosocomial flora of the burn unit (16). Alcohol-based handrub and proper sterilization/disinfection reduce antimicrobial-resistance by preventing cross contaminations, besides decreasing NI. In a multicenter study, it was reported that the number of MDR strains were decreased after adherence to hand hygiene (23). Clean gloves, with or without a gown, should be used for all high-risk hospitalized patients to prevent cross transmission of all multiresistant nosocomial pathogens (24).

The irrational use of broad-spectrum antibiotics contributes to drug resistance because, under the pressure of antibiotics, some opportunistic bacteria can develop resistance (17,21). Thus, antibiotic control is another important way to prevent antibacterial resistance and thereby, save money (21,25,26). Additionally, to control infections due to pandrug-resistant bacteria, sometimes cyclic use of antibiotics may be helpful (17). Accordingly, an infection specialist has a key role both in the prevention of NI by applying ICMs and in the management of rational antibiotic usage in a hospital. In our previous study, we found that appropriate antibiotic usage rates were increased (from 55.7% to 97.5%) by ID consultation (26). Even ID trainees are capable of evaluating patients and recommending appropriate antibiotics (27).

Systemic antibiotic prophylaxis in burn patients was not useful to reduce BWI (28). Systemic antibiotic administration in burn patients should only be used selectively and for a short period of time (1). Culture-specific laboratory information obtained from bacterial culture and susceptibility results for the burn wound and other sources should be used to guide the selection of effective antimicrobial agents for use as preoperative prophylaxis as well as treatment of overt clinical infections (1). The use of culture-specific antibiotics was found to be more

beneficial and cost-effective in the treatment of childhood burns (28). In our study, evidence-based usage of antibiotics was applied for a short time. Since 2003, the ICT has been applying an antibiotic policy about rational-use in our hospital. Broad-spectrum and expensive antibiotics were being used only upon an infection specialist's consultation. After this protocol was applied, antibiotic consumption (from 52.7% to 36.7%) and antibiotic-resistance rates were reduced (especially carbapenem resistance in gram-negative bacilli), and proper antibiotic usage rates were increased (from 55.5% to 66.4%) (26). Arda et al. (25) could decrease NI in the intensive care unit (ICU), and reduce some antibiotic-resistance in *Klebsiella pneumoniae*.

In our burn unit, carbapenem-resistance of *P. aeruginosa* strains peaked in 2004. Because MDR/pan-resistance *P. aeruginosa* strains continued in 2004, we used a carbapenem and quinolone/aminoglycoside combination for therapy. Therefore, carbapenem-resistance increased in 2004. After abandoning the hydrotherapy tank usage and placing an air ventilator in the surgical room at the end of 2004, the strains disappeared. Then, antibiotic usage was decreased, and antibiotic-resistance in gram-negative bacilli was reduced. Unfortunately, antibiotic resistance in staphylococci was not reduced in the study period. Methicillin-resistance of staphylococci can be reduced by ICMs, preemptive cohorting, and monitoring/eradicating nasal transfer in HCW. We did not attempt preemptive cohorting, and/or monitoring/eradicating nasal transfer for staphylococci. Therefore, methicillin-resistance rates could not be reduced in this period.

Previously, surgical debridement and dry dressing were used in our burn unit. Since 2005,

wet dressing with antibacterial agents and hydrogel, which facilitated autolytic debridement by creating a moist wound healing environment and increasing collagenase production, has been used (29).

During the study period, early debridement and grafting were applied. Early surgical intervention enhances asepsis; short-term use of antibiotic is advisable, and it may control the infection promptly as well as minimizing the emergence of antibacterial resistance (17). Early debridement led to an earlier discharge of patients from the hospital, and it has been recommended in other studies (30).

During the study period, the mean hospital stay was shortened in patients with NI. Additionally, sepsis and mortality decreased. Besides applying the new surgical technique, adherence to ICMs and decreasing antimicrobial resistance may have contributed to these results. The use of burn wound excision to facilitate early removal of the dead tissue and achieve prompt closure of the burn wound has further reduced the incidence of invasive burn wound sepsis as a cause of death (19). Raineri et al. (31) have also reported that appropriate antibiotic therapy is associated with a reduction in both ICU and in-hospital mortality.

In conclusion, we observed a sharp decrease in NI rates, sepsis, mortality, and antibiotic resistance of gram-negative microorganisms in the burn unit. Although a burn wound is capable of being infected, NI rates can be decreased via ICMs and better surgical therapy. Antibiotic usage should be rational and for a short period. A hydrotherapy tank should not be used if possible. A wet dressing with a wound healing agent, and early debridement and grafting are the mainstays of therapy.

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