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Universal contact precautions do not change the prevalence of antibiotic resistant organisms in a tertiary burn unit☆

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ABSTRACT

Objective: The prevalence of antibiotic-resistant organisms (ARO) in burn units is increasing worldwide and contributes significantly to morbidity and mortality. Study aims are to describe the burden of AROs in burn patients admitted to a tertiary burn unit, to evaluate the impact of contact precautions implemented after an outbreak of antibiotic-resistant *Acinetobacter baumannii*, and to identify possible predictors of ARO acquisition.

Methods: Data of burn inpatients between 2006 and 2010 were retrospectively reviewed. The antibiotic susceptibility profiles of ARO colonization/infection at or after admission were reviewed in detail. Organisms of interest included: methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), extended-spectrum beta-lactamase-producing *Escherichia coli*, and carbapenem-resistant *Pseudomonas* and *Acinetobacter*. Univariate and multivariate logistic regression analysis was employed with the p-value set at 0.05.

Results: Complete data analysis was available for 340 patients. The mean age was 41.8 years with male predominance. Among the AROs, the most prevalent was MRSA from clinical specimens. Prior to contact precaution implementation, the prevalence of all AROs was 27.9%, compared to 27.6% afterwards. There was an increase in *Pseudomonas* and VRE isolates and a disappearance of *Acinetobacter*. The most common isolate sites were the burn wounds. ICU stay, burns >20% TBSA, and surgical management were significant predictors of ARO acquisition.

Conclusion: This study describes the ARO profile of burn patients admitted to a tertiary burn unit. The results suggest that implementation of unit-wide contact precautions may not significantly reduce the frequency of AROs among burn patients. Contact precautions for patients transferred from the ICU, undergoing surgery, and large burns may be of benefit.

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1. Background

Innovations and developments in different areas of burn management such as fluid management, critical and surgical care, and local and systemic antimicrobial therapy, have contributed towards a reduction in mortality and morbidity rates for moderate and large burns (over 20% TBSA) [1]. However, the incidence of nosocomial infection amongst burn patients is on the rise; extended intensive care, hospital stay, invasive interventions and monitoring are some of the main culprits [2]. The sources of infection are not only the burn wounds, but also the lungs (pneumonia), blood, and gut (bacterial translocation) to enumerate a few [3].

Many of the bacteria isolated and cultured from burn inpatients belong to a group commonly referred to as antibiotic-resistant organisms (AROs). Significant interventions and efforts have been implemented worldwide in the last decade to prevent and decrease ARO infections and colonization in patients admitted with burns. Shifts over time in the predominance of pathogens causing infection among burn patients often lead to changes in burn care practices [4], however there is no consensus on the most effective infection control practices to prevent transmission of infection to and from patients with serious burns [5].

The prevention of transmission of ARO during the hospital stay is based on a multimodal approach which includes development of antimicrobial stewardship programs, increased level of education amongst members of the staff, adherence to hand hygiene and washing policies, and the use of strict barrier and isolation precautions [6]. However, this has not been shown in burn patients. Contact precautions are a standard method used to prevent patient-to-patient transmission of AROs in hospital settings. The Centre of Disease Control defines this as the use of gowns and gloves for all staff who have contact with the patient or the patient's environment [5]. There still remains controversy regarding the necessity and type of barrier precautions for the routine care of burn patients.

An outbreak of multi-drug resistant *Acinetobacter baumannii* in our Burn Unit in 2008 led to implementation of several infection control practices that included clustering and isolation of these patients in the Burn Unit as well as universal contact precautions. Following the outbreak, Infection Control's recommendations included meticulous routine practices, screening for all patients on admission and weekly, and screening for resistant gram-negative organisms for patients admitted from out of country. Discontinuing universal contact precautions of non-ARO patients in the Burn Unit was recommended a year later. However, it was decided that universal contact precautions would remain for all burn patients on the Burn Unit regardless of their ARO status and burn patients admitted to the Intensive Care Unit (ICU).

There are no previous studies describing the prevalence of AROs in the burn patient population admitted to our burn unit and how universal contact precautions that were implemented affected the transmission of ARO. Our study objectives were to describe the prevalence of AROs from burn patients admitted to a tertiary Burn Unit, as well as the impact of universal contact precautions and the predictors of ARO infection/colonization.

2. Patient and methods

2.1. Study sample

This study was approved by the Institutional Review Board. Burn patients admitted to our 24-bed tertiary burn unit from January 1, 2006 to December 31, 2010 were identified from a prospectively maintained Burn Registry Database. This database has been maintained since 1973.

2.2. Study design

We retrospectively reviewed the data of all burn patients identified during the study period from the burn database and hospital electronic medical records. A standard collection form was designed for data collection which included demographic information (age, gender, body mass index, smoking status, comorbidities) and clinical information relevant to burns (date of admission to hospital, etiology, total burn surface area (TBSA), contributing factors to burns (alcohol, drugs), presence of inhalational injury, number of days on the ventilator, admission to the ICU, and need for excision and skin grafting).

The primary outcome measure was the presence of AROs isolated at or during admission from patients with burns. The study did not extend to isolate fungi and yeasts. MRSA, VRE and wound culture and sensitivity swabs are routinely taken on admission and weekly unless they were already positive for MRSA or VRE.

Each positive culture (colonization or infection) was treated as an independent observation. All bacteriology cultures and antibiotic susceptibility testing results for the study sample were reviewed in detail. The AROs of interest included methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli*, and carbapenem-resistant *Pseudomonas* and *Acinetobacter* species. The ARO data included the culture collection date, specimen type (screening culture versus clinical specimen), collection source (blood; groin/perineum/perianal; stool/rectal swab; urine; catheter tip; wound; other) and also if it was colonization or infection.

To determine the efficacy of universal contact precaution policies on antimicrobial resistance, ARO colonization or infection was compared before and after the implementation. January 1, 2006 to December 31, 2007 represented the time period prior to contact precaution implementation and January 1, 2009 to December 31, 2010 represented the time period after contact precautions. 2008 was the year when universal contact precautions were implemented on the Burn Unit, due to the outbreak of antibiotic-resistant *A. baumannii*. Potential predictors of ARO colonization/infection in ARO patients and non-ARO patients were found and compared.

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2.3. Standard treatment protocol for admitted burn patients

Standard care for burn patients includes accurate TBSA estimation at time of admission and reassessment at 48–72 h after injury, fluid resuscitation for patients with burns >20% TBSA, application of standard silver based burn dressings (Flamazine®, Smith & Nephew, London, UK) or nanocrystalline silver dressings (Acticoat®, Smith & Nephew, London, UK). The assessment for early excision and grafting of deep dermal or full thickness burns is performed with the reassessment of the burn wounds, and the procedures are carried out on the next available operative day. Single dose antibiotics are administered perioperatively and only continued when patients demonstrate an infection based on polymorphonuclear leukocytes count and tissue biopsy culture results. There are specific protocols for central catheter placement and indwelling Foley catheters which remained unchanged during the study period.

2.4. Description of outbreak and infection control policy

In June 2008, two patients that were burned in a bus crash during a holiday in Egypt were transferred to our Burn Unit who were culture-positive for antibiotic-resistant *A. baumannii*. Shortly after, there was an outbreak of antibiotic-resistant *A. baumannii* cultured in another 6 patients, 3 of which were burn patients. Initial transmission of the index case was thought to be linked to the burn shower. All patients with antibiotic-resistant *A. baumannii* were clustered and contact precautions were implemented for all patients on the Burn Unit, irrespective of their ARO status.

Ongoing staff education, promotion of hand hygiene (hand washing, dispensers for alcohol-based hand rubs, and appropriate use of gloves), strict contact and isolation precautions, and strict environmental cleaning were implemented during the outbreak as a multimodal approach to stop dissemination. Extra environmental cleaning was initiated and stringent hand washing practices and weekly screening for MRSA, VRE and gram-negative bacilli were strictly adhered to. Barrier use and contact precautions were used for all patients on the Burn Unit and for burn patients admitted in the ICU due to its close proximity to the Burn Unit.

2.5. Microbiological methods

Bacterial cultures were processed in the clinical microbiology laboratory using standard microbiology techniques. Microorganism identification and antimicrobial susceptibility profiles were performed using MicroScan Rapid Gram-Negative Identification Type 3 Panel (Dade MicroScan Inc., West Sacramento, Calif.), Kirby-Bauer Disc Diffusion Method antibiotic testing, and Epicenter BACMAX BACDNA isolation kit. The following organisms were identified: *Staphylcoccus aureus*, *E. coli*, *Enterococcus faecalis*, *Pseudomonas aeruginosa*, and *A. baumannii*. The antibiotic susceptibilities and microbiology reports of these organisms were reviewed in detail to identify MRSA, VRE, ESBL-producing *E. coli*, and carbapenem-resistant *P. aeruginosa* and *A. baumannii*.

We used the definitions for colonization and infection in the burn population established by the American Burn Association consensus conference and CDC definitions for nosocomial infections [7,8]. In brief, *colonization* was defined as bacteria cultured from sputum/endotracheal suction, urine, wounds, catheter exit site, nose swab, rectal swab, or other body sites in the absence of microscopic evidence of infection. Microorganism in concentration *less than* 10^5 was considered colonization [7]. As burn wounds may show polymorphonuclear leukocytes due to the normal inflammatory response, their presence in sufficient numbers to indicate potential

Table 1 – Demographics and clinical information of 340 burn patients included in the analysis.

Variable	Frequency N=340	Percent (%)
Mean age (years ± SD)	41.81 ± 19.77	
Gender		
Male	266	78.5
Female	73	21.5
Ethnicity		
Caucasian	265	77.9
Non-Caucasian	75	22.1
Contributing factors		
Alcohol	40	13.4
Drugs	15	5.0
Smoking	1	0.3
Psychiatric illness	6	2.0
Epilepsy	3	1.0
Inhalational injury	56	16.9
Patients receiving ventilatory support	46	13.5
Ventilator days, mean ± SD	1.1 ± 4.2	
Length of stay in ICU, mean ± SD	2.0 ± 5.6	
Hospital days/TBSA, mean ± SD	2.3 ± 3.9	

infection was correlated with the type and amount of bacteria cultured to indicate if infection was present. Microorganism in concentrations *more than* 10^5 was considered infection.

2.6. *Statistical analysis*

The Student's *t*-test and Mann–Whitney analysis were used to compare normally and non-normally distributed variables, respectively. Fisher's exact test and Pearson chi-square analysis were used to compare categorical data where appropriate. Adjusted odds ratios and 95% confidence intervals were calculated for each independent variables using logistic regression analysis to evaluate predictors of ARO colonization or infection. Multivariate modelling was used to adjust for confounders and covariates significant on univariate analysis. Homer–Lemeshow and C-statistic values were calculated to assess model calibration and discrimination, respectively. A two-tailed value of $p<0.05$ was selected to indicate statistical significance. Analyses were performed using the STATA 11.0 software package (StataCorp LP, College Station, Texas).

3. Results

From 2006 to 2010, there were 362 admissions to the burn unit. Of these, 340 patients had complete data for analysis. The mortality of this cohort was 6.2% (21 patients). The mean age was 41.8 years. The majority of patients were male (78.5%) and Caucasians (77.8%) (Table 1). Flame burns represented the majority of burns (65.9%), followed by scald burns (14.4%) and electrical burns (7.7%). Eighty percent of the patients sustained burns <20% TBSA (273 patients), whereas only 22 patients (6.5%) sustained burns injuries involving more than 50% TBSA. Patients with TBSA >20% not undergoing intubation were resuscitated in the burn unit. The mean length of stay was 2.3. days/TBSA which since then has significantly decreased. The protocols for wound care remained same during the study period.

The total number of samples that cultured microorganisms was 359, with 169 (47.1%) patients with more than one isolate cultured. There was no significant variance in the number of samples taken annually. Seventy-six samples (21.2%) were identified as AROs. The most common ARO was MRSA (74.7%),

Table 2 – Site from where ARO were cultured and identified.

Variable	Carbapenem-resistant *Acinetobacter*	ESBL-producing *E. Coli*	VRE	MRSA	Carbapenem-resistant pseudomonas	Total
Nose						
Screening	0	0	0	11	0	11
Clinical	0	0	0	0	0	
Catheter tip/exit site						
Screening	0	0	0	0	0	7
Clinical	0	0	0	7	0	
Sputum						
Screening	0	0	0	0	0	11
Clinical	0	1	0	9	1	
Blood						
Screening	0	0	0	0	0	6
Clinical	0	0	0	6	0	
Groin						
Screening	1	0	0	6	0	10
Clinical	0	0	3	0	0	
Burn wound						
Screening	0	0	0	1	0	63
Clinical	2	2	3	50	5	
Stool/rectal						
Screening	0	0	2	0	0	3
Clinical	0	0	0	0	0	
Urine						
Screening	0	0	0	0	0	9
Clinical	1	2	2	2	2	
Other						
Screening	0	0	0	0	0	4
Clinical	0	0	0	4	0	

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followed by VRE (8.0%), *P. aeruginosa* (8.0%), *A. baumannii* (5.3%), and ESBL-producing *E. coli* (4%). The most common site from which the antibiotic-resistant isolates were recovered was the burn wound, followed by sputum and nose (Table 2).

3.1. *Impact of universal contact precautions on AROs transmission and dissemination*

The pre- and post-contact precaution groups were comparable, with the exception of a greater proportion of Caucasian patients in the pre-contact precaution group, and less inhalational injuries and older patients in the post-contact precaution group (Table 3).

The incidence of ARO prior to the *Acinetobacter* outbreak (2006–2007) was 27.9%, whereas in the period 2009–2010 the incidence was 27.6% (p>0.05). The breakdown of AROs for different microorganisms in the two groups is presented in Fig. 1. There was an increase in both *Pseudomonas* and VRE isolates after contact precautions, however, p-values were not calculated for these sub-groups due to small numbers in each group.

3.2. *Predictors of ARO infection/colonization*

In order to identify possible predictors amongst the burn patients' cohort, a comparison of patients colonized or infected with ARO and non-ARO patients was performed. The univariate analysis showed that the ARO group had statistically significant ($p<0.05$) higher number of patients who had larger (>20% TBSA), ICU admission, ventilatory support, and surgical excision and skin graft application, all speaking for the severity of the injury (Table 4). A multivariate logistic regression model was constructed to control for confounders. TBSA >20% (p=0.038), ICU stay (p=0.003), and surgical debridement ($p<0.001$) were independent predictors of ARO colonization or infection, after controlling for age, gender, and ethnicity (Table 5). Of total 56 patients admitted with inhalational injuries, 46 were intubated and apart from 6, all patients with inhalational injury were admitted to ICU. The statistical analysis showed high correlation between the ICU admission and the presence of inhalational injury, therefore it was not included in the multivariate analysis.

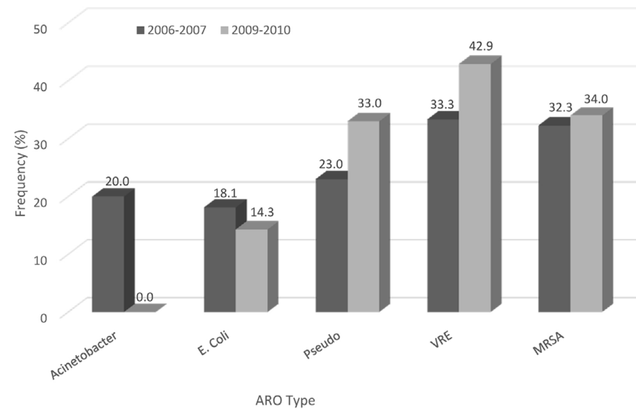

Fig. 1 – The incidence of ARO in the pre- and post-contact precautions groups.

4. Discussion

Outcomes in burn patients have improved substantially in the past few decades due to medical advances in fluid resuscitation, nutritional support, critical care, burn wound care, and infection control practices [1]. The incidence of nosocomial infections has been said to be on the rise, but this might also reflect the increased number of samples taken. The clinical benefit of routine surveillance has yet to be determined. Routine surveillance may provide early identification of organisms colonizing the wound that may progress to infection, however, disadvantages include unnecessary costs in a resource constrained environment and initiation of empiric antibiotic therapy that may be unnecessarily.

An accurate clinical diagnosis of infection in burn patients is challenging due to several factors that includes elevated

Table 3 – The clinical characteristics for burn patients in the pre and post contact precautions groups.

Variable	Pre-contact precautions (2006–2007) N=167 frequency (%)	Post-contact precautions (2009–2010) N=112 frequency (%)	p-Value
Length of stay/TBSA	2.6±4.8	2.2±3.2	0.4
Mean age±SD	39.6±19.1	46.4±20.8	**0.006**
Male gender	127 (76.1)	94 (83.9)	0.4
Caucasian	125 (74.9)	71 (63.4)	**0.04**
Ventilation	36 (21.6)	23 (20.5)	0.8
Mechanism of burn			
Flame	117 (70.1)	74 (66.1)	0.48
Contact	10 (5.9)	7 (6.2)	0.9
Electrical	10 (5.9)	9 (8.0)	0.5
Scald	23 (13.8)	16 (14.3)	0.9
Chemical	1 (0.6)	1 (0.6)	0.8
Inhalational burn	41 (24.9)	9 (8.1)	<**0.001**
TBSA Burn >20%	40 (23.9)	19 (16.9)	0.2
ICU admission	38 (22.8)	24 (21.4)	0.8
Surgery for burn	109 (66.1)	85 (75.9)	0.08

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Table 4 – Univariate analysis of ARO and control group.

Variable	ARO group N=68 frequency (%)	Non ARO control group N=272 frequency (%)	Odds ratio (SE)	p-Value
Age, mean (SD)	42.9 (20.0)	41.5 (19.7)	1.00 (0.007)	0.60
Male gender	51 (75.0)	215 (79.0)	1.28 (0.41)	0.44
Caucasian	53 (77.9)	189 (69.5)	1.55 (0.49)	0.17
Ventilation	21 (30.9)	49 (18.0)	2.03 (0.63)	0.02
ICU admission	25 (36.7)	47 (17.3)	2.78 (0.83)	0.001
Surgery	62 (91.2)	176 (64.7)	5.5 (2.46)	<0.001
TBSA burn >20%	26 (38.2)	55 (20.2)	2.44 (0.72)	0.002
TBSA burn <20%	42 (61.8)	217 (79.8)	Reference	–

Table 5 – Multivariate logistic regression model.

Variable	Odds ratio (standard error)	95% confidence interval	p-Value
Age	0.99 (0.007)	0.98–1.01	0.92
Gender	0.92 (0.33)	0.46–1.85	0.82
Caucasian	1.45 (0.49)	0.74–2.84	0.27
TBSA >20%	1.97 (0.64)	1.04–3.73	0.038
ICU admission	2.77 (0.94)	1.43–5.38	0.003
Surgery	5.96 (1.74)	2.41–14.68	<0.001

C-statistic=0.73; ventilation and inhalational injury removed from model because highly correlated with ICU admission.

normal body temperature due to hypermetabolic state, the immunosupressed status specific to burn, along with systemic inflammatory response syndrome. However, infection continues to be an important complication that occurs in this patient group, with major contribution to increased rates of morbidity, mortality and healthcare costs due to multidrug-resistant *S. aureus*, *P. aeruginosa*, *A. baumannii* infections [9].

The microbiological profile has changed in the last 3 decades. Group A beta-hemolytic *Streptococcus* was the most frequent cause of life-threatening burn wound and systemic infections in early 1980s [10]. The use of penicillin altered the spectrum of gram-positive pathogens [11,12] to place *S. aureus* as the most common Gram-positive early colonizer of the burn wound [11,13]. Prolonged hospitalization and the widespread and inappropriate use of antibiotics further led to the development of MRSA colonization and infections [12,14]. Despite studies that report an association between antibiotic use and AROs in burned patients, this may not extend to multi-drug resistant organisms and results from retrospective study designs should be interpretive cautiously. Retrospective studies cannot provide casual relationships and most importantly, do not control for confounders, such as the size of the burn and length of hospitalization.

We compared patients in two different time periods, before and after the universal contact precaution initiation with a 1year "ramp-up" period in between. This is important as it gives the staff time to get used to new protocols and it decreases the risk of non-compliance of following protocols. We found MRSA to be the most common ARO (74.7%) isolated from burn patients, with the majority from clinical specimens cultured from the burn wound. Alrawi et al. report *S. aureus* as the major source of colonization in the burn wound in the United Kingdom [15]. Thabet et al. have shown that *S. aureus* was the most frequent pathogen isolated from patients in a French burn unit, with a methicillin-resistance rate of 68.1% [16]. Similarly, burn centres around the world have reported this increasing incidence and prevalence of this organism [11,17–19].

In a prospective surveillance of nosocomial infections in a burn ICU, Gram-negative pathogens were the most commonly identified bacteria [20]. A recent review done by Azzopardi et al. has shown that Gram-negative micro-organisms (*P. aeruginosa*, *Klebsiella pneumoniae*, *E. coli*, *Enterobacter* species, and *Proteus* species) are the most common pathogens for the early period after burn, but it is not unusual for this pathogen to also be found beyond this period [21] which is in contrast with traditional teaching. There is a significant association between burn wounds infected with this "target set" of Gram-negative organisms and increased mortality [22]. The incidence of Gram-negative pathogens causing infections is similar across burn centres worldwide [21]. This may help contribute to more timely and effective clinical treatment regimens.

Our study identified predictors of ARO infection and colonization to include burns involving more than >20% TBSA, ICU admission, and surgical excision and skin grafting. These are all signals of higher acuity and severity of the injury, which perhaps is the variable that really matters. Alrawi et al. found a direct link between increased incidence of bacterial colonization in burn patients and delay in referral of >24h, larger burn size, and length of hospital stay [15]. Similar findings were shown by Tekin et al., who found that the risk factors associated with nosocomial burn wound infection with multidrug resistant *Acinetobacter* species included the extent of burn TBSA, ICU stay, and prior use of cephalosporins [23]. Abbreviated Burn Severity Index (ABSI) predicts mortality on admission of burn patient based on gender, presence of inhalation injury, full-thickness burn, age, and TBSA burned. An elevated ABSI score and burns located on the head and neck were found to be risk factors most significantly related to

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colonization or infection in an outbreak of multidrug-resistant K. *pneumoniae* in a critical burn patient unit [2].

We report fewer inhalational injuries in the post-contact precaution group. This is likely due to the over-diagnosis of inhalational injuries earlier in the study period with lack of bronchoscopic evidence in our centre. In the later time period that coincides with the post-contact precaution group, bronchoscopy was uniformly used to make the diagnosis, thus leading to a decrease in the proportion of patients diagnosed with an inhalational injury undergoing intubation.

Emerging multi-drug resistant pathogens have forced burn care providers across the world to search for alternative and additional methods of treatment in order to control and reduce the incidence of transmission and spread of AROs. In our study, the implementation of universal contact precautions did not significantly decrease rates or ARO, but on the other hand changed the profile of organisms identified. There have been many studies to evaluate the effectiveness of infection control practices on the incidence of AROs in various hospital settings. A randomized study evaluated the surveillance and barrier precautions for MRSA and VRE in an ICU setting found that this intervention did not significantly decrease the mean incidence of colonization and infection [24]. Trick et al. compared routine glove use alone to glove use with contact precautions by healthcare workers who looked after residents who were VRE and/or MRSA positive. Their study demonstrated no difference in ARO acquisition between the two interventions [25]. Slaughter et al. evaluated the effectiveness of gowning and gloving versus gloves alone on the acquisition of VRE in a medical ICU and no difference was found in the VRE colonization rates [26]. Interestingly, a recent study with 480 burn patients has shown that a bath with sterile water and chlorhexidine gluconate twice a day reduced the rate of hospital-acquired infection, which was clinically significant but not statistically significant due to insufficient power [27].

The infection control measures such as strict isolation and barrier precautions also have disadvantages. A recent systematic review performed by Morgan et al. highlighted several adverse outcomes associated with contact precautions that includes: less patient-health care worker contact, more noninfectious adverse events, an increase in depression and anxiety, and a reduction of patient satisfaction with the healthcare providers [28]. Additionally, there are studies that have demonstrated that physicians are less likely to examine patients in contact isolation [29,30].

Despite priority placed on preventing transmission of multidrug resistant organisms, there still remains a lack of consensus among recommended infection control guidelines. A systematic review published in the American Journal of Infection Control identified gaps in the literature including need for greater monitoring of implementation of the interventions, more cost analysis of interventions, determining the independent contribution of specific interventions, and identifying the minimum interventions needed to reduce transmission [31].

Based on the lack of literature demonstrating benefit of barrier precautions and our study results that identified significant predictors of ARO colonization and infection, we were able to alter current practice our burn unit by de-escalating universal contact precautions, which was implemented July, 2013. Contact precautions are now used for all burns transferred to the burn unit from ICU, TBSA >20% in all ages, and TBSA >15% in patients >70 years old.

Fact remains that we still do not really know what the true consequences of having a multi-resistant bacterium in a culture are. We know that regardless of precautions eventually there is a risk for not having an arsenal of antibiotics that we can use to treat these bacteria. However, not all burns greater than 20% TBSA have these bacteria, nor do all burns that need ICU or surgery. It seems that certain patients with certain risk factors or a severe enough burn just develop these bacteria regardless of our best efforts to prevent this from happening. It is a challenge of the future to find means to eliminate the development of these bacteria.

The limitations of this study is based on the retrospective design with a relatively small samples of the control and intervention groups, amalgamation of colonization and infection episodes and the assumption that compliance with infection control policies was 100%. We were not able to control for all confounders and did not measure all variables, such as antibiotic use and compliance. A prospective study is needed to evaluate all potential patient and clinic factors that may contribute to the increased incidence of AROs in burn patients.

In conclusion, our results suggest that the implementation of universal contact precautions may not significantly reduce the frequency of AROs among this compromised population but can change the profile of organisms found. Contact precautions for patients transferred from the ICU, undergoing surgery, and large burns may be of benefit. Continued surveillance after removal of universal contact precautions is an area of future research.

Conflicts of interest

None.

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