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Original Article

Effects of targeted care using a risk warning model on burn site infection

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Abstract

Introduction: Prevention and control of wound infection in burn patients is critical. This study aimed to establish an infection risk warning model based on the clinical characteristics of burn patients, by formulating targeted care programs according to the risk warning factors, and analyzing the effects of these programs on wound infection in burn patients.

Methodology: Data of 73 burn patients admitted to the hospital between 2020 and 2022 who underwent microbial culture examinations were analyzed. The patients were categorized into infected (50) and uninfected (23) groups. The infected group was further divided into nosocomial and out-of-hospital infections. The patients' clinical characteristics and their relationships with infection were analyzed. An infection risk warning model was established and targeted care programs were developed on the basis of these characteristics. In 2023, 50 patients were randomly assigned to routine care or targeted care groups, to assess the effects of targeted care on burn site infection with use of the risk warning model.

Results: Age, hypovolemic shock, and white blood cell counts were independent risk factors for wound infection in hospitalized patients with burn injuries. A degree III wound depth, hospitalization of ≥ 30 days, and duration from burn to first hospitalization of 3–72 hours were independent risk factors for nosocomial infection. Patients receiving targeted nursing care showed high wound healing efficiency, low nosocomial infection rates, and high satisfaction with nursing.

Conclusions: Use of an early warning model and implementing a targeted nursing program can effectively decrease infection risk in burn patients.

Key words: burn; warning model; targeted care; satisfaction.

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Introduction

Burn injuries were identified as the sixth leading cause of death in the most recent Global Burden of Disease (GBD) data from 2013, when 2.9 million people were hospitalized for burns worldwide, and 31 million more people required outpatient treatment. More alarmingly, the number of deaths from burns was 238,000 [1]. In 2017, burn-related statistics in China indicated age-standardized morbidity, mortality, and disability-adjusted life years of 108 per 100,000 deaths, 0.7 per 100,000 deaths, and 48 per 100,000 deaths, respectively [2]. In addition, the mortality in patients with burn-associated infections was more than twice of that in patients without infection [3].

Burn wound infection (BWI) is an important factor involved in the development of sepsis and septic shock in patients with severe burns. Although the number of burn patients dying from pneumonia currently exceeds the number with BWI, BWI and burn wound sepsis are serious complications in burn patients [4]. BWIs are categorized primarily into out-of-hospital infections and in-hospital infections. Control of out-of-hospital infection and prevention of nosocomial infection can greatly decrease mortality in burn patients. We evaluated the factors influencing BWI from a bacterial perspective to advance our understanding of BWI. We further established an infection risk warning model and implemented a targeted care program. Finally, we analyzed the characteristics of nosocomial infections, and observed the effects of targeted care on burn site infection with the use of our risk warning model.

Methodology

Study design and participants

We collected data for 73 patients admitted to our burn orthopedic department between 2020 and 2022,

whose wound secretions underwent microbial culture testing during hospitalization. Fifty patients admitted for burns in 2023 were assessed, to observe the effects of targeted care on burn site infection with use of our risk warning model. The inclusion criteria were as follows: patients with burns, including fire burns, water burns, chemical corrosion injury, or electric shock injury; whose wound discharge during hospitalization was sent for microbial culture (including sputum microbial culture in patients with respiratory burns). The exclusion criteria were as follows: patients without burns, except wound discharge specimens during hospitalization; and patients with incomplete clinical information. The patients were divided into infected (50 patients) and uninfected (23 patients) groups based on the microbial culture results. The clinical characteristics of burn patients and their relationship with infection were analyzed. Simultaneously, the infection group was divided into nosocomial infection (18 cases) and out-of-hospital infection (32 cases) groups, and the factors associated with nosocomial infection were analyzed. The clinical characteristics of burn patients were used to establish an infection risk warning model, and develop targeted care programs according to the risk warning factors. The determination of nosocomial infection cases was based on the diagnostic criteria for healthcare-associated infection (trial) issued by the National Health Commission of the People's Republic of China (PRC) in 2001 [5]. The BD Phoenix™ M50 (Becton, Dickinson and Company, Franklin Lakes, USA) automated microbiology system was used, and the results were determined according to the Clinical and Laboratory Standards Institute (CLSI) standards [6]. The quality control strains were *Escherichia coli* (ATCC25922), *Staphylococcus aureus* (ATCC25923), *Pseudomonas aeruginosa* (ATCC27853), *Enterococcus faecium* (ATCC35667), and *Enterococcus faecalis* (ATCC29212) [7].

The study protocol was approved by the research ethics board of Fuyang People's Hospital. The study procedures were performed in accordance with the Declaration of Helsinki and Clinical Practice Guidelines of the national government. Written informed consent was obtained from all participants before enrollment.

Nursing plan

The observation group received routine care and targeted care using the risk warning model, whereas the control group received only routine care. The infection

Table 1. Burn patients' clinical characteristics and their relationships with infection.

Characteristic	BWI (n = 50)	Uninfected group (n = 23)	Univariate		Multivariate	
			OR (95% CI)	*p value*	aOR (95% CI)	*p value*
Age (years)	50.60 ± 12.73	40.61 ± 15.86	1.020 (0.998, 1.043)	0.048*	1.12 (1.012, 1.254)	0.03*
Gender			1.225 (0.460, 3.421)	0.657		
Male	31 (62.00%)	13 (56.52%)				
Female	19 (38.00%)	10 (43.48%)				
BWI	23.55 ± 3.86	23.13 ± 5.36	1.022 (0.913, 1.144)	0.705		
Etiology						
Fire	34 (68.00%)	13 (56.52%)	——	——		
Scalds	14 (28.00%)	9 (39.13%)	1.478 (0.345, 2.113)	0.843		
Electricity	1 (2.00%)	0 (0.00%)	1.54 (0.97–2.43)	0.067		
Chemicals	1 (2.00%)	1 (4.35%)	1.95 (0.97–3.93)	0.612		
Depth			3.630 (1.292, 10.197)	0.0167		
II	15 (30.00%)	8 (34.80%)				
III	35 (70.00%)	15 (65.20%)				
TBSA (%)						
≤ 20	27 (54.00%)	11 (47.83%)	—	—		
20–50	6 (12.00%)	8 (34.78%)	1.731 (0.474, 6.324)	0.406		
≥ 50	17 (34.00%)	4 (17.39%)	0.306 (0.086, 1.088)	0.067		
Hypovolemic shock			2.174 (1.478, 2.824)	0.022	25.914 (1.177, 570.634)	0.039*
Yes	13 (38.00%)	4 (13.00%)				
No	37 (62.00%)	19 (87.00%)				
Hospital length of stay (days)						
≤ 15	17 (34.00%)	6 (26.09%)	—	—		
15–30	14 (28.00%)	6 (26.09%)	1.640 (0.499, 5.395)	0.415		
≥ 30	19 (38.00%)	10 (51.18%)	1.351 (0.403, 4.534)	0.626		
Duration from burn to first hospitalization (h)						
< 3	14 (28.00%)	10 (43.48%)	—	—		
3–72	11 (22.00%)	4 (17.39%)	1.750 (0.607, 5.044)	0.300		
> 72	25 (50.00%)	9 (39.13%)	5.333 (0.599, 47.468)	0.133		
WBC (10^9/mL)	15.61 ± 3.87	11.58 ± 1.32	0.946 (0.889, 1.006)	0.039	0.937 (0.843, 1.119)	0.031*
NEU (10^9/mL)	12.49 ± 4.25	9.02 ± 1.42	0.949 (0.890, 1.012)	0.112		
CRP (mg/L)	73.66 ± 48.47	78.35 ± 43.35	0.997 (0.989, 1.008)	0.590		

BWI: burn wound infection; CI: confidence interval; CRP: C reactive protein; NEU: neutrophils; OR: odds ratio; TBSA: total burns surface area; WBC: white blood cells; * statistically significant ($p < 0.05$).

Table 2. Receiver operating characteristic (ROC) curve analysis of age and white blood cell (WBC) indicators in the infected and uninfected groups.

Variables	AUC	95% Confidence interval (CI)	*p* value	Youden index
Age (years)	0.654	0.493~0.726	0.0134	0.5052
WBC (10^9 / mL)	0.710	0.549~0.776	0.0083	0.6345

risk factors were age > 48 years, white blood cell (WBC) count > 7.12 × 10^9/mL, hypovolemic shock, wound depth III, hospitalization for ≥ 30 days, and duration from burn to first hospitalization of 3–72 hours (Tables 1 and 2, Figure 1). Targeted care using the risk warning model included:

1) Independent risk factors based on nursing records and special marking. Risk factors identified through the application of risk warning models must be clearly marked with corresponding risk indicators.
2) Rigorous temperature and blood monitoring to accurately indicate patients' physical condition: The temperature and WBC counts of patients was monitored frequently, especially for the patients whose WBC levels were above the predetermined threshold.
3) Wound cleaning and care to decrease infection risk: In the case of patients with degree III wounds, the principle of aseptic operation was followed to increase the frequency of wound cleanings and keep the wound dry.
4) Correction of shock symptoms: In the case of patients with hypovolemic shock on admission, blood volume expansion and acidosis correction were applied. In addition, vasoactive drugs were used rationally to inhibit the excessive inflammatory response, improve cell metabolism, and reduce cell damage. Organ support was provided to prevent organ failure.
5) Dynamic observation: Increased wound and patient status monitoring were applied for patients above the threshold age (48 years) and with a longer hospital stay (> 30 days), to detect and handle any abnormal conditions.

Evaluation of nursing effects

The total wound healing response rate, nosocomial infection rate, and satisfaction with care were determined in the observation group.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) 26.0 (IBM Corp, Armonk, NY, USA) was used to process the data. Logistic regression analysis was used to the identify infection risk warning factors. The critical points of measurement were analyzed using receiver operating characteristic (ROC) curve analysis. Chi-square test was used to compare the effects of the two care options. $p < 0.05$ was as considered clinically significant.

Results

Burn patients' clinical characteristics and their relationships with infection

Age, hypovolemic shock, and WBC counts were independent risk factors for wound infection in hospitalized patients with burn injuries. The threshold values for age and WBC counts were 48 years and 7.12 × 10^9/mL, respectively (Tables 1 and 2, Figure 1).

Comparison of clinical data of in-hospital and out-of-hospital infection in burn patients

Wound depth III, length of stay ≥ 30 days, and duration of burn to first hospitalization 3–72 hours were independent risk factors for nosocomial infection in burn patients (Table 3).

Evaluation of the nursing effects on burn patients in the observation and control groups

The total wound healing response rate in the observation group was higher than that in the control group; and the low rate of nosocomial infection in the

Figure 1. Receiver operating characteristic (ROC) curve analysis of age and white blood cell (WBC) indicators in the infected and uninfected groups.

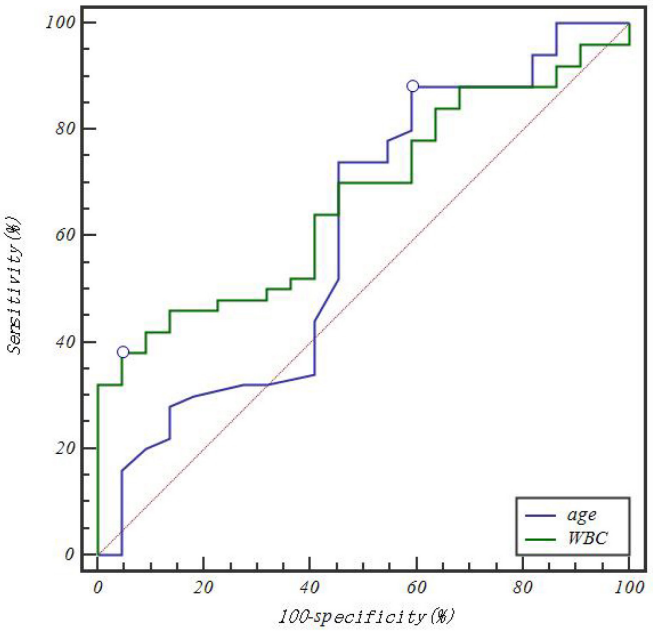

Table 3. Risk factors for nosocomial infection in burn patients.

Characteristic	Nosocomial infection (n = 18)	Non-nosocomial infection (n = 32)	Univariate		Multivariate	
			OR (95% CI)	*p value*	aOR (95% CI)	*p value*
Age (years)	44.11 ± 13.43	52.69 ± 12.75	0.979 (0.951, 1.008)	0.159		
Gender			0.855 (0.266, 2.748)	0.793		
Male	12 (66.67%)	19 (59.38%)				
Female	6 (33.33%)	13 (40.62%)				
BWI	23.92 ± 4.19	23.46 ± 4.52	1.025 (0.896, 1.173)	0.716		
Depth			0.083 (0.018, 0.374)	0.001*	0.097 (0.008, 0.214)	< 0.001*
II	12 (66.67%)	3 (9.36%)				
III	6 (33.33%)	29 (90.64%)				
TBSA (%)						
≤ 20	6 (33.33%)	21 (65.63%)	—	—		
20–50	2 (11.11%)	4 (12.50%)	0.308 (0.076, 1.245)	0.098		
≥ 50	10 (55.56%)	7 (21.87%)	0.375 (0.078, 1.799)	0.22		
Hypovolemic shock			0.239 (0.046, 1.231)	0.087		
Yes	2 (11.11%)	11 (34.37%)				
No	16 (88.89%)	21 (65.63%)				
Multidrug resistant			1.527 (0.468, 4.979)	0.482		
Yes	8 (44.44%)	11 (34.37%)				
No	10 (55.56%)	21 (65.63%)				
Hospital length of stay (days)						
≤ 15	2 (11.11%)	17 (53.12%)	—	—		
15–30	5 (27.78%)	9 (28.13%)	3.111 (0.575, 16.833)	0.188		
≥ 30	11 (61.11%)	6 (18.75%)	38.500 (5.576, 265.828)	< 0.001*	17.50 (5.576, 165.721)	< 0.001*
Duration from burn to first hospitalization (h)						
< 3	3 (16.67%)	11 (34.37%)	—	—		
3–72	10 (55.56%)	1 (3.13%)	8.519 (1.895, 38.285)	0.005*	9.714 (3.195, 48.285)	0.017*
> 72	5 (27.78%)	20 (62.50%)	0.96 (0.54, 1.71)	0.885		
WBC (10^9/mL)	10.91 ± 6.76	15.36 ± 8.67	0.788 (0.522, 1.19)	0.257		
NEU (10^9/mL)	8.41 ± 6.36	12.38 ± 8.33	1.24 (0.816, 1.885)	0.313		
CRP (mg/L)	19.31 ± 23.38	63.35 ± 5.85	0.969 (0.940, 1.000)	0.049*		

BWI: burn wound infection; CI: confidence interval; NEU: neutrophil; OR: odds ratio; TBSA: total burns surface area; WBC: white blood cell; * statistically significant ($p < 0.05$).

Table 4. Comparison of wound healing between patient groups.

Groups	n	Excellence	Effective	No effect	Total effective rate
Observation group	25	20 (80.00%)	4 (16.00%)	0 (0.00%)	24 (96.00%)
Control group	25	10 (40.00%)	8 (32.00%)	1 (4.00%)	19 (76.00%)
$\chi 2$					4.545
p value					0.033*

* statistically significant ($p < 0.05$).

Table 5. Comparison of nosocomial infection between patient groups.

Groups	n	Hospital infection	Uninfected individuals
Observation group	25	1 (4.00%)	13 (52.00%)
Control group	25	7 (28.00%)	6 (24.00%)
$\chi 2$		5.992	4.160
p value		0.015*	0.042*

* statistically significant ($p < 0.05$).

Table 6. Satisfaction with nursing care between patient groups.

Groups	n	Very satisfied	Satisfied	Basically satisfied	Unsatisfied	Degree of satisfaction
Observation group	25	15 (60.00%)	4 (16.00%)	5 (20.00%)	1(4.00%)	24(96.00%)
Control group	25	10 (40.00%)	7 (28.00%)	1 (4.00%)	7 (28.00%)	18 (72.00%)
χ^2						5.992
p value						0.015*

* statistically significant ($p < 0.05$).

burn patients in the observation group indicated high satisfaction with nursing care (Tables 4, 5, and 6).

Discussion

The aim of this study was to elucidate the factors underlying BWI and to characterize wound secretion cultures in burn patients. The skin is the functional barrier of the body against microorganisms. When the skin is damaged, the wound surface is prone to infection and inflammatory reactions, which may lead to sepsis in severe cases. Therefore, effective preventive measures should be taken to decrease the risk of infection and inflammatory response [8]. We evaluated BWIs from a bacterial perspective. We constructed an infection risk warning model through a detailed analysis of the characteristics of nosocomial infections, and implemented a targeted care program. Our results are expected to provide a scientific basis for clinical practice through observing the effects of targeted care using the risk warning model on the burn site.

The mean age of the wound infected group was 50 years and this was 10 years higher than that in the uninfected group (40 years); in contrast to findings from previous studies [9,10]. According to our analysis of patient characteristics, the age threshold for the wound infection in burn patients was 48 years. We used the ROC curve to identify the age threshold for wound infection in burn patients. The incidence of infection after a burn was high, and the older the age, the higher the incidence of infection. The clinical symptoms of infections in older patients after burns are usually atypical, with no clear fever symptoms; non-specific symptoms may also occur [11]. For example, in early stages of BWI, redness and swelling around the wound, elevated skin temperature, and WBC counts beyond the normal reference range are usually observed. However, in older patients, no such changes are observed, and the local inflammatory response at the wound is slow and unclear. In this study, the wounds of burn patients who were older than 48 years and who were admitted to the hospital were carefully monitored through dynamic observation of patients' condition and provision of nursing care. In addition to provision of routine care, the frequency of observation should be increased, and patients and their families should be informed to monitor the cleanliness and dryness of the wounds.

WBC counts refer to the measurement of the number of white blood cells per unit volume. WBC is an important component of the human immune system and plays a crucial role in resisting infections and maintaining physical health. Therefore, the status of immune function of the body can be evaluated through the detection of WBC count; thus, aiding in diagnosis of infections and blood diseases [12]. The WBC threshold for wound infection in burn patients in this study was 7.12×10^9/mL. Based on our observations, regular monitoring of body temperature and WBC count, especially for patients with WBC exceeding predetermined thresholds, and increased frequency of temperature monitoring are recommended.

Hypovolemic shock refers to the shock caused by a systemic inflammatory response leading to a hypovolemic state in burn patients. It is a common complication in burn patients, and if it is not diagnosed and treated in a timely manner, it can lead to multiple organ failure or even death. Close monitoring of vital signs and laboratory tests should be performed to enable early detection and correction of hypovolemic shock and to ensure the safety of patients with burns. Simultaneously, patients should be given appropriate care and treatment to control disease progression and decrease the occurrence of complications. We identified hypovolemic shock as an independent risk factor for infection in burn patients, in agreement with other research reports [13].

Analysis of the effectiveness of targeted care for infection risk indicated that targeted care is better for wound healing in burn patients than conventional care. Therefore, in clinical practice, targeted nursing measures are recommended for burn patients to improve wound healing.

The causes and prevention measures differ for intrahospital infection and out-of-hospital infection. We found that degree III wound depth, length of hospital stay ≥ 30 days, and a duration of 3–72 hours from burn to initial hospitalization were independent risk factors for hospital acquired infections in burn patients. Deeper burns were associated with longer hospital stays, longer times from the burn to the first hospitalization treatment, and elevated risk of hospital acquired infection. Preventive nursing measures included strengthening the protection for patient immunity, improving aseptic awareness in medical operations, and strengthening the cleanliness and disinfection of hospital environments. The implementation of these measures helped decrease the risk of hospital acquired infections in burn patients. Implementing care targeted at infection risk factors for burn patients, resulted in low hospital infection rate, and burn patients had high satisfaction with nursing care. This targeted care for infection risk factors included effective implementation of strict disinfection systems, and regular replacement of dressings, among other measures. To further improve nursing effectiveness, we recommend strengthening the

training of nursing staff to enhance their professional competence and operational skills, strengthen their communication with patients, and improve their service attitude. In addition, improving disinfection and isolation systems will ensure that all measures are implemented effectively. Safer and more efficient nursing services can be provided for burn patients by continually improving and optimizing nursing measures.

Conclusions

Targeted care must be developed according to the infection risk factors in the region to provide better nursing services for burn patients, and control and prevent in-hospital wound infections, beyond the provision of routine care measures. A comprehensive infection monitoring and early warning system should be established. Monitoring the patients' vital signs and laboratory test results in real time enables timely detection of signs of infection; so that effective measures for intervention and treatment can be taken, and the incidence of infection can be decreased. This strategy can provide burn patients with safer, more efficient, and high-quality nursing services; and can further help them recover as soon as possible. Simultaneously, the results of this study will provide a scientific basis for clinical practice and promote the development and progress of burn care.

Authors contributions

CS: data curation, manuscript-original draft, writing-review and editing; XW: methodology, data curation, writing-review and editing; DW: project administration, writing-review and editing.

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