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Original Article

Analgesic effect of alkalized lidocaine during burn wound dressing

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Abstract: Purpose: To investigate the analgesic effect of alkalized lidocaine on wound dressing operation in burn patients. Methods: 160 burn patients were divided into intervention group (N = 80) and control group (N = 80). The control group was treated with routine burn dressing, and the intervention group was sprayed with a 10:1 configuration of 2% lidocaine and 5% sodium bicarbonate mixture spray. The heart rate (HR), peripheral oxygen saturation (SpO_2), and pain (assessed using a visual analog scale [VAS]) were recorded 10 min before, during, and 10 min after debridement and dressing. The simplified version of the McGill pain questionnaire (SF-MPQ) was used to evaluate pain level. Results: The HR in the intervention group was significantly lower than that in control group ($P < 0.001$). The SpO_2 during the debridement and dressing in the intervention group was significantly higher than that in the control group ($P < 0.001$). The intervention group showed significantly lower VAS scores than control group ($P < 0.001$), and the pain sensation scores and pain scores during and after the debridement and dressing in the intervention group were significantly lower than those in the control group ($P < 0.001$). Conclusion: Alkalized lidocaine has significant analgesic and sedative effects during debridement and dressing of burn wounds, and it can relieve the anxiety and fear in burn patients, making patients relaxed and more amenable to undergo the debridement treatment.

Keywords: Alkalized lidocaine, lidocaine, burn wound dressing, analgesic effect

Introduction

Burns are serious tissue damage caused by a high temperature, a chemical, or an electrical current. The annual incidence of burns worldwide is between 200/100,000 and 400/100,000, which has become a global public health problem [1-3]. Burn patients not only face the threat of disfigurement, deformity, disability, or even loss of life, but also suffer from pain after treatment, which seriously affects their quality of life [4].

Severe pain not only causes damage to the body's immune system but also delays wound healing, aggravates wound infection, and is one factor associated with the post-traumatic stress disorder [5]. During the dressing change of burn wounds, patients feel pain and should be administered effective analgesic drugs to alleviate their fears. The management of pain in burn patients includes pharmacological and non-pharmacological therapy, which includes music therapy, dressing therapy, and relaxation therapy. Although the analgesic effect of non-pharmacological therapies is obvious, the effect is limited to patients with mild burns; the therapies are not effective for severe pain in patients with moderate and large burns [6, 7]. Therefore, drugs are the most effective analgesic method in the management of burn pain. Lidocaine has almost no vasodilatation and does not irritate the tissues, and it can relieve the pain of debridement and dressing to some extent [8]. When lidocaine is alkalized, its nucleobase molecular concentration increases, and the drug entering into the nerve cells is accelerated, thereby reducing the incubation period of anesthesia, accelerating the onset time of anesthesia, and enhancing the anesthetic effect [9]. Previous studies have shown that alkalized lidocaine can be used in various

forms of anesthesia, such as the epidural block and brachial plexus block [10, 11]. However, little research has been performed on the application of lidocaine in the pain management during burn wound dressing.

There is a need for a rapid and effective method to alleviate the pain during dressing change in burn patients. In this study, alkalized lidocaine was applied to the wound dressings of burn patients to investigate its effect on pain in burn patients during wound dressing. The objective was to identify a simple, safe, and effective method of relieving pain during wound dressing change.

Materials and methods

General information

Medical records of 160 burn patients were retrospectively analyzed. The 160 burn patients were divided into an intervention group and a control group; each group consisted of 80 patients. There were 67 males and 13 females in the intervention. The subjects were aged 22-50 years, with average age of 30.58 ± 4.63 years; 59 had II° burns, 21 had III° burns, and the average burn area was 24.63 ± 4.28% TBSA. There were 61 males and 19 females in the control group. The subjects were aged 24-51 years, with average age of (31.57 ± 5.06) years; 63 had II° burns, 17 had III° burn, and the average burn area was 23.57 ± 5.37% TBSA. This study was approved by the ethics committee of our hospital.

Inclusion and exclusion criteria

Inclusion criteria were as follows: burn area of 15% to 70% TBSA or III° burn area > 29% TBSA; analgesic requirements based on fitting in grade I (no systemic diseases other than local lesions with normal health) and II (mild and severe systemic diseases) of the American Society of Anesthesiologists (ASA) [12] classification; severe pain during burn wound dressing changes and a visual analogue scale (VAS) score of > 5 points; identification of both the subjects and the family members and provision of a written informed consent. The exclusion criteria were as follows: presence of acute upper respiratory tract infections; burns with severe inhalation injury; previous history of drug allergy or severe drug dependence; severe burns combined with injuries; mental health disorders; and loss of consciousness.

Debridement and dressing change method

The patients were not allowed to drink and they were required to fast for 2 hours before the dressing change. The control group underwent regular burn dressing. After the disinfection and cleaning of the wound, an antibacterial dressing of silver ion burned (Guangzhou Yimiti Medical Devices Co., Ltd.) was used to cover the wound. The intervention group was treated with a 10:1 configuration of 2% lidocaine and 5% sodium bicarbonate mixture sprays. The spray was administered according to the size of the burn area (8-10 ml for 1% burn area) such that the wound was completely wet. The wound was anesthetized after 5 minutes, and debridement was carried out for 5 min. Then, the wound was covered with the antibacterial dressing of silver ion burned.

Measurement indicators

The heart rate (HR), peripheral oxygen saturation (SpO_2), and pain (assessed using the visual analog scale [VAS]) were recorded 10 min before, during, and 10 min after the debridement and dressing [13]. Pain scores were assessed using VAS: a 10-cm-long ruler with intervals of 1 cm was used, whereby a score of 0 indicated no pain and a score of 10 indicated severe pain. The patient marked the corresponding position on the ruler based on degree of pain he or she experienced, and recorded distance from the 0 point to the marked point was the pain score. Pain assessment was also performed using the simplified version of the McGill Pain Questionnaire (SF-MPQ) [14]: pain perception scores (no pain, mild pain, moderate pain, severe pain, acute pain) and pain emotion scores (no pain and discomfort, mild pain and discomfort, moderate pain and discomfort, severe pain and discomfort, acute pain and discomfort) were assessed.

Statistical methods

Statistical analysis was performed using SPSS 17.0 (IBM Corp, Armonk, NY, USA), and the measured data are expressed as means ± standard deviations ($\bar{x}$ ± SD). For independent samples t test was used for significance testing. The count data are expressed as [n (%)], and the comparison between the count data of

Table 1. Baseline data of the intervention and the control groups [n (%)]/($\bar{x}$ ± sd)

Category	Intervention group (n = 80)	Control group (n = 80)	t/χ^2	P
Gender			1.406	0.323
Male	67 (83.75)	61 (76.25)		
Female	13 (16.25)	19 (23.75)		
Age (y)	30.58 ± 4.63	31.57 ± 5.06	1.291	0.198
Weight (kg)	58.63 ± 12.58	60.57 ± 11.23	1.029	0.305
Height (cm)	164.52 ± 7.54	163.74 ± 8.69	0.606	0.545
BMI (kg/m^2)	23.65 ± 3.58	24.47 ± 3.24	1.519	0.130
Educational level			0.956	0.620
Elementary school and below	21 (26.25)	23 (28.75)		
Junior high school	36 (45.00)	30 (37.50)		
High school and above	23 (28.75)	27 (33.75)		
Cause of burn			0.656	0.720
Hydrothermal fluid	53 (66.25)	49 (61.25)		
Flame	19 (23.75)	20 (25.00)		
Electricity	8 (10.00)	11 (13.75)		
Burn degree			0.552	0.578
II°	59 (73.75)	63 (78.75)		
III°	21 (26.25)	17 (21.25)		
Burn area (%)	24.63 ± 4.28	23.57 ± 5.37	1.381	0.169
Marital status			0.805	0.668
Unmarried	14 (17.50)	18 (22.50)		
Married	61 (76.25)	56 (70.00)		
Widowed	5 (6.25)	6 (7.50)		
ALT (U/L)	59.07 ± 8.41	58.22 ± 6.52	0.714	0.476
AST (U/L)	16.65 ± 5.87	17.37 ± 6.08	0.762	0.447
Glu (mmol/L)	6.02 ± 0.86	5.84 ± 0.72	1.435	0.153

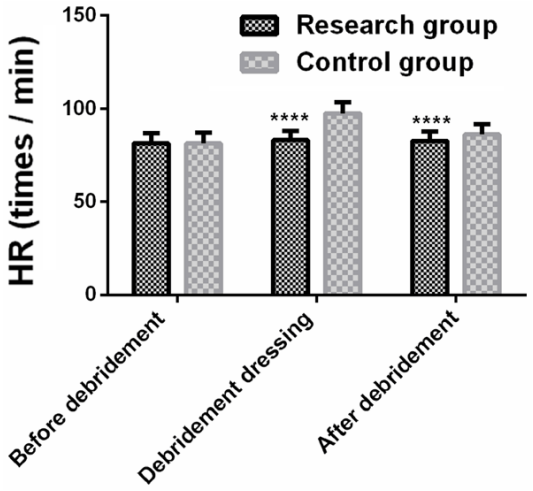

Figure 1. HR before, during, and after debridement in the intervention group and the control group. The HR in the intervention group was significantly lower than that in the control group. Note: ****P < 0.0001 compared with the control group.

the groups is measured by chi-square test. The comparisons of multiple time points were analyzed using repeated measures analysis of variance with post hoc Bonferroni test. P < 0.05 was considered statistically significant.

Results

Baseline data of the two groups

There were no statistically significant differences between the intervention group and the control group with respect to the following clinical baseline variables: gender, age, weight, height, BMI, education level, cause of the burn, burn degree, burn area, marital status, alanine aminotransferase (ALT) level, aspartate aminotransferase (AST) level, and blood glucose (Glu) level (all P > 0.05) (**Table 1**).

HR before, during and after debridement in the two groups

There was no significant difference between the intervention group and the control group before the debridement and dressing (P > 0.05). During and after the debridement and dressing, the HR in the intervention group was significantly lower than that in the control group (t = 16.7300, P < 0.0001; t = 4.1570, P < 0.001) (**Figure 1**).

SpO_2 before, during, and after debridement in the two groups

There was no significant difference between the intervention group and the control group before and after the debridement and dressing (P > 0.05). The SpO_2 during the debridement and dressing in the intervention group was significantly higher than that in the control group (t = 27.7800, P < 0.001) (**Figure 2**).

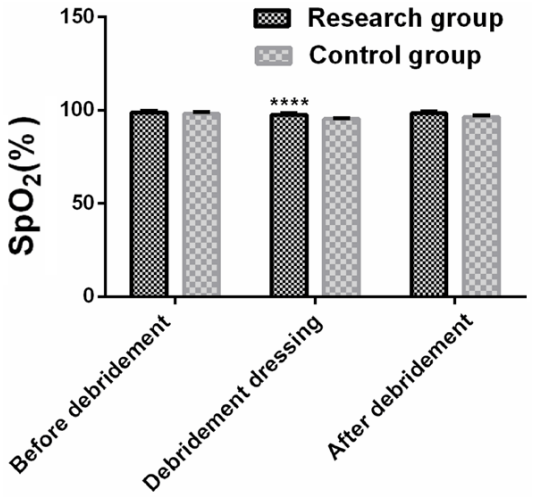

Figure 2. SpO_2 before, during, and after debridement in the intervention group and the control group. The SpO2 during the debridement and dressing in the intervention group was significantly higher than that in the control group. Note: ****P < 0.0001 compared with the control group.

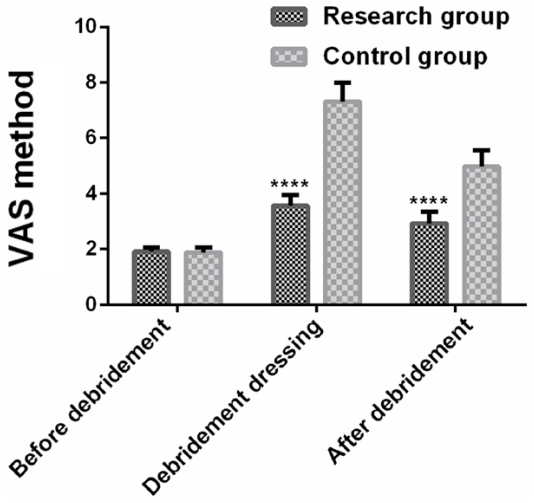

Figure 3. VAS scores before, during, and after debridement in the study group and the control group. After debridement, the VAS score in the intervention group was significantly lower than that in the control group. Note: ****P < 0.0001 compared with the control group.

VAS scores before, during, and after debridement in the two groups

After debridement, the VAS score in the intervention group was significantly lower than that in the control group (t = 42.9400, P < 0.001; t = 25.9900, P < 0.0001) (**Figure 3**).

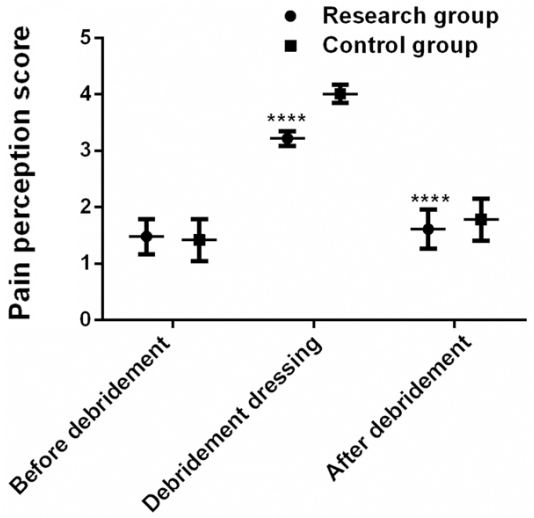

Figure 4. Pain perception scores before, during, and after debridement in the intervention group and the control group. After debridement, the pain perception scores in the intervention group were significantly lower than those in the control group. Note: ****P < 0.0001 compared with the control group.

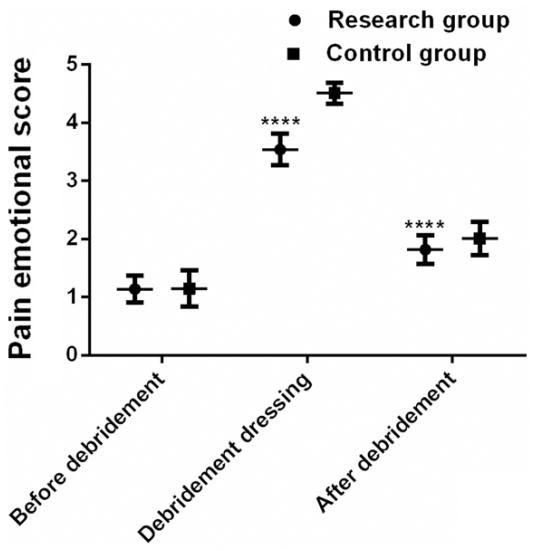

Figure 5. Pain sentiment scores before, during, and after debridement in the intervention group and the control group. After debridement, the pain emotion scores in the intervention group were significantly lower than those in the control group. Note: ****P < 0.0001 compared with the control group.

Pain perception scores before, during, and after debridement in the two groups

Before and during debridement, no significant differences were observed between interven-

tion group and control group. After debridement, the pain perception scores in the intervention group were significantly lower than those in the control group ($t = 34.2800$, $P < 0.0001$; $t = 4.3900$, $P < 0.001$) (**Figure 4**).

Pain emotion scores before, during, and after debridement in two groups

Before and during the debridement, there were no significant differences in the pain emotion scores between the intervention group and the control group ($P > 0.05$). After debridement, the pain emotion scores in the intervention group were significantly lower than those in the control group ($t = 26.7400$, $P < 0.0001$; $t = 4.4380$, $P < 0.001$) (**Figure 5**).

Discussion

Performing a dressing operation of the burn wound is often very difficult. The patient not only has to experience severe burn pain, but he/she also suffers from acute and severe wound dressing operation pain [15]. Acute pain often causes patients to fear the debridement and the dressing, and it also causes emotions such as nervousness and anxiety. Adverse psychological emotions may cause the patient's pain threshold to decrease, which can affect the patient's physiological processes such as breathing and blood circulation. These effects can cause pathological changes, and both physical and psychological pain can increase the difficulty of treatment in patients [16, 17]. Therefore, the use of analgesia and sedation in patients undergoing burn wound dressing operation is of great significance in preventing and relieving pain.

Lidocaine is applied to the mucosal surface during the surface anesthesia, and it passes through the submucosal nerve endings to induce a mucosa block, thus inducing the anesthetic effect [18]. Pain stimulation can cause abnormal changes in the body's neurohumoral system. The sympathetic system will be at an excited state, promoting the release of endogenous substances, increasing the heart rate and blood pressure, increasing gradually oxygen consumption in the myocardium, and lowering blood pressure and oxygen saturation. Relieving pain can also restore blood oxygen saturation and heart rate [19, 20]. After entering the tissue, lidocaine can be neutralized in a weakly alkaline tissue fluid. The free lidocaine is in a nucleobase molecular form. After restoring its fat solubility, lidocaine can penetrate the nerve membrane and the nerve sheath into the cell, and then, it binds to the sodium channel, where it induces the anesthetic effect [21]. Previous studies have shown that lidocaine can alleviate pain in wound debridement and dressing [22]. After lidocaine is alkalized, its pH value increases, its free fat-soluble nucleobases increase, the speed of crossing the nerve membrane begins to accelerate, and the time for anesthesia to take effect is also shortened. Lidocaine is widely used in gastrointestinal endoscopy, cystoscopy, and other procedures [23, 24]. In the process of inducing anesthesia in burn wounds, the anesthetic drugs must contact the normal tissues after first passing through different degrees of burn tissue. The concentration of the nonionic nucleobase of lidocaine with a low pH value is reduced, which limits the anesthetic effect. However, following the alkalization, the concentration of the nonionic nucleobases increases, and the ability of lidocaine to cross the nerve membrane is enhanced, and so is the anesthetic effect [25]. The results of this study showed that the HR in the intervention group was significantly lower than that in the control group during and after the debridement and dressing change. The SpO_2 in the intervention group was significantly higher than that in the control group during the debridement and dressing change. The VAS score, pain perception score, and pain emotional score in the intervention group during the debridement and dressing change were significantly lower than those in the control group, suggesting that the alkalized lidocaine had significant analgesic and sedative effects during and after the debridement and dressing operation of burn wounds. This suggests that lidocaine can alleviate the anxiety and fear in burn patients, making patients relaxed and more amenable to undergo the debridement and dressing change. This observation is similar to results from previous reports which showed that alkalized lidocaine relieves the symptoms of interstitial cystitis and relieves bladder pain [26].

The current study was conducted in strict observance of the exclusion criteria. No differences were found between the intervention group and the control group with respect to the follow-

ing baseline clinical data: gender, age, weight, height, BMI, education level, cause of the burn, burn degree, burn area, marital status, ALT level, AST level, and Glu level. This ensured that the study was rigorous and reliable. This study did not investigate the effect of alkalized lidocaine on wound healing in burn patients. In future studies, the effects of alkalized lidocaine on the prognosis of wounds in burn patients should be further studied.

In summary, alkalized lidocaine had significant analgesic and sedative effects during and after the debridement and dressing operation of burn wounds. Therefore, lidocaine can be used to alleviate the anxiety and fear in burn patients, making them relaxed and more amenable to accept debridement and dressing change.

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Disclosure of conflict of interest

None.

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