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ORIGINAL ARTICLE

Severe burn injury from the common Asian practice of heat application in patients with diabetic neuropathy

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Abstract

This was the first study to analyse patients who sustained severe self-induced burns from this common Asian practice. There is a need to raise public awareness and physician attention about the consequences of preventable burn injuries and the importance of first aid in patients with diabetic neuropathy. Retrospective data on 16 consecutive patients who had diabetes and neuropathy admitted to the plastic surgery ward at the Tri-Service General Hospital from January 1, 2015, to February 2, 2021 with burn injuries because of heat applications were collected and analysed for this study. Age, gender, season, first aid adequacy, comorbidity, interventions, total body surface area (TBSA), degree of burn, aetiology, length of stay (LOS), and status at discharge were reviewed. The mean age of the 16 patients was 65.13 years. The most common burn aetiology was contact (50%), followed by scald (37.5%) and radiation burns (12.5%). TBSA burn averaged ± standard deviation 1.54 ± 1.22. Seven patients (44%) had wound infections, and three patients underwent amputations. The average LOS was 28.2 days. Asian practice of heat application is the common aetiology of severe and preventable burn injuries. Education about neuropathy and the consequences of a burn injury should be provided to patients with diabetes.

KEYWORDS

burns, comorbidity, complications, diabetic neuropathies, surgery

Key Messages

- Severe burn injury caused by the practice of self-heat applications is common in Asian culture among patients with diabetic neuropathy
- The severity of burns depends on comorbidities, mechanism of injuries, and complications
- Awareness for the clinicians about the self-care education, especially the preventable burns, for diabetic patients

1 | INTRODUCTION

Diabetes is one of the most common diseases in Asia. The prevalence of diabetes in adults in Taiwan was 9.8% in 2019. Patients with diabetes are more prone to peripheral neuropathy than those without diabetes are.[1] Moreover, diabetes affects the microvascular and macrovascular systems, and the resulting impairment in the perfusion makes patients less tolerant of cold, especially their hands and feet. Most buildings in subtropical Asia are not equipped with central heaters or fireplaces, and people believe that the application of heat through hot water, heating pads, heaters, and infrared lamps could help increase circulation and keep the extremities warm. Self-induced thermal burns may occur if the length or temperature of the exposure is inadequate.[2] The severity of burn injuries might also be exacerbated by sensory loss, which delays pain or heat. Such injuries because of footbaths[3,4] and the use of hot water bottles[2] have been reported. Moreover, it is well established that patients with diabetes have impaired wound healing and increased infectious complications and vascular diseases.[5] Because of these factors, severe accidental but preventable burn injuries due to this common practice among Asians would be of interest.

2 | METHODS AND MATERIALS

For the present study, data were retrospectively collected by reviewing medical records. We identified patients with diabetes and neuropathy who had sustained burn injuries and were admitted to the plastic surgery ward at the Tri-Service General Hospital from 1 January 2015, to 2 February 2021. A comprehensive history was taken from each patient, and the wound was carefully evaluated. All patients were treated by burn surgeons according to their clinical presentations. Medical records were reviewed using the International Classification of Diseases codes for burn and diabetes mellitus. Peripheral neuropathy was clinically diagnosed if the patient had decreased sensation in the lower extremities. Patients whose mechanisms of burn injuries were because of heat application using warm footbaths, electric blankets, heaters, heating pads, and infrared lamps were enrolled. Ultimately, 16 patients were included in the analysis (Table 1). The following patient data were analysed: sex, age, site of injury, comorbidities, presence of peripheral arterial disease, mechanism of injury, degree of burn, percentage of total body surface area (%TBSA), adequacy of first aid, season and place of the burn event, length of hospital stay, intensive care admission, surgical intervention (numbers and types), and complications.

The burn mechanism was classified as scald (footbath), contact (electric blanket, heater, heating pad), and radiation (infrared lamp). Adequacy of first aid was classified as the application of cool running water for more than 20 minutes or immediate delivery to the clinic or hospital after injury. Wound infections treated with antibiotics were assessed for evidence of bacteria or fungi from discharge or tissue culture. The diagnosis of peripheral arterial disease was based on diminished or absent pulses and imaging findings from arterial studies. Coronary artery disease was defined as a history of percutaneous coronary intervention or coronary artery bypass graft.

3 | RESULTS

3.1 | Patient demographics

Sixteen patients with burns because of heat applications, including footbaths, electric blankets, heaters, heating pads, and infrared lamps, were admitted to the Tri-Service General Hospital during the study period (Table 2). All patients had diabetic neuropathy. Of these patients, 12 were male (75%), and four were female (25%), with a mean age of 65.13 years (SD $\pm$ 10.06). Half of these patients were elderly (greater than 65 years old). Most had comorbid diseases (87.5%), including peripheral arterial disease (7 patients, 44%), hypertension (11, 69%), cerebrovascular accident (1, 6%), and coronary artery disease (6, 37.5%). A large number also had chronic kidney disease (69%), and seven received haemodialysis.

3.2 | Mechanism of injury and burn severity

In our population, the most common mechanism of injury was contact (50%), followed by scald (37.5%) and radiation burns (12.5%). Figures 1-3 illustrate examples of the typical cases. Most of the injuries occurred during winter (75%), followed by spring (19%). All contact burns occurred in winter. Only one patient experienced a burn injury on the hand, with most injuries occurring on the ankle and foot. All injuries occurred at home, and the heat applications were prepared by the patients themselves or their caregivers. There was a higher rate of first aid adequacy in the scald-burn group than in the contact or radiation-burn group. However, only five patients (31%) received adequate first aid.

The mean %TBSA was 1.54 (SD $\pm$ 1.22). The mean %TBSA of scald burn was 2.67, higher than that of the others (contact burn: 1.01, radiation burn: 0.75). The

TABLE 1 Summary of demographics of patients, intervention, and the outcomes

Patient	Age	Mechanism of burn	Season	Site of injury	%TBSA	Burn degree	Comorbidity	Intervention	Complications	Length of stay (days)
1	64	Footbath	Spring	Foot	2	2	+	Deb, STSG	–	14
2	89	Footbath	Winter	Foot	2	3	+	Deb, STSG,PTA	–	15
3	57	Heating pad	Winter	Finger	0.2	3	+	Deb, STSG,HBO	Amputation, infection	35
4	67	Footbath	Winter	Foot	1	2	+	hydrotherapy	–	8
5	54	Infrared lamp	Autumn	Foot	0.5	2	+	Deb, HBO, PTA	–	31
6	56	Electric blanket	Winter	Foot	2	3	–	Deb, STSG,HBO	Infection	22
7	67	Footbath	Spring	Foot	1	2	+	Deb, NPWT,STSG,PTA	Amputation	61
8	76	Infrared lamp	Winter	Foot	1	3	+	Deb, STSG	–	9
9	69	Heater	Winter	Foot	0.5	3	+	Deb, NPWT,STSG,HBO, PTA	Infection	46
10	52	Heater	Winter	Foot	1	2	+	Change dressing	–	14
11	61	Electric blanket	Winter	Foot	2	4	+	Deb, NPWT,STSG	Infection	36
12	73	Heating pad	Winter	Foot	0.1	3	+	Deb, primary closure	–	7
13	57	Electric blanket	Winter	Foot	0.3	3	+	Deb, PTA	infection	27
14	76	Footbath	Spring	Foot	5	2	+	Deb, STSG, PTA	Infection	70
15	71	Footbath	Winter	Foot	5	2	+	Deb, STSG	Infection	21
16	53	Heater	winter	Foot	1	3	+	Deb, PTA	Amputation	20

Abbreviations: Deb, debridement, HBO, hyperbaric oxygen therapy; NPWT, negative-pressure wound therapy; PTA, percutaneous transluminal angioplasty; STSG, split-thickness skin graft; TBSA, total body surface area; –, No; +, Yes.

TABLE 2 Characteristics of burn injury from Asian common heat applications in patients with diabetic neuropathy

Variable	Results
Demographic	
Male	12 (75%)
Female	4 (25%)
Age (average ± SD)	65.13 ± 10.06
<65 y	8 (50%)
>65 y	8 (50%)
Comorbidity	14 (87.5%)
Hypertension	11 (69%)
Chronic kidney disease	11 (69%)
Peripheral arterial disease	7 (44%)
Cerebral vascular disease	1 (6%)
Coronary artery disease	6 (37.5%)
Mechanism of injury	
Scald	6 (37.5%)
Contact	8 (50%)
Radiation	2 (12.5%)
Site of injury	
Upper extremity	1 (6%)
Lower extremity	15 (94%)
Place of event	
Domestic	16 (100%)
Season	
Spring	3 (19%)
Summer	0 (0%)
Autumn	1 (6%)
Winter	12 (75%)
First aid adequacy	
Adequate	5 (31%)
Inadequate	11 (69%)
%TBSA	
Average ± SD	1.54 ± 1.22
Degree of burn	
Second	7 (44%)
Third	8 (50%)
Fourth	1 (6%)
Intervention	
Debridement	14 (87.5%)
STSG	10 (62.5%)
NPWT	3 (19%)
PTA	6 (37.5%)
Hyperbaric oxygen therapy	4 (25%)
Number of operation	
None	2 (12.5%)
1	6 (37.5%)
2 or more	8 (50%)
Complication	
Infection	7 (44%)
ICU admission	1 (6%)
Amputation	3 (19%)
Length of stay (Average ± SD)	28.2 ± 19.1
≦14 d	5 (31%)
>14 d	11 (69%)

majority of the burns were classified as second- (43.8%) and third-degree burns (50%). Most second-degree injuries were scald burns. In contrast, most third-degree injuries were caused by contact injuries. However, one patient had a fourth-degree burn injury caused by an electric blanket (Figure 2A) (Table 3).

3.3 | Clinical treatment and outcomes

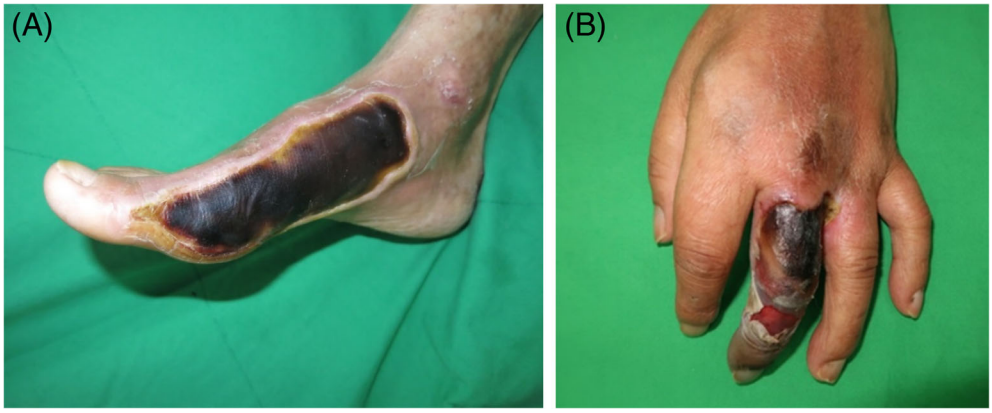
Only two patients, who had second-degree burn injuries, did not require surgery. Instead, they received hydrotherapy using Aquacel Ag (ConvaTec, Princeton, NJ, USA). Among the 14 patients requiring surgery, the average number of surgeries was 2.31. All patients underwent debridement. Specifically, 10 patients received split-thickness skin grafts, and three patients received negative-pressure wound therapy. Moreover, six patients underwent percutaneous transluminal angioplasty on the affected side of the burn injury during hospitalisation. As for the non-surgical interventions, four patients underwent hyperbaric oxygen therapy. All patients were discharged under stable conditions with a simple dressing. Fourteen patients were followed up at the outpatient clinic department with satisfactory recovery (Figure 4), while two patients were lost to follow-up after discharge.

3.4 | Complications and length of stay

The complications included soft tissue infection and amputation. Seven patients (44%) had wound infections, requiring antibiotic treatment. Three patients underwent amputations, with one patient undergoing amputation of his left middle finger from the metacarpophalangeal joint, and two had amputations from the metatarsal cuboid joint. One patient was admitted to the intensive

FIGURE 1 Burn injuries related to footbaths. A, The photo depicts the local findings on the left foot on admission in a 64-year-old patient with diabetes and polyneuropathy who had accidental burn injury of the bilateral feet during a therapeutic footbath for Tinea pedis. B, A 71-year-old with diabetes and polyneuropathy had a scald burn injury during footbath in order to maintain warmth. Severe burn injuries because of footbaths usually occur bilaterally

FIGURE 2 Burn injuries related to warm packs. A, A 61-year-old man had a fourth-degree contact burn injury on admission after using an electric blanket to maintain warmth. B, A 57-year-old man used a heating pad on his hand. Blisters were initially noted in his middle finger but turned ischaemic after a week



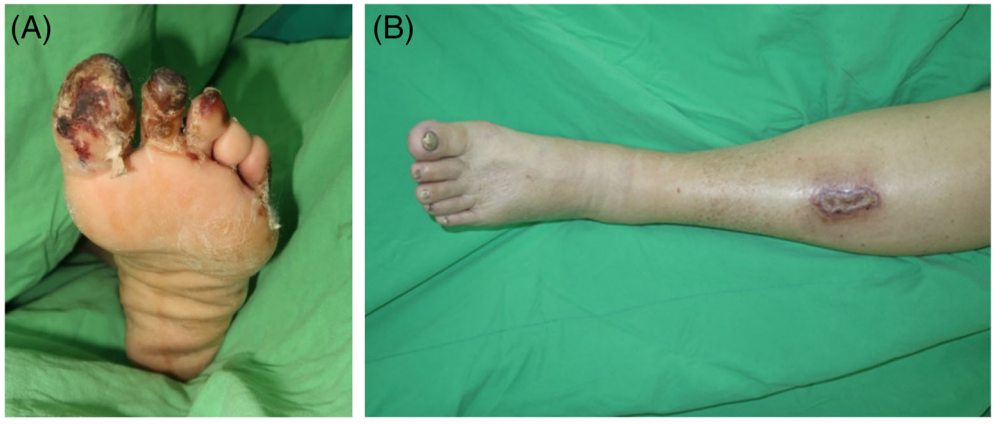


FIGURE 3 Burn injuries related to infrared lamps. A, A 56-year-old woman with diabetic neuropathy believed that radiation could improve local circulation. Burn injuries were observed after using an infrared lamp. The figure depicts the local findings of her left foot on admission. B, A 76-year-old patient with diabetes and polyneuropathy also used an infrared lamp for her lower extremities and presented with severe burn injuries on admission

care unit. The average length of stay (LOS) was 28.2 days (SD ± 19.1). Eleven patients (69%) stayed in the hospital for over 14 days, with six suffering from complications of wound infection.

4 | DISCUSSION

In Asian culture, people believe that the use of heat applications, such as footbaths, heating pads, heaters, or

Mechanism of injury	First aid adequacy (%)	%TBSA (Average)	Dominant degree of burn
Scald	50	2.67	Second
Contact	25	1.01	Third
Radiation	0	0.75	Second and third

TABLE 3 Differences in the mechanism of burn injury

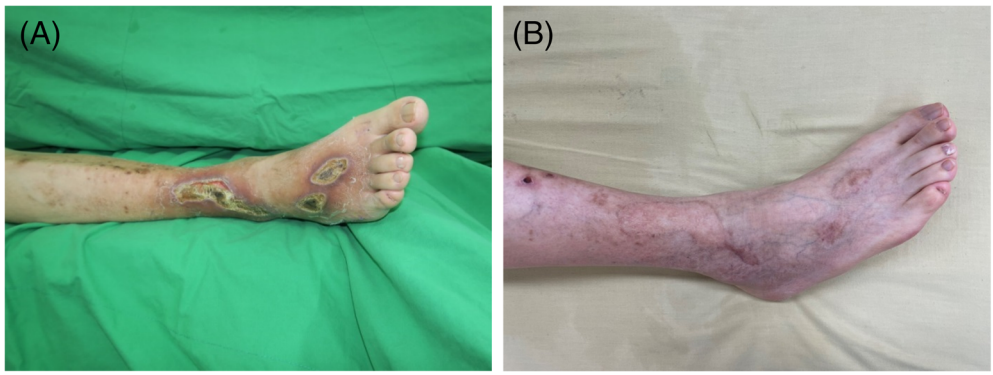


FIGURE 4 This figure depicts a 56-year-old male with diabetic neuropathy suffering from burn injuries on the right lower limb upon admission after using an electric blanket (A). A split-thickness thigh skin graft (0.010 in. thick) was harvested to cover his right lower and dorsal foot. His wound completely healed after 2 years of follow-up at the outpatient clinic (B)

infrared lamps, on the distal extremities could improve local circulation and even neural sensation. These are often used without a doctor's advice and the practice of safety precautions. Common mistakes include a prolonged time of exposure, overheating of the thermal source without checking the temperature before usage, and improper distance from the thermal source. Several thermal injuries in the present study were attributed to this practice.

Diabetic foot burns have been a popular topic in many studies.[1,5,6] It is well documented that there are many factors affecting the healing process in patients with diabetes. Because most of these patients have comorbid macrovascular and microvascular diseases, severe complications and poor circulation may occur. Hyperglycaemia leads to tissue inflammation, impairing the immune system and delaying wound healing. Peripheral neuropathy, present in more than half of patients with diabetes, is the most common complication of diabetes.[7] Although the pathogenesis of diabetic neuropathy is not well understood, microvascular dysfunction is believed to be the cause of axonal damage.[8] This loss of sensation could put patients with diabetes at risk because they may have prolonged exposure to an injurious stimulus without immediate feedback, leading to a deep dermal or larger extent of burn injuries. Moreover, they may miss the golden time for receiving first aid if they do not notice the injury immediately, given their decreased pain sensation compared with patients without diabetes. Some patients also use heat applications during sleep. As such, even if they noticed the wounds, they could not recall the exact time the burn developed. Given these, the limited number of first aid adequacy may have been because of the unnoticed wounds caused by peripheral neuropathy or the lack of information on the first aid for burns.

Diab et al's retrospective analysis indicated that patients with diabetes were 1.7 times more likely to sustain thermal injuries during winter than patients without diabetes were. Similar to our study, most of our patients suffered burn injuries during winter, followed by spring. In Asia, which has a subtropical monsoon climate, the coldest months are January and February, with an average temperature of 16°C, although this could dip to below 10°C because of cold currents. Patients with diabetes are susceptible to cold during this period, increasing the use of heat applications. With the progress in medicine, infrared phototherapy has been widely studied, and even monochromatic infrared energy, delivered through light-emitting diodes, has been approved by the Food and Drug Administration as a complementary therapy for improving blood perfusion and reducing pain, although there is limited evidence that it is beneficial for diabetic neuropathy.[9] However, in our study, the patients suffering from radiation injuries used infrared halogen lamps, whose thermal effect is much greater than that of light-emitting diodes. Therefore, the use of infrared halogen

lamps is a contraindication for people who are insensitive to heat or have advanced diabetes.

The percentage of patients requiring operations in our population was 87.5%, and half of those required at least two operations. There are several reasons contributing to the high operation rate and the high number of operations. First, most of these patients had severe wounds that were not treated immediately. Second, more than 90% of the patients had comorbidities, which impact wound healing and may even result in skin graft failure. We also demonstrated a mean LOS of 28.2 days. A previous study showed a significant difference in the surgical interventions and LOS among the patients with diabetes compared with the non-diabetic group,[5] emphasising that diabetic neuropathy could aggravate the severity of burn injury.

Diab et al[5] also noted that the foot burn wound infection rate was 3.6 times higher in patients with diabetes. Nerone et al found that the incidence rate of infection was 45.5% in diabetic foot burns. Similarly, our findings showed a high infection rate (44%), although not all of our patients sustained foot burns (94%). This may have resulted from several factors. A systematic review by Sayampanathan showed the higher odds of patients with diabetes sustaining local and wound infections compared with the group without diabetes based on the triad of vasculopathy, neuropathy, and immunopathy.[10] Three patients in our study underwent amputation with the comorbidity of peripheral arterial disease. In other studies, some patients required amputations because of osteomyelitis or necrotizing fasciitis,[6,11] but none of these occurred in our patients.

There were many limitations to our study. This was a retrospective study. Our population was gathered using diagnostic codes, and we did not include a control group. However, this study had the largest number of burn injury cases in patients with diabetes and neuropathy from common heat applications in Asia.

Published studies on lower extremity and foot burn outcomes among patients with diabetic neuropathy have shown that they are more susceptible to burns, infection, and other complications. Our report emphasised the Asian practice of heat application as the common aetiology of severe and preventable burn injuries. Education about neuropathy and the consequences of a burn injury should be provided to patients with diabetes. Before a footbath, the water temperature should be tested by a person without diabetes, with a thermometer or a body part with normal sensation. A water temperature less than 38°C (100°F) is considered safe. Furthermore, hot packs, heaters, and infrared lamps should be used with caution. Patients with diabetes and neuropathy should avoid prolonged contact, especially during sleep. Maintaining a safe distance from the heaters and infrared lamps is also important. Once the heat application has been completed, the patients should check for any burn injuries. Adequate first aid of running cooling water for 20 min after the injury is required as soon as possible. Medical specialists should educate patients with diabetic neuropathy who have the habit of heat application.

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CONFLICT OF INTEREST

The authors indicate no potential conflicts of interest.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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REFERENCES

1. Kimball Z, Patil S, Mansour H, Marano MA, Petrone SJ, Chamberlain RS. Clinical outcomes of isolated lower extremity or foot burns in diabetic versus non-diabetic patients: a 10-year retrospective analysis. *Burns*. 2013;39(2):279-284.
2. Jose RM, Vidyadharan R, Roy DK, Erdmann M. Hot water bottles and diabetic patients – a cautionary tale. *Br J Gen Pract*. 2005;55(512):222-223.
3. Loh HH, Tan F. Self-induced burn injury from thermal footbath in patients with diabetes neuropathy—a common mishap in Asian culture. *Br. J. Med. Pract.* 2014;7(1):a702.
4. Putz Z, Nadas J, Jermendy G. Severe but preventable foot burn injury in diabetic patients with peripheral neuropathy. *Med Sci Monit*. 2008;14(9):CS89-CS91.
5. Diab J, O'Hara J, Pye M, Parker C, Maitz PKM, Issler-Fisher A. Foot burns: a comparative analysis of diabetic and non-diabetic patients. *Burns*. 2021;47(3):705-713.
6. Nerone VS, Springer KD, Atway SA. Diabetic foot burns: a case series. *J Foot Ankle Surg*. 2014;53(4):453-455.
7. Feldman EL, Callaghan BC, Pop-Busui R, et al. Diabetic neuropathy. *Nat Rev Dis Primers*. 2019;5(1):42.
8. Park Y. Oxidative stress and diabetic neuropathy. In: Preedy VR, ed. *Diabetes: Oxidative Stress and Dietary Antioxidants*. San Diego, CA: Academic Press; 2014:3-13: chap 1.
9. Robinson CC, Klahr PDS, Stein C, Falavigna M, Sbruzzi G, Plentz RDM. Effects of monochromatic infrared phototherapy in patients with diabetic peripheral neuropathy: a systematic

review and meta-analysis of randomized controlled trials. *Braz J Phys Ther*. 2017;21(4):233-243.
10. Sayampanathan AA. Systematic review of complications and outcomes of diabetic patients with burn trauma. *Burns*. 2016; 42(8):1644-1651.
11. Dijkstra S, vd Bent MJ, vd Brand HJ, et al. Diabetic patients with foot burns. *Diabet Med*. 1997;14(12):1080-1083.

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