

# *The Epidemiology of Foot Burns at Chiang Mai University Hospital: A 6-Year Retrospective Analysis*

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## **Abstract**

The epidemiology of isolated foot burns and foot burns with multifocal areas was evaluated. A total of 114 patients with 174 diagnosed foot burns who were treated in the burn unit of Chiang Mai University Hospital between January 2007 and December 2012 were retrospectively reviewed. Two-thirds of patients were referred cases. Ninety-four patients (83 %) were male, and 20 patients (17%) were female. Thirty-five patients (31 %) were children. The etiology of the burns was flame injury in 40 % of patients, scalding in 22%, electrical in 3 %, blast injury in 12%, and contact burns in 4%. Scalding was the most common cause of burns in children (57 %). Anatomic and specific locations, extent and depth of burn, and modality of treatment were recorded. Conservative wound dressings, appropriate splinting, and rehabilitation were used for superficial and deep dermal foot burns. Autografting was applied to 23 % of patients. One locoregional flap was created for coverage. Fourteen patients underwent amputations of various types. Electrical injury, a common occurrence with electricians, resulted in significantly more amputations than those without electrical injury ( $p < 0.001$ ). Third and fourth degree burns were associated with a higher risk of amputation ( $p = 0.004$ ). Although the foot accounts for a small percentage of the body surface area, foot burns is a catastrophic influence on patients' quality of life.

**Keywords:** Foot burn, epidemiology, amputation, risk factor

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## **INTRODUCTION**

There are few conditions more devastating than severe burns in term of suffering, financial loss, disability, and death. Although the surface area of the feet is only 7 % of the total body surface area, there are many serious consequences of foot burns, such as foot

amputation and subsequent disability. There is limited epidemiological data on foot burns. Only two small clinical studies have been reported<sup>1,2</sup>. No such data are available from Asia.

The skin of the foot is composed of specialized tissue components, which is extremely difficult to

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replace. However, appropriate footwear can protect certain burn injuries. Foot burns can occur in all age groups<sup>3</sup>. Hot liquid scalds in children usually occur when they accidentally pour containers of hot water or cooking oil on themselves. For older people, common causes of foot burns are flame or contact burn injuries<sup>3</sup>. Customary treatment of foot burns include bed rest, foot elevation, edema management, pain control, splinting, and rehabilitation<sup>3</sup>. The objectives of treatment are to restore normal functions to the foot, and to provide proper coverage of the burn defect<sup>3</sup>.

The aims of the present study were to identify the etiology of burns, the location and extension of burns, and the types of treatment provided. The findings obtained may provide useful clinical and prognostic information for future foot burn patients.

## METHODS

A retrospective observational study was conducted. Records of all burn patients admitted to the Burn Unit at Chiang Mai University Hospital between January 2007 and December 2012 were reviewed. Only patients with foot burns were included.

The protocol of treatment for foot burns in our center follows standard guidelines<sup>3</sup>. In brief, when burn patients are seen at the Emergency Department, cardiovascular resuscitation was applied as per the Parkland formula<sup>3</sup>. When the hemodynamic status was stable, wound dressing was applied using silver sulfadiazine cream, and the dressings were changed daily. Best efforts were applied to preserve the remaining tissue as much as possible by using advanced wound dressings and skin grafts. Indication for major amputation included the finding of non-viable muscle or bone.

Demographic data, type of admission, date of burn, date of admission and discharge, etiology of burn, anatomic location of burn, specific area of burn (right or left or bilateral; dorsum or plantar areas or both), total body surface area (TBSA) of burn, depth of burn, and modalities of treatment were abstracted from the medical records. Patients were the units of analysis, not the foot. Area of foot burns was defined as drawn on the standard Lund and Browder chart<sup>3</sup>. In cases where foot burns were in conjunction with burns at other areas of the body, they were noted as foot burns with multifocal involvement. Data analysis was

performed with STATA statistical package (Release 11, 2011: STATA Corporation, College Station, TX). Categorical variables and continuous variables were summarized using frequency (percent) and mean  $\pm$  standard deviation, respectively. Student *t*-test was used to compare continuous variables between groups, and Fisher exact test was used to compare categorical variables. *P*-values less than 0.05 were considered significant. This study was reviewed and approved by the Research Ethics Committee, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand.

## RESULTS

One hundred and fourteen patients with foot burns (174 feet) were included in the present study. Seven patients had isolated foot burns, while the vast majority had foot burns with multifocal involvement. Admissions to our center vary from 16 to 21 patients per year, with an average of 19 patients per year. The majority of patients were male (83%), and 35 patients (31%) were in the pediatric group (less than 15 years old). Two patients had epilepsy, and one patient had

**Table 1** Demographic data of foot-burn patients (n = 114)

| Characteristics    | Number | (%) |
|--------------------|--------|-----|
| Gender             |        |     |
| Female             | 20     | 17  |
| Male               | 94     | 83  |
| Age (years)        |        |     |
| Less than 15       | 35     | 31  |
| 15-60              | 67     | 59  |
| More than 60       | 12     | 10  |
| Occupations        |        |     |
| Electrician        | 12     | 11  |
| Housekeeper        | 14     | 12  |
| Worker             | 45     | 40  |
| Student            | 20     | 17  |
| Government officer | 1      | 1   |
| Child              | 22     | 19  |
| Underlying disease |        |     |
| Diabetes mellitus  | 2      | 2   |
| Hypertension       | 5      | 4   |
| Autistic           | 1      | 1   |
| Epilepsy           | 2      | 2   |
| Others             | 6      | 5   |
| Type of admission  |        |     |
| New cases          | 28     | 25  |
| Referred cases     | 86     | 75  |

NIDDM. Most patients (75 %) were referred from other hospitals (Table 1).

The most common cause of all foot burns was flame injury (39%) followed by scald and electrical injuries (both 22%). Blast injuries causing burns from flaming and explosive force constituted 12 %. Scalding was the most common cause of pediatric foot burns, at 57 % (Table 2). The etiology of burns varies by age. Scald burns were more common in children, whereas electrical burns were significantly more common in adults (Table 3). All electrical burns were of high voltage (> 1,000 volts).

There were 7 patients (6 %) who had isolated foot

burns, and 107 had multifocal burns. Fifty-four patients (47 %) had single foot burns, while the remaining (53%) were paired injuries. The most common site of foot burns was on the dorsum (Table 4). The extent of burn occurred on both sides of the feet, varying from 0.25 % to 3.5% of the TBSA. Whole foot burns were found in 10 patients (6 patients on right side and 4 patient on left side) (Table 5).

Burn depth in our study was categorized as superficial (first degree), deep dermal (second degree), full thickness (third degree), and with musculoskeletal involvement (fourth degree) (Figures 1 to 4). In cases where there were mixed burn depths, the wound was categorized according to the deepest burn. Deep dermal was identified as the most common depth of injury on both sides; 46% on the right side, and 40 % on the left side. Superficial burns were found in 28 patients (31 %) on the right side, and 30 patients (36%) from the left. Musculoskeletal involvement was apparent in 13 patients (Table 6).

Burn treatment in the present study was divided into five groups: dressing only, debridement, split thickness skin grafts (STSG), locoregional flap, and

**Table 2** Causes of foot burns

| Etiology of Burn | Number of patients (%) |
|------------------|------------------------|
| Flame            | 45 (40)                |
| Scald            | 25 (22)                |
| Electrical       | 25 (22)                |
| Contact          | 5 (4)                  |
| Blast injury     | 14 (12)                |

**Table 3** Comparing causes of burn between adults and children

| Etiology of Burn | Age < 15 years | Age > 15 years | p-value |
|------------------|----------------|----------------|---------|
|                  | Number (%)     | Number (%)     |         |
| Flame            | 11 (31)        | 34 (43)        | 0.301   |
| Scald            | 20 (57)        | 5 (6)          | <0.001  |
| Electrical       | 0              | 25 (32)        | <0.001  |
| Contact          | 3 (9)          | 2 (3)          | 0.168   |
| Blast injury     | 1 (3)          | 13 (16)        | 0.061   |

**Table 4** Anatomic and specific locations of foot burns

| Locations          | Number (%) |
|--------------------|------------|
| Trunk              | 75 (66)    |
| Upper extremities  | 58 (51)    |
| Leg                | 84 (74)    |
| Face and scalp     | 24 (21)    |
| <b>Foot burn</b>   |            |
| Single foot        | 54 (47)    |
| Both feet          | 60 (53)    |
| Right foot         |            |
| Dorsum             | 72 (63)    |
| Dorsum and plantar | 17 (15)    |
| Left foot          |            |
| Dorsum             | 65 (56)    |
| Plantar            | 3 (3)      |
| Dorsum and plantar | 16 (14)    |
| Isolated foot burn | 7 (6)      |

**Table 5** Extent of foot burn

| % TBSA burn      | Number of patients (%) |                   |
|------------------|------------------------|-------------------|
|                  | Right foot; n = 89     | Left foot; n = 84 |
| 0.25             | 8 (9)                  | 8 (10)            |
| 0.5              | 14 (16)                | 12 (14)           |
| 1.0              | 15 (17)                | 21 (25)           |
| 1.5              | 11 (12)                | 12 (14)           |
| 1.75             | 0 (0)                  | 1 (1)             |
| 2                | 30 (34)                | 21 (25)           |
| 2.5              | 4 (4)                  | 4 (5)             |
| 3                | 2 (2)                  | 1 (1)             |
| 3.5 (whole foot) | 6 (7)                  | 4 (5)             |

TBSA = total body surface area

**Table 6** Depth of foot burns

| Degree burn                                    | Number of patients (%) |                   |
|------------------------------------------------|------------------------|-------------------|
|                                                | Right foot; n = 89     | Left foot; n = 84 |
| Superficial (1 <sup>st</sup> )                 | 28 (31)                | 30 (36)           |
| Deep dermal (2 <sup>nd</sup> )                 | 41 (46)                | 33 (39)           |
| Full thickness (3 <sup>rd</sup> )              | 14 (16)                | 14 (17)           |
| Musculoskeletal involvement (4 <sup>th</sup> ) | 7 (8)                  | 6 (7)             |



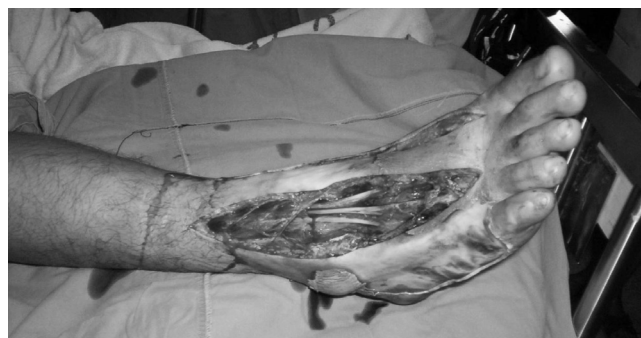
**Figure 1** Right foot burn with musculoskeletal involvement and superficial burn on left foot



**Figure 3** Full thickness burn on plantar area of left foot from electrical injury



**Figure 2** Scald superficial burn on right foot



**Figure 4** Fasciotomy of right foot after high-voltage electrical injury causing musculoskeletal burn injury

**Table 7** Treatment of foot burn (n = 114)

| Treatment                         | Right foot |     | Left foot |     |
|-----------------------------------|------------|-----|-----------|-----|
|                                   | Number     | (%) | Number    | (%) |
| Dressing                          | 51         | 45  | 46        | 40  |
| Debridement and dressing          | 33         | 29  | 34        | 30  |
| One debridement                   | 10         | 30  | 15        | 44  |
| Two debridement                   | 15         | 46  | 12        | 35  |
| Three debridement                 | 1          | 3   | 2         | 6   |
| Four debridement                  | 3          | 9   | 2         | 6   |
| Five debridement                  | 3          | 9   | 3         | 9   |
| Six debridement                   | 1          | 3   | 0         | 0   |
| Split-thickness skin graft (STSG) | 13         | 11  | 13        | 11  |
| One STSG                          | 11         | 92  | 9         | 82  |
| Two STSG                          | 1          | 8   | 2         | 18  |
| Locoregional flap                 | 0          | 0   | 1         | 1   |
| Amputation                        | 10         | 9   | 6         | 5   |
| Above knee amputation             | 4          | 40  | 0         | 0   |
| Below knee amputation             | 5          | 50  | 3         | 43  |
| Toe amputation                    | 1          | 10  | 4         | 57  |
| Topical agents                    |            |     |           |     |
| Silver sulfadiazine               | 67         | 59  | 62        | 54  |
| Bacitracin                        | 8          | 7   | 6         | 5   |
| Silver mesh                       | 12         | 11  | 17        | 15  |
| Exudate absorbable dressings      | 1          | 1   | 1         | 1   |

amputation. The basic topical agent for burn wound dressing in our burn unit was silver sulfadiazine cream and Bacitracin ointment, but we occasionally applied silver mesh and exudate absorbable dressings as well. Approximately 29 % of right and 30 % of left foot burns required debridement, which consisted of tangential excisions. Some patients required multiple debridements. STSG was performed on 26 patients. One patient with a left foot burn required locoregional flap coverage. Ten patients with right-sided foot burns, and 6 patients with left-sided foot burns underwent various types of amputations (Table 7).

### DISCUSSION

Foot burns are classified as major burns by the American Burn Association<sup>1</sup>. Even though the body surface percentage of the foot is quite small, its function is extremely important. Every effort is needed to preserve the foot. This retrospective study presented 114 patients (174 foot burns), their characteristics, and modalities of treatment, at Chiang Mai University Hospital Burn Unit between the years 2007 to 2012.

Zachary and Schoen reported that scald injuries were the most common cause of foot burns. In the present study, however, flaming accounted for the largest number foot burns, followed by scalding and electrical injury<sup>1,4</sup>. Scald injury was a common cause of foot burn in the pediatric group. Contact burns and electrical injuries were rare, but severe, and often associated with amputations.

The treatment of foot burns varies. This includes wound dressing, debridement, STSG, local tissue flaps, or amputation, depending on depth and site of the wounds. Treatment of a burned sole has always been challenging because this load-bearing area of the foot requires coverage with specialized tissue, sufficient to bear heavy pressure, and does not easily slip<sup>5</sup>.

Zachary suggested that proper management of foot burns should be immediate hospitalization for edema control, especially in the first 2 to 3 days, along with splinting and topical wound care<sup>1</sup>. Hemington-Gorse showed that 75% of isolated foot burns were managed conservatively with dressings and edema control, by strict elevation for at least 24 hours<sup>2</sup>. Our patients with superficial burns were allowed to heal spontaneously by epithelization. Simple dressings with silver sulfadiazine, silver mesh, Bacitacin ointment, or

exudate absorbable materials were suitable for these kinds of foot burns.

As generally accepted, a wound remaining unhealed, or predicted not to heal by three weeks, should be promptly treated by excision and grafting<sup>5-9</sup>. In our study, we performed STSG on 26 patients (23 %) in combination with appropriate splinting and range of motion exercise protocol, which was in accordance with other studies. Shakirov suggested autografting after debridement, during the initial stage of wound granulation, on the 14<sup>th</sup> to 16<sup>th</sup> day after injury<sup>5,10</sup>. Shakirov and Barret treated their entire foot burn population by grafting, and using rehabilitation protocols for preventing contraction and other complications<sup>6,8</sup>. They also suggested that early excision and immediate skin grafting helped to restore foot function, lessen contracture and joint deformities, shorten the hospital stay, and reduce hospital expenses.

Thais commonly walk barefoot both indoors and out, so repairing the foot holds a special need. Soft tissue loss in the plantar area is a challenging problem. Many kinds of skin flaps have been proposed for plantar foot reconstruction<sup>11-14</sup>. Chai et al. concluded that early flap repair of large, deep burn wounds had a valuable role in preserving function<sup>11</sup>. We successfully created a locoregional flap for a plantar forefoot reconstruction.

Foot burns can result in serious complications, such as burn wound infections, disabling scars and deformities, and are most unacceptable. Hemington-Gorse S, et al. revealed that there was an 18% complication rate for foot burns in their unit<sup>2</sup>. The complications included hypertrophic scarring in 8% of patients, graft loss/delayed healing in 6%, infection in 5 %, a toxic shock syndrome in 1%, and a risk of amputation of 1%. Smoking, diabetes, and peripheral vascular disease increase the complication rates. Of 14 patients (including 15 feet), our study showed a 12 % amputation rate, and none had underlying disease or co-morbidity. Among the amputated group, 9 patients (64%) sustained electrical injury, 2 from flame burn, and 1 each from contact, blast and scald burns. In the electrical injury patients, fasciotomies were promptly and adequately done to prevent microcirculation damage.

To prevent further infection, proper wound care was administered to all patients. The cause of amputation was not from infection or improper

fasciotomy, but from direct tissue damage caused by high voltage electrical current. The one contact burn patient who underwent below knee amputation was an elderly man who had become unconscious during the accident, causing bone damage. Another patient who sustained scald burns, had delayed referral time (approximately three months), later underwent below knee amputation.

### CONCLUSION

At the Chiang Mai University Hospital Burn Unit, an average of 19 foot burn patients are seen per year. Foot burns, even if small, may result in serious complications. To reduce complication rates and shorten hospital stay, proper treatment such as rest, elevation, wound dressing, splinting, and rehabilitation are recommended. Scalding commonly causes superficial wounds that can heal spontaneously. Deep foot burns require skin grafts or flap coverage. Electricians have a higher risk of electrical injury and their feet are the most common site of injury. Electrical burns of the feet are frequently third or fourth degree, and may eventually require amputation.

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### CONFLICT OF INTEREST

None to declare.

### REFERENCES

1. Zachary LS, Hegggers JP, Robson MC, et al. Burns of the feet. *J Burn Care Rehabil* 1987;8:192-4.
2. Hemington-Gorse S, Pellard S, Wilson-Jones N, Potokar T. Foot burns: epidemiology and management. *Burns* 2007;33:1041-5.
3. Thorne CH, Beasley RW, Aston SJ, Bartlett SP, Gurtner GC, Spear SL, editors. *Grabb and Smith's Plastic Surgery*. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2007.
4. Schoen NS, Gottlieb LJ, Zachary LS. Distribution of pedal burns by source and depth. *J Foot Ankle Surg* 1996;35:194-8.
5. Shakirov BM, Tursunov BS. Treatment of severe foot burns in children. *Burns* 2005;31:901-5.
6. Shakirov BM. Deep foot burns: effects of early excision and grafting. *Burns* 2011;37:1435-8.
7. Kimball Z, Patil S, Mansour H, et al. Clinical outcomes of isolated lower extremity or foot burns in diabetic versus non-diabetic patients: a 10-year retrospective analysis. *Burns* 2013;39:279-84.
8. Barret JP, Herndon DN. Plantar burns in children: epidemiology and sequelae. *Ann Plast Surg* 2004;53:462-4.
9. Shakirov BM. Treatment of sandal burns of the feet in children in a moist environment. *J Burn Care Rehabil* 2014;40:520-4.
10. Shakirov BM. Sandal burns and their treatment in children. *J Burn Care Rehabil* 2004;25:501-5.
11. Chai J, Song H, Sheng Z, et al. Repair and reconstruction of massively damaged burn wounds. *Burns* 2003;29:726-32.
12. Mozafari N, Moosavizadeh SM, Rasti M. The distally based neurocutaneous flap: a good choice for reconstruction of soft tissue defects of lower leg, foot and ankle due to fourth degree burn injury. *Burns* 2008;34:406-11.
13. Baumeister S, Koller M, Dragu A, Germann G, Sauerbier M. Principles of microvascular reconstruction in burn and electrical burn injuries. *Burns* 2005;31:92-98.
14. De Lorenzi F, van der Hulst R, Boeckx W. Free flaps in burn reconstruction. *Burns* 2001;27:603-12.

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บทคัดย่อ    **อุบัติการณ์ของแผลไฟไหม้-น้ำร้อนลวกบริเวณเท้าในโรงพยาบาลมหาราชนครเชียงใหม่: การศึกษาย้อนหลัง 6 ปี**

พญ.พุดตาน วงศ์ตรีรัตนชัย, นพ.กฤษณ์ ขวัญเงิน, นพ.โอภาส พิณไชย, พญ.วิมล สิริมหาราช  
หน่วยศัลยศาสตร์ตกแต่ง ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

ทำการศึกษาอุบัติการณ์ของแผลไฟไหม้-น้ำร้อนลวกบริเวณเท้า ทั้งแผลที่พบเฉพาะที่เท้า และมีแผลที่เท้าร่วมกับแผลอื่นตามร่างกาย จากจำนวนบาดแผลทั้งสิ้น 174 แผล ในจำนวนผู้ป่วย 114 คน ซึ่งรักษาตัวภายในหน่วยไฟไหม้-น้ำร้อนลวก โรงพยาบาลมหาราชนครเชียงใหม่ ช่วงเดือนมกราคม ปี 2552 ถึงเดือนธันวาคม ปี 2555 ซึ่งคนไข้ 2/3 ส่วนจากจำนวนคนไข้ทั้งหมด เป็นผู้ป่วยที่ถูกส่งต่อมา ประกอบด้วย ผู้ป่วยชายจำนวน 94 คน (ร้อยละ 83) หญิงจำนวน 20 คน (ร้อยละ 17) และเด็กจำนวน 35 คน (ร้อยละ 31) สาเหตุที่ทำให้เกิดแผล แบ่งเป็นจากเปลวไฟ (ร้อยละ 40) น้ำร้อนลวก (ร้อยละ 22) ไฟฟ้าดูด (ร้อยละ 3) แร้งระเบิด (ร้อยละ 12) และจากกระทะวัตถุร้อน (ร้อยละ 4) จากข้อมูลพบว่าแผลที่เกิดจากน้ำร้อนลวกพบบ่อยที่สุดในกลุ่มผู้ป่วยเด็ก ซึ่งมีการเก็บข้อมูลรายละเอียดเกี่ยวกับตำแหน่งของแผล ระดับความลึกของแผล ความกว้างของแผล และการรักษาในแต่ละแผลด้วย โดยทุกแผลได้รับการทำแผลตามความเหมาะสม ใส่เฝือกและทำกายภาพตามขั้นตอน สำหรับแผลที่ได้รับการทำปลูกถ่ายผิวหนัง (Skin Grafting) คิดเป็นร้อยละ 23 และมีทำการย้ายเนื้อเยื่อแบบ flap 1 แผล ซึ่งผู้ป่วยจำนวนทั้งสิ้น 14 คนที่ถูกตัดอวัยวะในระดับที่แตกต่างกันไป โดยพบว่าไฟฟ้าดูดเป็นสาเหตุทำให้ถูกตัดอวัยวะมากที่สุดอย่างมีนัยสำคัญที่ระดับน้อยกว่า 0.001 สำหรับข้อมูลแผลความลึกระดับ 3-4 บ่งชี้ว่ามีนัยสำคัญน้อยกว่า 0.004 ซึ่งนำไปสู่การตัดอวัยวะ แม้ว่าเท้าจะเป็นอวัยวะที่มีพื้นที่ขนาดเล็กเมื่อเทียบกับขนาดร่างกายทั้งหมด แต่การมีแผลไฟไหม้-น้ำร้อนลวกที่เท้า ส่งผลให้เกิดผลเสียต่อคุณภาพชีวิตของผู้ป่วยอย่างมาก

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