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Short Communication

Could fasciotomy prevent amputation in patients with electrical burn injuries? Insights from a cross-sectional study in Indonesia

Citra A. Hidayati[1*], Iswinarno D. Saputro[1,2] and Magda R. Hutagalung[1,2]

[1]Department of Plastic Reconstructive and Aesthetic Surgery, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia; [2]Department of Plastic Reconstructive and Aesthetic Surgery, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

*Corresponding author: citraayyuu@gmail.com

Abstract

The amputation rate resulting from electrical burn injuries remains high, yet no study has investigated whether early fasciotomy may reduce the amputation rate. The aim of this study was to analyze the success rate of fasciotomy in preventing amputation and determine the optimal timing for fasciotomy in electrical burn injuries. This study was conducted at Dr. Soetomo Hospital from January 2020 to July 2023. Total sampling was employed to recruit the patients. Clinical data, voltage characteristics, burn location, affected total body surface area, burn depth, hospital arrival time, and time interval from incident to fasciotomy were assessed. Chi-squared test was used to assess factors associated with the fasciotomy incidence and factors associated with amputation after fasciotomy. A total of 45 patients were included, of which 97.8% were male, with a mean age of 37.60 years old. Approximately 73% of patients had full-thickness burn injuries, with the left upper extremity being the most affected (80%). There are seven patients (15.6%) had fasciotomy and five (11.1%) patients had an amputation. Our data indicated a significant association between voltage characteristics and fasciotomy incidence (p=0.034). Additionally, our data indicated that earlier arrival to the hospital (p=0.002) and timely fasciotomy conducted upon arrival (p<0.001) were associated with a reduced rate of amputation. This study highlights that prompt arrival to the hospital and early fasciotomy may prevent amputation in patients with electrical burn injuries.

Keywords: Burn, electrical burn injury, fasciotomy, amputation, hospital arrival time

Introduction

Electrical burn injury is the fourth leading cause of work-related deaths, with 75% occurring in the workplace [1]. This condition accounts for approximately 0.04–5% of inpatient admissions in burn units in developed countries and up to 27% in developing countries [2,3]. Electrical burn injury is very serious and may be fatal [4,5]. In high-voltage electrical burn injury, muscle necrosis may occur, extending to areas far from the visible burn site, which can lead to compartment syndrome due to vascular ischemia and muscle edema [6].

Amputation is a life-saving decision that improves the overall condition of the patients and provides an optimal survival rate [7]. Of the patients who had electrical burn injuries, 78% of those who had an amputation survived [8]. A study involving 65 major amputations for electrical burn injuries found a mortality rate of 20% and this was influenced by delayed referral, inadequate decompression, and a high incidence of kidney failure [9].

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Fasciotomy in electrical burn injury is an emergent surgical decompression management at limb tissue salvage, where the fasciotomy is expected to reduce the amputation rate [10,11]. Previous studies have shown that patients with electrical burn injury mostly underwent amputation, with a higher rate observed in high-voltage injury [12-15]. Predictors for amputation in electrical burn patients include initial levels of creatinine kinase and myoglobin, renal failure, compartment syndrome, and sepsis [16]. Early decompression, serial necrotomies, and delayed early reconstruction, improve the outcomes of the patients [16]. Although the amputation rate in electrical burn injury is high, no study has investigated whether early fasciotomy may reduce the amputation rate. The aim of this study was to analyze the success rate and the optimal timing of fasciotomy in electrical burn injury cases.

Methods

Study design, setting and patients

A cross-sectional study was conducted at Dr. Soetomo Hospital, Surabaya, Indonesia, from January 2020 to July 2023. The patients' characteristics, fasciotomy, and factors influencing the success rate of fasciotomy were assessed. Total sampling was employed by following the inclusion criteria: patients with electrical burn injuries treated at Dr. Soetomo Hospital from January 2020 to July 2023. Patients who died within 24 hours or were hospitalized for less than one day were excluded.

Study variables

Patients' demographic data, including sex and age, were collected. Clinical parameters, such as cause and location of the incident, early fluid resuscitation, first aid, presence of other trauma, total body surface area (TBSA), burn depth, burn location, the fasciotomy data, the presence of amputation, time interval from incident to fasciotomy, and length of stay, were collected. The causes of electrical burn injury were divided into two categories: high-voltage injury and low-voltage injury. A high-voltage electrical source was defined as higher than 1000 volts, while a low-voltage electrical source was lower than 1000 volts. TBSA was calculated based on the rule of nine after initial debridement. Burn depth was categorized into full-thickness, deep dermal, mid-dermal, and superficial dermal depths. The timing of fasciotomy was categorized as <24 hours, 24–48 hours, >48 hours, or not performed. The decision to perform fasciotomy was primarily based on clinical assessment. Fasciotomy was indicated if the burn caused disrupted distal flow on physical examination and the presence of the 5Ps (pain, paresthesia, pallor, paralysis, and pulselessness).

Statistical analysis

The data was statistically assessed with SPSS version 25.0 software (IBM SPSS, Chicago, IL, USA), with $p \leq 0.05$ was considered statistically significant. Continuous data were presented as mean and standard deviation, and categorical data were presented as percentages. Shapiro-Wilk test was utilized to determine data normality. Chi-squared test was employed to assess factors associated with the fasciotomy incidence and factors associated with amputation after fasciotomy.

Results

Characteristic of patients

A total of 45 patients were included and their characteristics are presented in **Table 1**. The distribution of male patients was higher than female patients (97.8% vs 2.2%). Most electrical burn injury patients were 20–40 years old (n=27). The causes of electrical burn injuries in patients were high-voltage injury (48.9%) and low-voltage injury (51.1%). The majority of electrical burn injuries occurred at workplace (55.6%), followed by incidents at home (44.4%). Early fluid resuscitation was administered to 40 patients (88.9%) and first aid was provided to 41 patients (91.1%). A total of 31 patients (68.9%) had burn injuries with TBSA <10%. Full-thickness injuries were observed in 33 patients (73.3%), followed by deep dermal, mid-dermal, and

superficial dermal depths. Regions affected by electrical burns included left upper extremity (80%), right lower extremity (68.9%), right upper extremity (66.7%), and left lower extremity (64.4%) (**Table 1**).

Fasciotomy was performed on seven patients (15.6%) with the time interval from incident to fasciotomy was <24 hours (4.4%), 24–48 hours (8.9%), >48 hours (2.2%). Most patients were hospitalized for 10–30 days (n=24) with the longest hospital stay was 49 days (2.2%) and the shortest was one day (6.7%).

Table 1. Baseline characteristics of the included patients (n=45)

Patients' characteristics	Frequency	Percentage
Sex		
Male	44	97.8
Female	1	2.2
Age (year), mean±SD	37.60±11.26	
<20 years old	1	2.2
20–40	27	60.1
41–60	15	33.3
>60	2	4.4
Cause		
High voltage	22	48.9
Low voltage	23	51.1
Location of incident		
Workplace	25	55.6
Household	20	44.4
Fluid resuscitation		
Yes	40	88.9
No	5	11.1
First aid		
Yes	41	91.1
No	4	8.9
Presence of other trauma		
Yes	28	62.2
No	17	37.8
Total body surface area (TBSA), mean±SD	1.42±0.72	
<10%	31	68.9
10.5–20%	10	22.2
20.5–30%	3	6.7
>30%	1	2.2
Burn depth [a]		
Superficial dermal	20	44.4
Mid-dermal	28	62.2
Deep dermal	30	66.7
Full-thickness	33	73.3
Burn region [a]		
Facialis-colli	17	37.8
Thoracoabdominal	17	37.8
Thoracolumbar	10	22.2
External genital	2	4.4
Right upper extremity	30	66.7
Left upper extremity	36	80
Right lower extremity	31	68.9
Left lower extremity	29	64.4
Fasciotomy		
Yes	7	15.6
No	38	84.4
Time interval from incident to fasciotomy		
<24 hours	2	4.4
24–48 hours	4	8.9
>48 hours	1	2.2
Not performed	38	84.4
Length of stay		
<10 days	17	37.8
10–30 days	24	53.4
>30 days	4	8.8

[a] Each patient could have more than one

Factors associated with fasciotomy incidence

Chi-squared tests revealed a significant association between voltage characteristics and fasciotomy incidence (p=0.034) (**Table 2**). There was no association between the burn location, the TBSA, and the burn depth with the incidence of fasciotomy (**Table 2**).

Table 2. Association between the cause of electrical burn, burn location, surface area, and burn depth with fasciotomy incidence (n=45)

Variables	Fasciotomy		p-value
	Yes, n (%)	No, n (%)	
Cause			0.034
High voltage	6 (85.7)	16 (42.2)	
Low voltage	1 (14.3)	22 (57.8)	
Burn location [a]			
Facialis-colli	2 (7.7)	15 (10.5)	0.585
Thoracoabdominal	2 (7.7)	15 (10.5)	0.585
Thoracolumbar	2 (7.7)	8 (5.5)	0.660
External genital	1 (3.8)	1 (0.7)	0.169
Right upper extremity	5 (19.3)	25 (17)	0.771
Left upper extremity	7 (26.9)	29 (19.7)	0.150
Right lower extremity	4 (15.4)	27 (18.4)	0.465
Left lower extremity	3 (11.5)	26 (17.7)	0.194
Total body surface area (TBSA)			
<10%	4 (57.0)	27 (71.1)	0.477
10.5–20%	3 (43.0)	7 (18.4)	
20.5–30%	0 (0.0)	3 (7.9)	
>30%	0 (0.0)	1 (2.6)	
Burn depth [a]			
Superficial dermal	2 (10.5)	18 (19.5)	0.358
Mid-dermal	4 (21.1)	24 (26.1)	0.763
Deep dermal	6 (31.6)	24 (26.1)	0.245
Full-thickness	7 (36.8)	26 (28.3)	0.083

[a] Each patient could have more than one

Factors associated with amputation after fasciotomy

Our data indicated that factors reducing the rate of amputation after fasciotomy included prompt arrival to the hospital (p=0.002) and timely fasciotomy conducted upon arrival (p<0.001) (**Table 3**). The types of voltage, the percentages of TBSA, and the burn depth were not associated with the amputation (**Table 3**).

Table 3. Factors reducing the rate of amputation after fasciotomy (n=45)

Variables	Amputation		p-value
	Yes, n (%)	No, n (%)	
Causes			0.140
High voltage	4 (80.0)	18 (45.0)	
Low voltage	1 (20.0)	22 (55.0)	
Total body surface area			0.893
<10%	4 (80.0)	27 (67.5)	
10.5–20%	1 (20.0)	9 (22.5)	
20.5–30%	0 (0.0)	3 (7.5)	
>30%	0 (0.0)	1 (2.5)	
Burn depth [a]			
Superficial dermal	1 (9.5)	19 (19.0)	0.243
Mid dermal	2 (18)	26 (26.0)	0.277
Deep dermal	3 (27)	27 (27.0)	0.737
Full-thickness	5 (45.5)	28 (28.0)	0.153
Arrival time			0.002
<24 hours	1 (20.0)	31 (77.5)	
24–48 hours	2 (40.0)	1 (2.5)	
>48 hours	2 (40.0)	8 (20.0)	
Time interval from incident to fasciotomy			<0.001
<24 hours	0 (0.0)	2 (5.0)	
24–48 hours	3 (60.0)	1 (2.5)	
>48 hours	0 (0.0)	1 (2.5)	
Not performed	2 (40.0)	36 (90.0)	

[a] Each patient could have more than one

Discussion

This study presented 45 patients with electrical burn injuries, of which seven of them had fasciotomy done. Two factors that could reduce the rate of amputation after fasciotomy among electrical burn injuries are arrival time and time interval from incident to fasciotomy. Performing fasciotomy within 24 hours significantly reduces amputation rates. Prompt hospital arrival enables early burn management, ideally within 24 hours, to minimize the risk of amputation [17]. Compartment syndrome, which may develop within 48 hours due to myonecrosis and fluid resuscitation, may result in irreversible muscle damage and necessitate amputation if left untreated [18]. The earlier the patient arrives at the emergency department, the sooner the fasciotomy is performed, resulting in a lower rate of amputation during inpatient care, particularly in cases of high-voltage electrical burns [11].

In the present study, seven patients (15.6%) had fasciotomy, with six of them (85.7%, 6/7) had high voltage injuries. There was a significant association between voltage characteristics and the incidence of fasciotomy in electrical burn injury patients (p=0.034). The human body conducts the electricity, which is then transformed into heat. The heat damages the bones, muscles, soft tissues, and skin. Higher voltage results in severe damage [19-21]. Electrical-induced damage occurs through two primary mechanisms: thermal injury and direct tissue disruption [22]. Thermal injury results in coagulative necrosis, while the passage of electrical current through tissues disrupts cell membranes [20,23]. The effects of electrical burn injuries are influenced by several factors, including type and voltage of the current, tissue resistance, current strength, current pathway through the body, duration of exposure, and individual susceptibility [19,20].

The higher amputation rate was attributed to a lack of initial first aid and delayed emergency department presentation (>24 hours), leading to ischemia, thrombus formation, vessel narrowing, and tissue necrosis [11]. Tissue damage in extremities often necessitates finger amputation, observed in both high- and low-voltage burns [20]. A study reported a 74.7% amputation rate in high-voltage burns and 15.6% in low-voltage burns [24].

Early fasciotomy often limits further ischemic damage to distal tissues by alleviating vascular compression effects, thereby reducing the site of amputation and ensuring fewer complications and better survival of body parts and overall life [20]. The risk of amputation in extremities remains high, ranging from 37–65%, even with adequate medical therapy and surgical interventions [2,25]. The primary goal of amputation is to obtain a healthy stump so that the amputated limb may function as an excellent foundation for prosthetic fitting [10].

The present study is limited by a small sample size from a single healthcare center and a lack of data on factors affecting tissue damage, such as current amount, patient resistance, and contact duration. Despite these limitations, this study demonstrated the reduced morbidity and amputation risk in electrical burn injury patients if they received early management, including fasciotomy.

Conclusion

This study indicated that prompt arrival at the hospital and early fasciotomy may prevent amputation in patients with electrical burn injuries. Fasciotomy performed within 24 hours reduces the rate of amputation effectively. Fasciotomy is recommended to prevent the long-term consequences in electrical burn injury cases.

Ethics approval

The study protocol was reviewed and approved by Research Ethics Committee of Dr. Soetomo Hospital, Surabaya, Indonesia (approval number: 1417/LOE/301.4.2/VIII/2023).

Competing interests

The authors declare that there is no conflict of interest.

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Underlying data

Derived data supporting the findings of this study are available from the first author on request.

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References

1. Shih JG, Shahrokhi S, Jeschke MG. Review of adult electrical burn injury outcomes worldwide. J Burn Care Res 2017;38(1):e293-e298.
2. Gandhi G, Parashar A, Sharma RK. Epidemiology of electrical burns and its impact on quality of life - the developing world scenario. World J Crit Care Med 2022;11(1):58-69.
3. Ramli RN, Prawoto A, Riasa NP, *et al.* Epidemiology and knowledge of first aid treatment related to burn injury in the rural region of Kulon Progo, Indonesia. Open Access Maced J Med Sci 2021;9(E):101-108.
4. Shaikh SA, Telang PA, Arora S. Physical therapy interventions of an electrical burn injury-afflicted patient: A case report. Cureus 2022;4(11):e31176.
5. Widiono E, Fawzy A, Prasetyo YE. A case report: Revealing delayed cardiac phenomenon in electrical burns, An interesting puzzle. J Rekon Estetik 2023;8(2):66-72.
6. Teodoreanu R, Popescu SA, Lascar I. Electrical injuries. Biological values measurements as a prediction factor of local evolution in electrocutions lesions. J Med Life 2014;7(2):226-236.
7. Tarim A, Ezer A. Electrical burn is still a major risk factor for amputations. Burns 2013;39(2):354-357.
8. Winkley J, Gaspard D, Smith LL. Amputation as a life-saving measure in the burn patient. J Trauma 1965;5(6):782-791.
9. Haberal M. Electrical Burns: A five-year experience–1985 evans lecture. J Trauma 1986;26(2):103-109.
10. Sasaki J, Matsushima A, Ikeda H, *et al.* Japanese Society for Burn Injuries (JSBI) clinical practice guidelines for management of burn care (3rd Edition). Acute Med Surg 2022;9(1):e739.
11. Jang YS, Lee BH, Park HS. Lower amputation rate after fasciotomy by straight midline incision technique for a 22,900-V electrical injury to the upper extremities. Injury 2017;48(11):2590-2596.
12. Abebe MW, Ewing EL, Weldemicheal HA. Electrical burn and amputations in a burn center in Addis Ababa, Ethiopia. Plast Reconstr Surg Glob Open 2024;12(2):e5566.
13. Kim E, Wan B, Solis-Beach KJ, *et al.* Outcomes of patients with amputation following electrical burn injuries. Eur Burn J 2023;4(3):318-329.
14. Kim E, Kowalske K, Solis KJ, *et al.* Outcomes of amputation following electrical burn injuries: A five-year follow-up. J Burn Care Res 2023;44 Suppl 2:S71-S71.
15. Hsueh YY, Chen CL, Pan SC. Analysis of factors influencing limb amputation in high-voltage electrically injured patients. Burns 2011;37(4):673-677.
16. Pedrazzi N, Klein H, Gentzsch T, *et al.* Predictors for limb amputation and reconstructive management in electrical injuries. Burns 2023;49(5):1103-1112.
17. Özkan A, Şentürk S, Tosun Z. Fasciotomy procedures on acute compartment syndromes of the upper extremity related to burns. Electron J Gen Med 2015;12(4).
18. Pannucci CJ, Osborne NH, Jaber RM, *et al.* Early fasciotomy in electrically injured patients as a marker for injury severity and deep venous thrombosis risk: An analysis of the national burn repository. J Burn Care Res 2010;31(6):882-887.
19. Waldmann V, Narayanan K, Combes N, *et al.* Electrical cardiac injuries: Current concepts and management. Eur Heart J 2018;39(16):1459-1465.

20. Jeschke M, Kamolz L, Sjöberg F. Handbook of burns. Cham: Springer International Publishing; 2020.
21. Saputro I, Riestiano B, Hoekstra LT, *et al.* The effect of oral N-acetylcystein on prevention of extensive tissue destruction in electrical burn injury. Burns 2018;44(8):2059-2063.
22. Angilia C, Sary NL, Indah R, *et al.* Wound healing effect of nutmeg (*Myristica fragrans*) cream on second-degree burn in animal model. Narra J 2024;4(1):e621.
23. Wulandari E, Hariani L, Budi AS. Correlation of hypernatremia to success rate of skin graft in burn patients Dr. Soetomo Hospital Burn Centre from 2014-2018. J Rekon Estetik 2021;4(2):44.
24. Kym D, Seo DK, Hur GY, *et al.* Epidemiology of electrical injury: Differences between low- and high-voltage electrical injuries during a 7-year study period in South Korea. Scand J Surg 2015;104(2):108-114.
25. Ding H, Huang M, Li D, *et al.* Epidemiology of electrical burns: A 10-year retrospective analysis of 376 cases at a burn centre in South China. J Inter Med Res 2020;48(3):030006051989132.