



# Clinical profile, management and risk factors for seizure-related burn injuries among patients with epilepsy in southwest China

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## ABSTRACT

**Objective:** The epidemiological information associated with seizure-related burn injuries is lacking in China. Therefore, this study aims to analyze the clinical profile, management, outcome, and risk factors of burns that are directly caused by seizures among epileptic patients, and identify the epidemiological characteristics to develop effective preventive strategies.

**Methods:** This study was conducted between January 2002 and December 2022 in a large Chinese burn center. Data including clinical profile, wound treatment, and outcome were analyzed. A multiple linear regression was used to screen the risk factors for the length of hospital stay (LOS), and a multiple logistic regression was used to screen the contributory factors for the amputation. **Results:** A total of 184 burn patients (55.98 % females) were enrolled, with a 0.78 % incidence rate during the study period. The mean age of the patients was 36.16 years (SD: 17.93). Patients aged 20–29 were the most affected age groups (23.37 %). Most burns were caused by flame, accounting for 60.33 % (111/184) of all cases. In total, 76.09 % of the 184 patients underwent at least one operation, and 35 patients (19.02 %) still required amputation during the study period. Burn sites (hands) had the greatest impact on amputation (OR = 3.799), followed by flame burns (OR = 3.723). The mean LOS/TBSA was  $6.90 \pm 8.53$  d, and a larger TBSA, full-thickness burns, and a higher number of operations were identified as the risk factors for a longer LOS. There was one death among the 184 patients, with a mortality rate of 0.54 %.

**Conclusion:** This study demonstrates that burn injuries are extremely harmful to individuals with epilepsy in China because they are at high risk of amputation and disability. Effective healthcare education and preventive programs that focus on lifestyle modifications and seizure control should be implemented to reduce the burn incidence in these populations.

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## 1. Introduction

Epilepsy is a prevalent neurological disease that affects approximately 65 million people worldwide [1]. It is characterized by the loss of consciousness, tonic clonus, uncontrolled movements, or abnormal behaviors [1,2]. Therefore, it is widely believed that patients with epilepsy are more susceptible to accidents and injuries during seizures. For instance, a 12-month follow-up study has shown that persistent seizures are associated with a 20%–40% risk of body injuries [1]. Furthermore, the risk of death in people with epilepsy is about four times higher than those in the normal population [3].

Burn injuries during seizures are common among epilepsy patients, with Hampton et al. reporting a 38% incidence rate [4–7]. Due to prolonged exposure to heat during the period of epileptic attack, many seizure-related burn injuries can be deep and severe and even result in amputation or death [8,9]. Josty et al. revealed that 65% of patients with epilepsy required surgeries such as burn excision and skin grafting [10]. A previous study has shown that the rate of amputation after burns in patients with epilepsy could be as high as 19% [11]. As a developing country, the burdens of both burn injury and epilepsy are high in China [12–14]. According to the Global Burden of Disease Study, epilepsy in China is responsible for 1.6 million disability-adjusted life years (DALY), which accounts for 12% globally and 95% in East Asia [13]. This situation causes significant physical and psychological problems for individuals, while also placing a heavy economic burden on families and society. Moreover, patients with epilepsy are at risk of developing wound granulation tissue hyperplasia, scarring, disability, and dysfunction after burns, resulting in a lower quality of life.

On the other hand, previous studies have shown that seizure-related burn injuries often occur when patients engage in ordinary daily activities, which suggests that most of these injuries can be preventable by taking a few safety interventions based on adequate information on epidemiological data [4,15]. However, to the best of our knowledge, there is a lack of information on demographic characteristics, severity, risk factors, management, and outcome of seizure-related burn injuries in China. In particular, the risk factors related to length of hospital stay (LOS) and amputation for seizure-related burn injuries have not been explored further [5,11,16–20]. As a result, seizure-related burn injuries cannot attract enough awareness and attention accurately from the public. Therefore, it is urgent to develop effective strategies for the prevention of seizure-related burns in China, based on comprehensive epidemiological data.

The Institute of Burn Research at Southwest Hospital of the Third Military Medical University (Army Medical University) is one of the earliest and largest burn centers in the world [21]. This center contains 108 general inpatient beds and 18 ICU beds and specializes in burn care and treatment. It receives approximately 1300 burn patients from southwest China every year [22]. We hypothesize that burn injuries are extremely harmful to individuals with epilepsy in China, and these patients are at high risk of amputation and disability. Therefore, the main aim of our study is to investigate the epidemiology of seizure-related burn patients in southwest China admitted to the burn center of the Southwest Hospital over the last 21 years, and identify constructive advice for the education and prevention strategies for patients with epilepsy.

## 2. Materials and methods

### 2.1. Ethical approval and informed consent

This study was approved by the Institutional Review Board of the Southwest Hospital (Ethics approval number: (B) KY2023051), Third Military Medical University (Army Medical University). In accordance with national law and institutional requirements, written informed consent from the participants' legal guardians/next-of-kin was not required in this retrospective study.

### 2.2. Study design

This retrospective study was carried out from January 2002 to December 2022 at the Institute of Burn Research, Southwest Hospital, Third Military Medical University (Army Medical University). Data were analyzed by reviewing medical records of the inpatient database, and 184 patients who sustained their burns during an epileptic seizure were included in the study. The incidence rate here refers to the proportion of patients with seizure-related burn injuries in the total burn patients during the same period in our hospital. Patient demographics, clinical features (mainly including burn etiology, burn depth and area, burn site, history of epilepsy, associated injuries, operation times and types), and outcomes (mainly including length of hospital stay, amputation, and mortality) were noted.

### 2.3. Statistics

Data were primarily entered using Microsoft Excel 2010 (Microsoft Corporation), and mean, standard deviation (SD), frequency, and percentage were used to describe the sample characteristics. Statistical analysis was conducted using SPSS software, Version 20 (SPSS, Inc., Chicago, IL) and GraphPad Prism 6 (GraphPad Software Inc). The Chi-square test was used to assess significant associations between two categorical variables (percentage and frequency). The *t*-test was used to compare the means of quantitative variables. Multiple linear regression was used to screen the risk factors for the length of hospital stay, and multiple logistic regression (forward LR method, entry:  $P = 0.05$ ; removal:  $P = 0.10$ ) was used to screen the contributory factors for the amputation. In this study,  $p < 0.05$  was set as the level of statistical significance.

### 3. Results

#### 3.1. Demographic characteristics

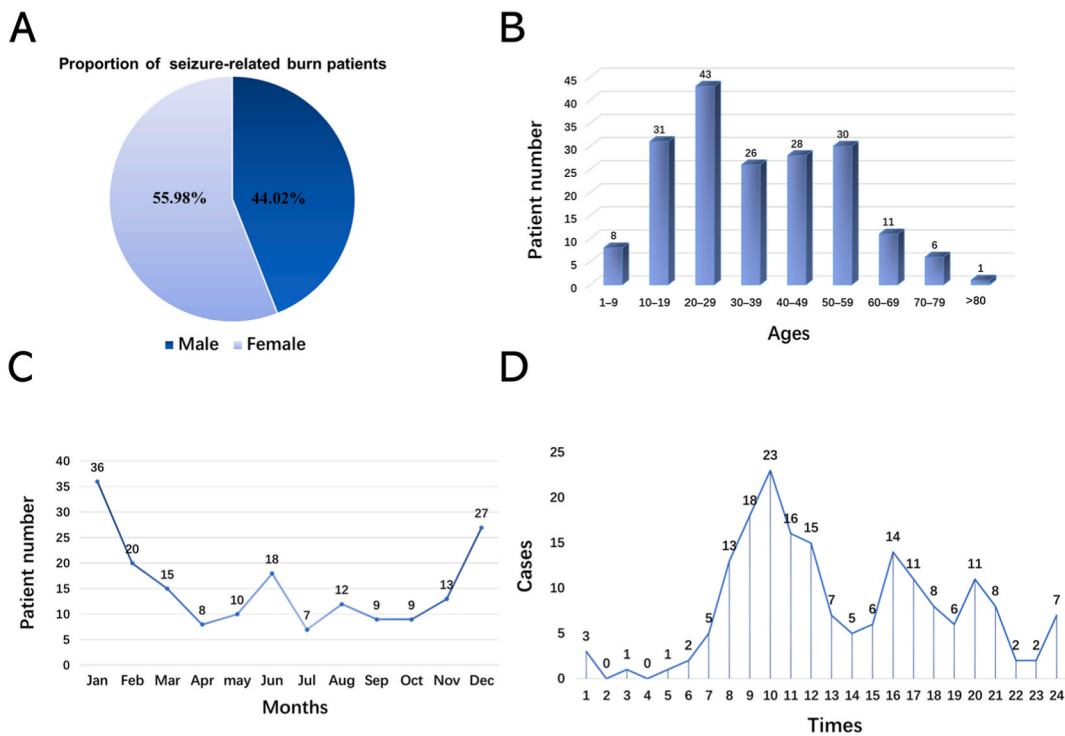
From January 2002 to December 2022, a total of 23,520 burn patients were admitted to our burn center. Of these, 184 patients suffered burns sustained during an epileptic seizure. We found a 0.78 % incidence rate during the period of the investigation in our center. Eighty-one (44.02 %) of the 184 patients were male, and the ratio of male to female was 0.79 (Fig. 1A). The mean age of epileptic burn patients was 36.16 years (SD: 17.93, Table 1), ranging from 1 to 82 years. Patients aged 20–29 were the most affected age groups (23.37 %, Fig. 1B). Urban patients accounted for 69.02 % in total (Fig. 2B). The prevalence of burns peaked in December, January, and February (Fig. 1C), which is the coldest period in southwest China. A greater number of accidents occurred between 8 and 12 a.m. (n = 85, 45.95 %) than at any other time of day (Fig. 1D). The majority of patients (n = 108, 58.70 %) took antiepileptic medication irregularly. Almost half of the patients (n = 90, 48.91 %) had epilepsy for over 10 years (Table 1).

#### 3.2. Etiology

Most burns were caused by flame (Table 2), accounting for 60.33 % (111/184) of all cases, followed by scalding at 39.13 % (72/184). The overwhelming majority of patients (n = 182, 98.91 %) suffered seizures at home while making fires for warmth, handling hot water, cooking and other household tasks (Fig. 2A). According to the mechanism of burns in patients with epilepsy, 92 (50.00 %) were caused by stove/charcoal fire, 64 (34.78 %) by overheated liquid, 14 (7.61 %) by natural gas/coal gas, 4 (2.17 %) by hot metal, 1 (0.54 %) by gasoline, 1 (0.54 %) by electricity and 8 (4.35 %) by other objects (Table 2). Most of the seizures were not witnessed, so the type of seizure in burn patients could not be accurately confirmed. By reviewing the medical record, we found that nearly half of the patients (n = 88, 47.83 %) experienced loss of consciousness during the seizure (Table 1).

#### 3.3. Burn sites and burn severity

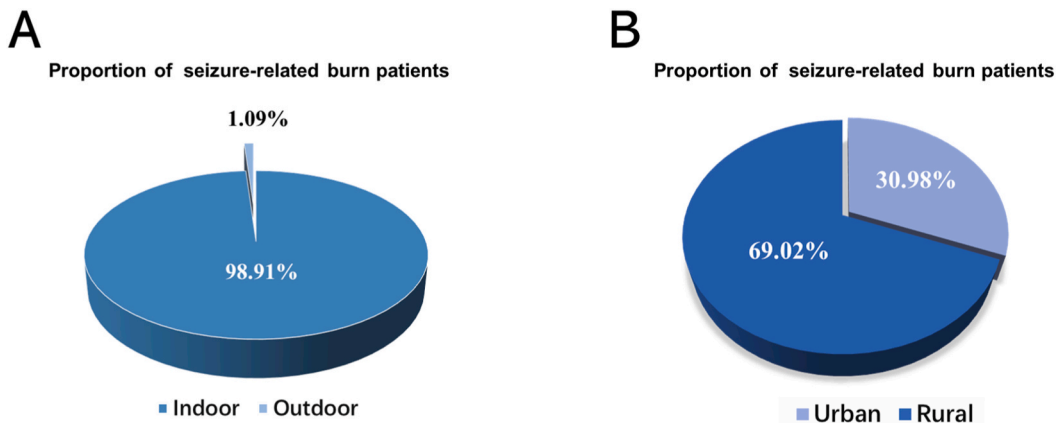
According to Table 3, the most common burn site was the upper limbs, accounting for 61.96 % of all cases. The second most common burn site was the lower limbs (52.72 %). It was found that 46.74 % of the patients had burns on their hands and 24.46 % had burns on their feet. As many as 20.11 % of patients suffered burns on both the upper and lower extremities. The average total body surface area (TBSA) was  $9.36 \pm 10.83$  (median 5 %) with a range of 1%–55 % (Table 1). The average full-thickness burn area was  $6.95 \pm 9.35$ . As shown in Table S1, the rate of full-thickness burn among patients with seizures was also significantly higher than that of patients without seizures (86.96 % vs. 29.16 %,  $p < 0.001$ ). Five patients suffered inhalation injury (2.72 %). The majority of burn



**Fig. 1.** Distribution of gender, ages, months, and times. (A) The distribution of male and female patients. (B) Age distribution of all burn patients. (C) Number of patients in each month. (D) The distribution of burn patients by different o'clock.

**Table 1**  
Clinical features of burn patients with epilepsy.

Characteristics	Total(n = 184)	Male(n = 81)	Female(n = 103)	P-value
<b>Age(mean ± SD)</b>	36.16 ± 17.93	37.70 ± 19.20	34.95 ± 16.86	0.303
<b>Burn severity</b>				
Total body surface area (mean ± SD)	9.36 ± 10.83	10.91 ± 11.81	8.14 ± 9.88	0.084
Burn index (mean ± SD)	8.00 ± 9.85	9.29 ± 10.81	6.98 ± 8.94	0.115
Baux score (mean ± SD)	45.98 ± 21.47	49.25 ± 22.85	43.42 ± 20.06	0.067
Full-thickness burn area (mean ± SD)	6.95 ± 9.35	8.24 ± 10.19	5.96 ± 8.56	0.166
Inhalation injury (n,%)	5(2.72 %)	3(3.70 %)	2(1.94 %)	0.466
<b>Associated injuries (n,%)</b>	8(4.35 %)	5(6.17 %)	3(2.91 %)	0.476
Fracture	2(1.09 %)	1(1.23 %)	1(0.97 %)	
Ocular burn	4(2.17 %)	2(2.47 %)	2(1.94 %)	
Carbon monoxide poisoning	1(0.54 %)	1(1.23 %)	0(0 %)	
Others	1(0.54 %)	1(1.23 %)	0(0 %)	
<b>Loss of consciousness (n,%)</b>				0.607
Yes	88(47.83 %)	37(45.68 %)	51(49.51 %)	
No	96(52.17 %)	44(54.32 %)	52(50.49 %)	
<b>Transfusion (n,%)</b>				0.414
Yes	49(26.63 %)	24(29.63 %)	25(24.27 %)	
No	135(73.37 %)	57(70.37 %)	78(75.73 %)	
<b>Antiepileptic therapy (n,%)</b>				0.096
Regular medication	76(41.30 %)	39(48.15 %)	37(35.92 %)	
Irregular medication	108(58.70 %)	42(51.85 %)	66(64.08 %)	
<b>History of epilepsy (n,%)</b>				<0.001
0–5 years	47(25.54 %)	37(45.68 %)	10(9.71 %)	
5–10 years	47(25.54 %)	13(16.05 %)	34(33.01 %)	
>10 years	90(48.91 %)	31(38.27 %)	59(57.28 %)	
<b>Length of hospital days (mean ± SD)</b>	26.96 ± 23.29	27.02 ± 27.06	26.90 ± 19.97	0.972
<b>Length of hospital days/TBSA</b>	6.90 ± 8.53	5.16 ± 6.10	8.28 ± 9.85	0.014
<b>ICU stay (mean ± SD)</b>	1.70 ± 6.47	2.10 ± 7.32	1.38 ± 5.73	0.456
<b>Mortality, n(%)</b>	1(0.54 %)	1(1.23 %)	0(0 %)	0.904



**Fig. 2.** Distribution of the place of injury and region. (A) Distribution of burn patients by the environment of injury. (B) The regional distribution of burn patients.

patients (n = 132, 71.74 %) suffered burns to less than 10 % of TBSA (Fig. 3B). Patients with TBSA of 11~20 % accounted for 16.30 % of all cases. Only two (1.09 %) of the burn patients had burns greater than 50 % of TBSA. Furthermore, full-thickness burns were the most common wounds (64.98 %), followed by partial-thickness burns (26.31 %) (Fig. 3A).

### 3.4. Operations and outcome

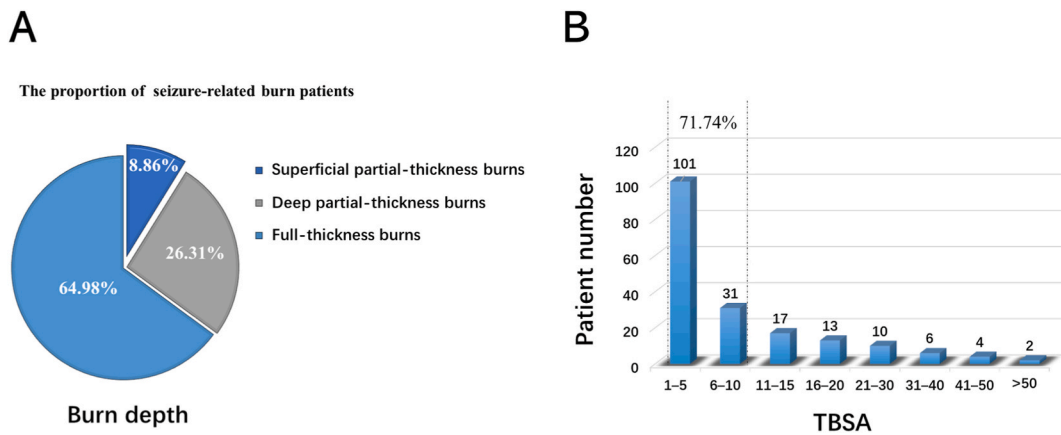
In total, 76.09 % of the 184 patients underwent at least one operation as part of their recovery process. Table 4 illustrates the distribution of operation types and numbers. Of all the patients, 71.74 % (n = 132) underwent skin autografting and 15.76 % (n = 29) received various types of skin flap coverage in repairing deep tissue defects. A total of 22 patients (11.96 %) underwent a sequestrectomy procedure. As part of the operating procedure, a minority of allograft (0.54 %), and xenograft (0.54 %) skin was applied to the deep wound to prepare it for flaps or skin autografts (Table 4). In general, the mean LOS was 26.96 ± 23.29 d and the median LOS was 21.5 days (Table 1). The mean LOS/TBSA was 6.90 ± 8.53 d. The average length of ICU stay was 1.70 ± 6.47d. A multiple linear

**Table 2**  
Etiology of burn injury with epilepsy.

Etiology	Number	Percentage (%)
<b>Type of burns</b>		
Flame burns	111	60.33 %
Scald	72	39.13 %
Electric burns	1	0.54 %
<b>Source of injury</b>		
Stove/Charcoal fire	92	50.00 %
Overheated liquid	64	34.78 %
Natural gas/coal gas	14	7.61 %
Hot metal	4	2.17 %
Gasoline	1	0.54 %
Electricity	1	0.54 %
Others	8	4.35 %

**Table 3**  
Anatomic burn distribution.

Anatomic site	Number	Percentage (%)
Head/face/neck	39	21.20 %
Trunk	56	30.43 %
Hands	86	46.74 %
Feet	45	24.46 %
Upper limb(excludes hands)	74	40.22 %
Lower limbs(excludes feet)	89	48.37 %
Upper limbs	114	61.96 %
Lower limbs	97	52.72 %
Upper and lower limbs	37	20.11 %
Hip	22	11.96 %
Perineum	13	7.07 %



**Fig. 3.** The analysis of burn depth, and area. (A) The proportion of different burn depths in all burn patients' wounds. (B) The TBSA distribution.

regression analysis was performed to identify the risk factors associated with LOS. Of these factors, the most significant prolongation of LOS was associated with increased amounts of operations (standardized coefficient = 0.791,  $P < 0.001$ ), followed by burns with a larger TBSA (standardized coefficient = 0.188,  $P < 0.001$ ) and a larger full-thickness burn area (standardized coefficient = 0.188,  $P = 0.015$ ) (Table 5). There was one death among the 184 patients, with a mortality rate of 0.54 % in the overall study (Table 1).

**3.5. Amputation and risk factors**

Unfortunately, 35 burn patients still needed amputations during the study period. Table 4 illustrated the distribution of amputation sites. Two of the patients had two-site amputations, so of the 35 burn patients who had amputations, 37 sites were amputated. Hands (finger and wrist) were the most frequently amputated site ( $n = 21$ , 60.00 %), followed by feet (toe and ankle,  $n = 6$ , 17.14 %). As shown in Table S1, the amputation rate of patients with seizures was significantly higher than that of patients without seizures (19.02

**Table 4**  
Surgery in burn patients with epilepsy.

Feature	Number	Percentage (%)
<b>Operation number</b>		
0	44	23.91 %
1	80	43.48 %
2	37	20.11 %
3	13	7.07 %
>3	10	5.43 %
<b>type of operations</b>		
Skin autograft	132	71.74 %
Amputation	35	19.02 %
<i>Finger</i>	20	57.14 %
<i>Wrist</i>	1	2.86 %
<i>Forearm</i>	1	2.86 %
<i>Upper arm</i>	2	5.71 %
<i>Toe</i>	4	11.43 %
<i>Ankle</i>	2	5.71 %
<i>Shank</i>	4	11.43 %
<i>Thigh</i>	3	8.57 %
Flap graft	29	15.76 %
Sequestrectomy	22	11.96 %
Skin allograft	1	0.54 %
Skin xenograft	1	0.54 %

**Table 5**  
Multiple linear regression analysis of risk factors associated with LOS.

Variables	Unstandardized beta coefficients	Standardized beta coefficients	t	P
Larger TBSA	2.525	0.188	4.992	0.000
More operations	13.029	0.791	16.324	0.000
Full-thickness burn	11.522	0.188	2.466	0.015
Etiology	3.506	0.073	1.378	0.170
Gender (Male)	-3.017	-0.064	-1.357	0.177
Older Age	-0.077	-0.059	-1.215	0.226
Inhalation injury	-7.519	-0.053	-1.112	0.268

% vs. 3.70 %,  $p < 0.001$ ). A multiple logistic regression analysis was conducted to explore the potential risk factors for amputation, and the results were shown in Table 6. It was found that burn sites (hands) had the greatest impact on amputation (OR = 3.799), followed by flame burns (OR = 3.723). Amputation risk can be significantly increased by both of these factors.

#### 4. Discussion

Epilepsy is a prevalent chronic encephalopathy with various underlying causes. Globally, nearly 85 % of individuals suffer from epilepsy occurring in developing and less developed countries [23]. The disease burden of epilepsy remains high in China, particularly in Western China [24]. The incidence of seizure-related injuries was 29.5 per 100,000 [25]. Burns are one of the most common accidental injuries in epileptic patients [26]. It was reported that 38 % of epileptic patients suffered burns following seizures [27]. In our study, 184 patients suffered burns during an epileptic seizure, representing a proportion of 0.78 % of all inpatients with burns over the last 21 years, which is similar to that reported in other studies ranging from 0.41 % to 1.1 % [11,19].

Inconsistent with other previous studies [11,17,19], 60.33 % of burns in patients with epilepsy in this study were caused by flames, followed by scalds (39.13 %). According to the mechanism of burns in patients with epilepsy, 50.00 % of burns in patients with epilepsy were caused by stove/charcoal fire. In our study, 69.02 % of the patients were from rural areas. Due to the practice of burning wood for cooking and heating in rural areas of China where socio-economic status was low and electricity or natural gas plumbing was unavailable, as well as inadequate treatment and care for epileptic patients in rural areas, seizure-related burn injuries were more likely to occur. Due to their constant involvement in household chores, women are more likely to suffer from burns in epileptics [26]. Our study also found that adult females (aged 20–59 years) were more likely to suffer seizure-related burns, and the majority of epilepsy patients were injured in the morning while doing housework. Therefore, women's domestic activities, especially cooking and handling hot liquids, should be targeted in health education to help reduce the morbidity of burns.

The results of our study showed that burns with full-thickness were the most common wounds among patients with epilepsy (64.98 %). Patients often lose consciousness during seizures and do not respond to painful stimuli when they are burned. Our study showed that nearly half of the patients (47.83 %) experienced loss of consciousness during a seizure. Patients are exposed to heat sources for prolonged periods due to the loss of the normal escape response, resulting in deeper burn wounds. Our study found that almost half of the patients (48.91 %) had suffered epilepsy for more than 10 years. However, the majority of patients took their antiepileptic

**Table 6**  
Multiple logistic regression analysis of risk factors related to Amputation.

Variables	B	SE	Wald	OR	95 % CI	P
Etiology (Flame burns)	1.315	0.510	6.640	3.723	1.370–10.120	0.010
Anatomic site(hands)	1.329	0.443	9.021	3.779	1.587–8.998	0.003
Regular medication	0.567	0.413	1.885	1.764	0.785–3.965	0.170
Full-thickness burn	0.003	0.020	0.030	1.003	0.966–1.043	0.862
Gender (Male)	–0.236	0.429	0.303	0.790	0.341–1.829	0.582
Older Age	0.012	0.012	0.993	1.012	0.989–1.035	0.319

medication irregularly. Most epileptic patients are unable to participate in complex social activities, resulting in financial constraints that prevent them from receiving regular treatment. The social and governmental sectors must, therefore, pay more attention to these patients' lives and financial strain so they can receive more appropriate and effective treatment.

In this study, 76.09 % of patients underwent at least one operation. The most common type of surgery was autologous skin grafting, accounting for 71.74 %. Various flaps are used to cover wounds with exposed tendons, bones, or joints. An amputation is performed if all blood vessels have been damaged and a distal limb is deprived of blood supply. The amputation rate in our study was 19.02 % and ranged from 4.3 % to 19.0 % in previous studies [11]. The most common site of amputation was the hand. This may be due to the frequent handling of heat sources by hand. Through logistic regression, we found that flame burns and hand burns were risk factors for amputation. Epilepsy patients experience high rates of disability after burns, which further aggravates their living conditions.

In our study, the mean LOS was  $26.96 \pm 23.29$  d, and the mean LOS/TBSA was  $6.90 \pm 8.53$  d. The length of hospital stay in epileptic burn patients was longer than that in the general burn population (the median LOS: 17d) [22]. Furthermore, we found that a larger TBSA, full-thickness burns, and more operations were the risk factors for a longer LOS. This may be because burn wounds tend to take longer to heal when the TBSA of the burn victim is greater. In addition, deep wounds may require multiple operations to repair and may remain in the hospital for plastic surgery and rehabilitation after wound healing. In this study, the mortality rate of seizure-related burn injuries was 0.54 %, which was lower than the 9.5 % in Ghana and 17.2 in Iran reported in other studies [19,26]. Since there were so few deaths, a mortality risk factor analysis was not conducted in this study.

Based on our findings and previous studies, we recommend the following strategies to mitigate burn risks among epileptic patients in China: 1) Patients should go to the department of neurology in time and follow up closely because accurate identification of the seizure type and epilepsy syndrome is fundamental for drug therapy [1]. Furthermore, patients must adhere to regular medication to minimize the recurrence of seizures; 2) Our results indicated that burn sites (hands) and flame burns were major risk factors for amputation. Therefore, we strongly recommend that patients with epilepsy avoid engaging in flame contact activities such as cooking indoors. If contact with flame is necessary, patients should wear protective gloves and preferably do this under supervision; 3) The family members of patients should enhance their support and provide attentive care to ensure the mental stability and physical health of the patients, as dramatic mood fluctuations can induce epileptic seizures [27]; 4) For inpatients with epilepsy, there are also additional points to pay attention to. First, inpatients must be accompanied by at least one person during the hospital stay in case of reinjury. Second, burn wound dressings should be soft and easy to change, as far as possible, to reduce pain and stimulation of inpatients. Third, infection in burn victims should be controlled promptly and effectively to avoid seizures triggered by high fever. More importantly, emergency medication such as diazepam must always be available, because such inpatients may have an acute seizure at any time [28].

Nevertheless, the results of our study should be interpreted with caution because of the following limitations. First, the study only included data from our burn center, and most of the burn patients with epilepsy were from Chongqing Municipality, Sichuan, Yunnan, and Guizhou provinces in southwest China. Due to this, the findings cannot be generalized directly to the whole region of China. Second, the patients enrolled in the study were only inpatients who were often transferred from other hospitals and were more severe, so the incidence of burns among patients with epilepsy may be underestimated, and the severity of the burns in our study was probably higher than in the overall burn population. Third, due to the retrospective study, the electronic medical records of epileptic patients often lacked detailed records of their medication use. Therefore, statistical analyses of their medication regimens were not available.

## 5. Conclusion

In summary, our study showed that burn injuries among epilepsy patients were at high risk of amputation and disability. Burn sites (hands) and flame burns were major risk factors for amputation, and a larger TBSA, full-thickness burns, and a higher number of operations were the risk factors for a long LOS. Burns are extremely harmful to individuals with epilepsy, but most can be avoided. The most fundamental approach is to reduce the risk of burns by controlling the recurrence of epilepsy and enhancing safety awareness. Therefore, based on these risk factors, health education and prevention programs including lifestyle modification and seizure control should be implemented to reduce the incidence of burns in these populations.

## Ethics approval statement

This study was approved by the Institutional Review Board of the Southwest Hospital (Ethics approval number: (B) KY2023051), Third Military Medical University (Army Medical University). In accordance with national law and institutional requirements,

participants' legal guardians/next-of-kin were not required to provide written informed consent in this retrospective study.

### Data availability statement

Data associated with our study has not been deposited into a publicly available repository. Data included in article/supp. Material/referenced in article.

### CRediT authorship contribution statement

**Yangping Wang:** Writing – original draft, Formal analysis, Data curation, Conceptualization. **Lan Luo:** Methodology, Formal analysis, Data curation. **Haisheng Li:** Supervision, Methodology, Data curation. **Maojun Li:** Formal analysis, Data curation. **Yuqun Huang:** Data curation. **Yuting Huang:** Data curation. **Gaoxing Luo:** Supervision, Resources, Conceptualization. **Menglong Liu:** Writing – review & editing, Writing – original draft, Resources, Formal analysis, Conceptualization.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e23908>.

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