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# Timing of early excision and grafting following burn in sub-Saharan Africa[☆]

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## Abstract

**Background—**This study sought to establish appropriate timing of burn wound excision and grafting in a resource-poor setting in sub-Saharan Africa.

**Methods—**All burn patients (905 patients) admitted to Kamuzu Central Hospital (KCH) Burn Unit in Lilongwe, Malawi over three years (2011–2014) were studied.

**Results—**275 patients (30%) had an operation during their admission. In patients who received an operation, median age was 5 years (IQR, 2.7–19) and median total body surface area burn was 15% (IQR, 8–25). 91 patients (33%) had early excision (≤5 days) and 184 patients (67%) had late excision (>5 days). Mortality was significantly greater in the early group (25.3% vs. 9.2%, $p$ = 0.001). Controlling for total body surface area burn and age, the adjusted predictive probability of mortality were 0.256 (CI 0.159–0.385) and 0.107 (CI 0.062–0.177) if operated ≤5 and >5 days, respectively ( $p$ = 0.0114). The odds ratio for mortality if operated >5 days is 0.34 (CI 0.15–0.79, $p$ < 0.000).

**Conclusions—**Early excision and grafting in a resource-poor area in sub-Saharan Africa is associated with a significant increase in mortality. Delaying the timing of early excision and grafting of burn patients in a resource-poor setting past burn day 5 may confer a survival advantage.

## Keywords

Early excision and grafting; Burns in Africa; Timing of burn excision; Burn care in Malawi; Global surgery; Operative timing

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**Conflict of interest**

The authors have no conflict of interest and financial relationships to disclose.

## 1. Introduction

Burns are among the most devastating of all injuries and a major global public health crisis. The burden of burn with associated morbidity and mortality is high in low- and middle-income countries (LMIC) particularly in sub-Saharan Africa and other regions that generally lack the necessary infrastructure to reduce the incidence, severity, and sequelae of burn. Globally, 90% of mortality from burn occurs in low-and middle-income countries [1].

One of the major transformative concepts in burn care since the 1970s is the survival advantage that early burn wound excision and grafting confers. This is a surgical procedure performed to remove the burn wound eschar and cover the exposed wound with autograft, allograft skin, or artificial skin substitutes. The aim is prevention or control of infection, conservation of all viable tissue, maintenance of form and function, timely closure of all wounds, early return to rehabilitative therapy, and decrease in mortality. Early excision and grafting fulfills all of these conditions [2].

Janzekovic first successfully practiced tangential burn wound excision with immediate grafting in 1970 [3] and Burke et al. showed improved survival in massively burned children following early burn wound excisions to fascia in 1976 [4]. In developed countries, this is now considered standard of care in the treatment of severely burned patients [5]. The optimal timing of early burn excision and grafting varies. Past studies have described early excision to range from 24 h to within 6 days of the burn [6–10].

In the resource-poor setting, there are several obstacles that may limit the utility of early excision and grafting. These include inadequate primary resuscitation, delayed presentation, and pre-existing malnutrition and anemia with the inability to tolerate major surgery and blood loss [11]. As a result, early excision and grafting may be prohibitive due to a lack of a direct correlation to survival benefit.

Few epidemiologic studies have assessed the association between burn mortality and the timing of early excision and grafting in sub-Saharan Africa. There is particular need to characterize this association. To address this gap, we conducted a comparison of patients with early and late burn wound excision in a burn unit in Lilongwe, Malawi.

## 2. Methods

This study is a retrospective analysis of prospectively collected burn registry data at Kamuzu Central Hospital (KCH), a 600-bed tertiary care hospital in the capital city of Lilongwe, which serves as a referral center for approximately 5 million people in the central region of Malawi. The KCH Burn Unit was established in 2011 and averages 25–40 admissions per month [12]. Pediatric and adult patients are admitted to the same unit. The KCH Burn unit is a 31-bed unit with 5 full-time nurses, and 2 trained clinical officer staff with surgical consultant oversight.

Patients are admitted to the burn unit from the emergency department and fluid resuscitation is initiated before transfer using the Parkland Formula (24-h intravenous volume = 4 × patient's mass (kg) × %TBSA). In larger burns, Foley catheters are placed and further resuscitation is guided by urine output and physical examination. The burn unit has a dedicated operative theater along with a post-operative care unit in the burn center. Pre and post-operatively patients undergo wound-dressing changes three days a week where they are routinely dressed with sodium hypochlorite solution (Eusol) soaked gauze or silver sulfadiazine.

The burn registry was established to collect patient demographic, clinical characteristics, and outcome data. Specifically, data points utilized in this study include age, sex, date of admission, mechanism of injury, time to presentation to hospital, percentage total body surface area burn (%TBSA), comorbidities, laboratory values, date and type of operative procedures, length of hospital stay, and outcome (discharge, abscond, or death). All patients admitted between June 2011 and August 2014 were included in this study.

We performed bivariate analysis to compare variables between operative and non-operative burn patients. Specific variables included age, gender, burn mechanism, %TBSA, time to presentation, time to operation, and discharge disposition (death vs. discharge/abscond). %TBSA was recorded both in the casualty (emergency department) and at the patient's first dressing change in the ward. Owing to missing data in both observations, the smaller of the two values was used in analysis if both were recorded. If only one observation for %TBSA was recorded, that one was used. The smaller value was used to avoid overestimating the severity of burn if there was a discrepancy in recording. Superficial burns were not included in %TBSA. Burn depth was not recorded but we can infer from the mechanism of injury that patients with scald burns likely had more superficial burns while patients with flame burns had deeper burns.

Additionally, bivariate analysis was performed with the same set of variables comparing those receiving early versus late burn wound excision. Early excision was defined as operative intervention performed ≤5 days after admission and late excision as >5 days, based on review of the literature. While there is no consensus on the definition of early excision, most burn centers consider early excision within five days [13]. Thus, we chose this time period as the basis of our analysis. Logistic regression modeling was utilized to determine odds of mortality and predictive probability of death based on timing of operative intervention.

All statistical analysis was performed using Stata/SE 13.1 (StataCorp LP, College Station, TX). Ethics approval was obtained from the University of North Carolina Institutional Review Board and the Malawi National Health Services Review Committee.

## 3. Results

Between June 2011 and August 2014, 905 patients were admitted to the KCH Burn Unit. Median age was 3 years (range 1 month to 91 years) with 55% being male. 81% of our burn population is <18 years old. For all patients, median %TBSA was 15% (IQR 8–23%). 451 patients had a %TBSA recorded in both the casualty and on the ward but the mean absolute difference in documented %TBSA was only 2.4. Only 14% of patients reported a comorbidity and the overwhelming majority was epilepsy (81%). 168 (19%) patients reported using traditional medicine techniques before presenting to the hospital.

In our study cohort, 275 (30%) patients received an operation during their hospitalization. Age distribution was similar between operative and non-operative groups except for a larger group aged 12–24 months in the non-operative cohort. Median age in the non-operative group and operative groups were 3 (IQR 1.8–8) and 5 years (IQR 2.7–19) ( $p = 0.000$), respectively. There was a statistically significant difference in the sex composition between the operative (50.6% male, 49.4% female) and non-operative groups (57.3% male, 41.9% female, $p = 0.023$) due to a higher percentage of men in the non-operative group. There was no statistically significant difference in %TBSA between the groups, with a median of 15% (IQR 8–25) and 13.3% (IQR 8–22) ( $p = 0.409$), respectively. Mechanism of injury was very different with scald burns comprising the overwhelming majority of the non-operative group (70.0%) and flame being the most common mechanism in the operative group (61.8%, $p < 0.000$). Those who received an operation had a much longer median hospital stay, 37 days vs. 9 days ( $p < 0.000$). Time from injury to presentation at casualty was recorded for each patient and different between the two groups. Non-operative patients presented earlier with 65.6% presenting within 48 h of injury versus 52.0% in the operative group ( $p < 0.000$). Almost half (42.5%) of the operative group presented after 48 h. Mortality for the entire cohort was 17.2% but was higher in the non-operative group compared to the operated group at 18.4% compared to 14.6% ( $p = 0.004$). (Table 1)

Within the operative group, we analyzed the unadjusted relationship between timing of operation and mortality and there was a clear relationship as shown in Fig. 1. Two cohorts were then created based on timing of operation, early versus late excision. There were no differences between the early and late groups in terms of age, gender, %TBSA, mechanism of injury, time to presentation, comorbidities, or laboratory values. The late excision group had a significantly longer median length of stay, 20 days versus 41 days ( $p < 0.000$) and had higher incidence of fever with 139 patients (71.3%) compared to 56 patients (28.7%) in the early group ( $p = 0.016$). The most common procedure was debridement (50.5%) and skin graft (36.3%). Comparing early and late excision shows a comparable number of debridements (49.4% vs. 51.1% of total procedures) but far more escharotomies (18% vs. 1.7%) in the early cohort and more skin grafts in the late group (22.5% vs. 42.8%). Amputations were uncommon in both groups with only one recorded in each cohort. Initial hemoglobin levels were measured in 177 patients (64.3%) from the operative cohort but there was not a statistically significant difference between the early and late operative groups ( $p = 0.669$) (Table 2). Mean initial hemoglobin level in the entire operative cohort was 10.2 (SD ±3.1). There were also no differences in initial white blood cell count ( $p = 0.892$) or platelet count ( $p = 0.250$).

Most notably, mortality was significantly higher in the early excision group, 25.3% vs. 9.2% ( $p = 0.001$). With logistic regression modeling controlling for %TBSA and age, the adjusted predictive probability of mortality were 0.256 (CI 0.159–0.385) and 0.107 (CI 0.062–0.177) if operated ≤5 and >5 days, respectively ( $p = 0.011$). (Fig. 2) The odds ratio for mortality if operated >5 days is 0.34 (CI 0.15–0.79, $p < 0.000$).

The exact cause of death was not available for patients due to diagnostic limitations such as a lack of readily available blood cultures. However, there are some clues to differences in the cause of death between the early and late operative groups. First, the deaths in the early group trended toward occurring sooner after their initial operation than in the late group. 30.4% of the early group died within 5 days after their operation versus 23.5% of the late group ( $p = 0.084$). 60.8% of all deaths in the early group happened within ten days with only 29.4% dying in that period in the late group. This may mean that a great proportion of patients in the late operative group were dying of a traditionally later cause of death, infection, rather than resuscitation or complications from anesthesia. This is further supported by a higher rate of fever in the late operative cohort, 71.3% versus 28.7% ( $p = 0.016$). When examining patients that died between the two groups, the difference is not statistically significant but shows a fever rate of 76.5% in the late group versus 56.5% in the early group ( $p = 0.191$). The high rate of fever in both groups suggests that sepsis, as a cause of death, is very prevalent in our population.

Across the entire burn patient cohort there are several factors that may affect the relatively high mortality rate and the first is %TBSA and age. Mechanism of injury is also associated with mortality. 59.5% of patients that died had a flame burn compared to just 33.3% of patients that survived ( $p = 0.000$). Lastly, anemia is associated with mortality. 61.1% of patients that died had an initial hemoglobin level below 10 g/dL while just 39.4% of patients who survived did ( $p = 0.000$). The presence of inhalation injury was not recorded but is largely non-existent in our cohort because nearly all burns are due to small cooking fires often outside the home. Concomitant trauma was also absent. Factors such as gender, medical comorbidities, and time to presentation do not have any association with mortality in our population. On bivariate analysis, there were no statistically significant differences between the early and late operative groups based on anemia, gender, mechanism of injury, or comorbidities.

Patients missing a recorded %TBSA or disposition were compared with those not missing these data from the entire cohort. 89 patients (10.1%) were missing a recorded %TBSA. There were no significant differences between those missing a %TBSA and those with one recorded comparing the variables of age, gender, length of stay, mechanism of burn, or time to presentation. The only significant difference was a much lower mortality rate in the group missing a %TBSA (6.7% vs. 20.1%, $p = 0.002$). The rate of missing %TBSA between the early and late operative cohorts was similar (12.1% vs. 11.4%, $p = 0.870$).

51 patients (6.4%) are missing disposition data from the entire cohort and only 11 patients (4%) in the operative cohort were missing data. There were no significant differences in age, gender, %TBSA, length of stay, mechanism of burn, or time to presentation. The rate of missing disposition between the early and late operative cohorts was similar (1.1% vs. 5.4%, $p = 0.084$).

## 4. Discussion

Burn is a devastating form of injury and represents a major cause of mortality and morbidity, as well as a significant drain on limited health care resources. Advances in resuscitation,

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critical care, protective ventilatory strategies, early burn wound debridement, and the institution of appropriate nutritional support complemented by prompt recognition and treatment of burn related wound sepsis have reduced mortality due to thermal injuries worldwide. However, the aforementioned success has not translated to improved survival in developing countries that bear the highest burden of burn.

The baseline burn mortality rate in sub-Saharan Africa is high. World Health Organization (WHO) estimated that 43,000 people die of burns in Africa every year with a rate of 6.1 per 100,000 [14]. Commonly in LMIC, burn patients are treated with dressings and topical antimicrobial agents until the eschar separates. The granulating wound would then be covered with split thickness skin graft, a process that could take 3–5 weeks [15]. Patients with severe burns treated in this manner are more likely to die from sepsis due to the massive release of inflammatory mediators from the burn wounds. This is further exacerbated by subsequent infection of these wounds. The rationale for early excision of burns is that it decreases release of inflammatory mediators and bacterial colonization of wounds. This, in turn, attenuates the systemic inflammatory response syndrome (SIRS) hence reducing the occurrence of metabolic derangements, sepsis, and multi-organ failure [10,16]. In addition to improvement in prognosis, early excision and grafting procedures have been shown to decrease the duration of hospitalization, incidence of metabolic complications, burn wound contamination, post-burn contractures, and cost of burn treatment [17,18].

However, in resource-poor settings, one must be careful in prescribing such aggressive burn therapy in the absence of an adequate burn care infrastructure. The literature is unequivocal about the benefits of early excision and grafting as it relates to mortality when compared to no surgery. This was supported by our study, which showed a statistically significant increase in mortality in the non-operative versus the operative groups. Our overall mortality rates are high compared to burn centers in developed countries but comparable or better to many centers in sub-Saharan Africa where available data shows rates from 10% to 40% [19,20]. In Bugando Hospital in Mwanza, Tanzania, a setting similar to ours, the case fatality rate, which averaged 2.2% for all injury, was 13% for burn [21]. Similarly, in a burn unit in Ghana, pediatric burn mortality was identified to be 21% [22].

The timing of excision and grafting in resource-poor environments is less well defined. In our burn cohort, delaying excision after post burn day 5 imparts a survival advantage and the reasons for this are multifactorial and mostly related to the burn care infrastructure and overall health care expenditure. In the acute post-burn phase, inadequate resuscitation leading to refractory shock will result in poor outcomes if coupled with early excision of burn wounds. Furthermore, 58% of our burn cohort was less than age 5 years. Pediatric burn resuscitation is particularly challenging in our environment given the need for weight based intravenous fluids and the usual clinical cues or end points of resuscitation may not be as apparent in burn patients. Hence education efforts focused on early assessment and the end points of resuscitation must be an integral part in education for burn care providers. We did not specifically assess the level of resuscitation, fluid requirement, and time to end point of resuscitation between the early and late operative groups in this study but we believe that both groups were similarly exposed to the resuscitation pattern of our burn unit.

Pre-operative anemia may have a role in our observation. In sub-Saharan Africa, with the existing endemic falciparum malaria and malnutrition there exists a baseline anemia prevalence rate between 57 and 77% in children less than 11 years [23]. Additionally, anemia is also a consequence of severe burn [24]. The opponents of early excision when it was first practiced were mainly concerned with the associated massive blood loss [25]. Unfortunately, our data point on preoperative hemoglobin and transfusion requirement were not consistently collected to help analyze differences in hemoglobin between groups or its effect on mortality.

The limitations of our study are consistent with other burn studies with a retrospective methodology. There was the possibility of selection bias whereby those patients who appeared sicker or were septic at presentation were perhaps fast tracked to early operative intervention. Secondly, the exact cause of death is unknown in our patients. Perioperative mortality may be related to post-anesthesia care given the variability of pediatric anesthesia capabilities in our unit and this was not adjusted for in our model. Our database was also missing some data such as %TBSA that was missing in 12% of our patients. However, our analysis suggests this data was missing at random, and if anything, the magnitude of effect was underestimated due to the lower rate of mortality in those missing %TBSA. In those missing disposition data, there were no differences between them and those with a recorded disposition. We also lacked patient data on burn depth. While this is an important factor is assessing burn severity, we are able to estimate depth severity using the mechanism of injury. Also, we were not able to adequately assess comorbidities in our patients, although our population is mostly pediatric where the prevalence of comorbidities is likely low. Furthermore, the high mortality rates in our setting may have magnified differences between early and late operative groups. Lastly, most of our operative procedures were skin excisions and debridement with or without grafting. The role of skin coverage specifically on mortality was not assessed.

## 5. Conclusion

Based on our study cohort, early excision with or without skin grafting in a resource-poor area in sub-Saharan Africa, though feasible, is associated with a significant increase in mortality. Delaying the timing of early excision and grafting of burn patients in this setting after post-burn day 5 may confer a survival advantage. The role of other clinically important variables such as resuscitation status, anemia, and anesthesia care will need to be further elucidated.

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Study data were collected and managed using REDCap electronic data capture tools hosted at UNC. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical

packages; and (4) procedures for importing data from external sources, responsibility for the integrity of the data and the accuracy of the data analysis.

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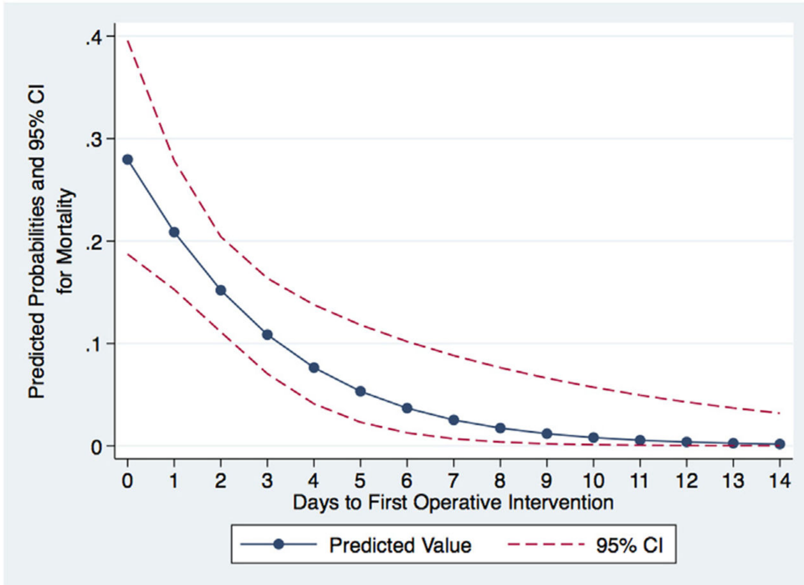


**Fig. 1.**
The unadjusted predicted probability of mortality based on days to first operative intervention.

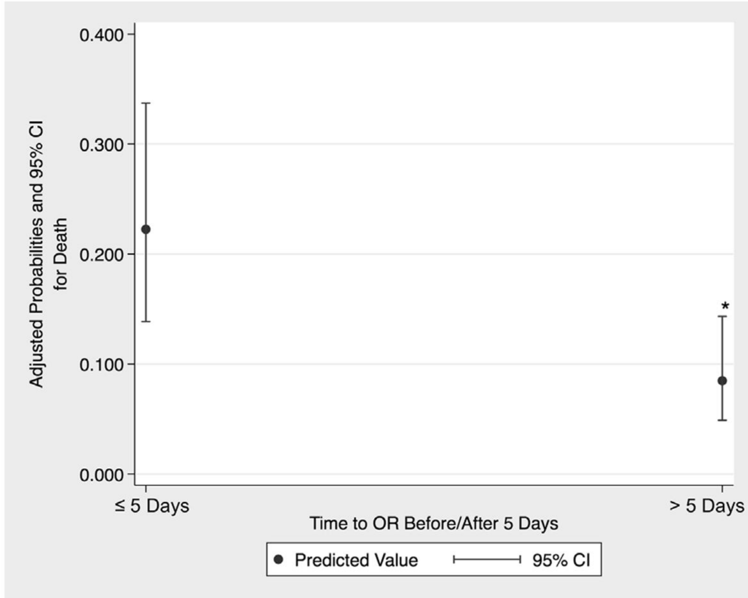


**Fig. 2.**

The predicted probability of mortality based on early versus late excision after adjusting for covariates (age and TBSA).

**Table 1**

Bivariate analysis between non-operative and operative patients. *p*-Values calculated with Chi-square analysis.

| | Non-operative (*n* = 630) | Operative (*n* = 275) | *p*-Value |
|---|---|---|---|
| Patient age (years) | | | |
| Median (IQR) | 3 (1.8–8) | 5 (2.7–19) | |
| Age categories: *N* (%) | | | |
| 0–11 months | 61 (9.7) | 22 (8.0) | |
| 12–24 months | 155 (24.6) | 35 (12.7) | <0.000 |
| 2–4 years | 181 (28.7) | 68 (24.7) | |
| 5–10 years | 98 (15.6) | 52 (18.9) | |
| 11–20 years | 40 (6.4) | 33 (12.0) | |
| 21–30 years | 39 (6.2) | 23 (8.4) | |
| 31–40 years | 21 (3.3) | 19 (6.9) | |
| >40 years | 27 (4.3) | 19 (6.9) | |
| Missing | 8 (1.3) | 4 (1.5) | |
| Gender: *N* (%) | | | |
| Female | 264 (41.9) | 139 (50.6) | 0.023 |
| Male | 361 (57.3) | 136 (49.4) | |
| Missing | 5 (0.8) | 0 (0) | |
| % TBSA | | | |
| Median (IQR) | 13.3 (8–22) | 15 (8–25) | 0.237 |
| Mean (SD) | 18.0 ± 16.0 | 17.9 ± 13.6 | |
| Missing (%) | 76 (12.1) | 32 (11.6) | |
| Mechanism: *N* (%) | | | |
| Flame | 155 (24.6) | 170 (61.8) | |
| Scald | 441 (70.0) | 87 (31.6) | <0.000 |
| Other | 6 (1.0) | 3 (1.1) | |
| Missing | 28 (4.4) | 15 (5.5) | |
| LOS (days) | | | |
| Median (IQR) | 9 (4–14) | 37 (20–59) | <0.000 |
| Missing (%) | 55 (8.7) | 12 (4.4) | |
| Time to presentation from injury: *N* (%) | | | |
| 0–12 h | 308 (48.9) | 88 (31.3) | |
| 12–24 h | 76 (12.1) | 44 (16.0) | <0.000 |
| 24–48 h | 29 (4.6) | 13 (4.7) | |
| >48 h | 137 (21.8) | 117 (42.6) | |
| Missing | 80 (12.7) | 15 (5.5) | |
| Initial hemoglobin level: *N* (%) | | | |
| <7 g/dL | 10 (1.6) | 18 (6.5) | |
| 7–10 g/dL | 33 (5.2) | 59 (21.4) | |
| 10–13 g/dL | 34 (5.4) | 82 (29.9) | <0.000 |
| >13 g/dL | 18 (2.9) | 18 (6.6) | |

| | **Non-operative ($n$ = 630)** | **Operative ($n$ = 275)** | ***p*-Value** |
|---|---|---|---|
| Missing | 535 (84.9) | 98 (35.6) | |
| Morality: $N$ (%) | 116 (18.4) | 40 (14.6) | 0.004 |
| Missing | 59 (9.4) | 11 (4.0) | |

**Table 2**

Bivariate analysis between patients who underwent early (≤5 days) and late (>5) operative intervention. *p*-Values calculated with Chi-square analysis.

| | Early operation (*n* = 91) | Late operation (*n* = 184) | *p*-Value |
|---|---|---|---|
| Patient age (years) | | | |
| Median (25–75%) | 6 (2.8–25) | 5 (2.6–15) | |
| Age categories: *N* (%) | | | |
| 0–11 months | 7 (7.7) | 15 (8.2) | |
| 12–24 months | 11 (12.1) | 24 (13.0) | 0.638 |
| 2–4 years | 22 (24.1) | 46 (25.0) | |
| 5–10 years | 12 (13.2) | 40 (21.7) | |
| 11–20 years | 12 (13.2) | 21 (11.4) | |
| 21–30 years | 11 (12.1) | 12 (6.5) | |
| 31–40 years | 6 (6.6) | 13 (7.1) | |
| > 40 years | 8 (8.8) | 11 (6.0) | |
| Missing | 2 (2.2) | 2 (1.1) | |
| Gender: *N* (%) | | | |
| Female | 44 (48.4%) | 95 (51.6%) | 0.609 |
| Male | 47 (51.6%) | 89 (48.4%) | |
| Missing | 0 | 0 | |
| % TBSA | | | |
| Median (25–75%) | 15 (6.5–25.5) | 15 (9–25) | 0.531 |
| Mean (SD) | 18.7 ± 15.9 | 17.6 ± 12.4 | |
| Missing (%) | 11 (12.1) | 21 (11.4) | |
| Mechanism: *N* (%) | | | |
| Flame | 57 (62.6) | 113 (61.4) | |
| Scald | 30 (33.0) | 57 (31.0) | 0.741 |
| Other | 1 (1.1) | 2 (1.1) | |
| Missing | 3 (3.3) | 12 (6.5) | |
| LOS (days) | | | |
| Median (25–75%) | 20 (11–43) | 41 (25–62) | <0.000 |
| Missing (%) | 1 (1.1) | 11 (6.0) | |
| Time to OR | | | |
| Median (25–75%) | 2 (1–4) | 14 (9–25) | |
| Time to presentation from injury: *N* (%) | | | |
| 0–12 h | 22 (24.2) | 64 (34.8) | |
| 12–24 h | 19 (20.9) | 25 (13.6) | 0.293 |
| 24–48 h | 4 (4.4) | 9 (4.9) | |
| >48 h | 42 (46.1) | 75 (40.7) | |
| Missing | 4 (4.4) | 11 (6.0) | |
| Initial hemoglobin level: *N* (%) | | | |
| <7 g/dL | 7 (7.7) | 11 (6.0) | |

| | **Early operation (*n* = 91)** | **Late operation (*n* = 184)** | ***p*-Value** |
|---|---|---|---|
| 7–10 g/dL | 18 (19.8) | 41 (22.3) | 0.813 |
| 10–13 g/dL | 26 (28.6) | 56 (30.4) | |
| >13 g/dL | 8 (8.8) | 10 (5.4) | |
| Missing | 32 (35.2) | 66 (35.9) | |
| Morality: *N* (%) | 23 (25.3) | 17 (9.2) | 0.001 |
| Missing | 1 (1.1) | 10 (5.4) | |