

The Optimal Time for Early Excision in Major Burn Injury

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Introduction: Early excision and grafting (E&G) drastically changed burn care in America by reducing morbidity, mortality and hospital length of stay (LOS). The present study was intended to determine whether an optimal time window exists between resuscitation and wound sepsis for the first E&G in a patient with a large burn.

Material and Method: The authors conducted a retrospective study of patients admitted between January 1994 and December 2000 with $\geq 40\%$ TBSA burns and at least 1 E&G procedure. Patients were grouped according to the day of their first operation. Patients allowed to heal indeterminate burns prior to excision and grafting of deep partial or full thickness burns were grouped as $\geq d7$ and were excluded from the present study. The authors correlated the time of first excision with infection, mortality and LOS.

Results: Seventy-five patients were identified and 12 patients allowed to heal indeterminate burn prior to excision and grafting of deep partial or full thickness burns were excluded. Sixty-three remaining patients included 51 males and 12 females. Mean burn size was 49% of total body surface area (TBSA) (44% deep partial or full thickness) and the mean age was 36 years. There were 61 flame (2 combined with electrical injuries), 1 scald and 1 chemical burn. Twelve died (19%) and 52 patients developed 121 infections. Whereas there was no statistical difference in mortality for patients operated on different days ($p > 0.2$), 60% of patients operated within the first 48 hours after injury died; this was not significant due to a small patient number.

Conclusions: The present data suggest that patients who undergo early excision and grafting within seven days following a major burn $\geq 40\%$ TBSA have equivalent infection or mortality rates regardless of when the first operation occurs between post burn day (PBD) 2 and PBD 7 ($p > 0.2$).

Keywords: Burn, Early excision, Grafting, Optimal time

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Methods of treating burn wounds have changed in recent decades⁽¹⁾. Early burn wound excision and grafting is now the standard treatment for deep partial or full thickness burn wounds^(1,2). Early removal of burn eschar reduces bacteremia and inflammatory mediator release⁽²⁾. Many studies have shown

that early excision and grafting drastically reduces morbidity⁽³⁾, mortality^(4,5), and length of hospital stay (LOS)^(3,6,7) for burn patients. But, the optimal timing for the initial burn wound excision is not clear. Since the authors define early excision to be within the first 7 days following injury, the authors wanted to determine whether surgery performed earlier during the first week after injury improved outcome for patients with major burns $\geq 40\%$ TBSA.

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Material and Method

The present retrospective study was conducted between January 1994 and December 2000 in burn patients with $\geq 40\%$ total body surface area (TBSA) admitted to the University of Washington Burn Center. The present review was performed in accordance with and approved by the University of Washington Institutional Review Board. The authors' inclusion criteria identified patients with deep partial or full thickness burns who received at least one burn wound excision and grafting procedure during their hospital stay. Patients were grouped according to the day of their first operation.

Seventy-five patients were identified and 12 were excluded because shallow burns were allowed to heal prior to excision and grafting of deep partial or full thickness burns. Sixty-three patients (51m, 12f) were identified who underwent surgery within the first seven days after thermal injury. These patients were assigned to 6 groups according to the day of first excision: post burn day (PBD) 2, 3, 4, 5, 6 or 7. Groups were compared with regard to patient demographics including age, presence of inhalation injury, TBSA burn (%), deep burn (% deep partial or full thickness), size of first excision (cm^2), LOS (days), days on a ventilator and days in the intensive care unit (ICU).

The authors' protocol was to excise and cover the burn wound once resuscitation is complete, the patient is hemodynamically stable and operative room time is available. Chart review in the present study confirmed that day of surgery for most of these patients was not selected based on clinical criteria but rather on operating room and staff availability; three patients operated on PBD 2 were felt to need removal of thoracic eschar to improve thoracic expansion for ventilation. Usually, no more than 20% TBSA was excised with each procedure. Tangential or fascial burn wound excision was used for deep partial thickness and full-thickness burns according to burn depth and patient condition. Wounds were covered with autograft or in situations of limited donor sites with the dermal replacement template INTEGRA (Johnson & Johnson Medical, Inc., NJ). Patients returned to the operating room sequentially until the entire burn wound was excised and covered.

The present criteria for infection diagnosis included cellulitis, catheter related infections, pneumonitis, UTI, wound purulence, positive burn wound cultures, bacteremia, sepsis as diagnosed by at least 2 burn team physicians and treated with antibiotics anytime during the hospital stay. Pneumonia diagno-

sis was based on clinical signs and symptoms, productive sputum with positive sputum cultures and gram stains, elevated white blood cell counts and radiographic findings. Urinary tract infection was diagnosed when urine cultures grew more than 100,000 organisms and urinalysis revealed white cells. Diagnosis of intravenous catheter infections were made with signs of erythema around the insertion site or positive catheter tip cultures.

Statistical analysis

The binary outcomes of interest were mortality and infection (wound, bacteremia, pneumonia, urinary tract (UTI), intravenous (IV) catheter, and bacterial endocarditis). The categorical variable of interest was the number of days from thermal injury to first burn wound excision. Other demographic predictors included age, gender, presence of inhalation injury, % TBSA, % deep partial or full thickness burn, size of first excision, mechanical ventilation time (days), intensive care time (days), and LOS. Descriptives of the data were analyzed first. Non parametrics used the two-sample Mann-Whitney U test to evaluate for potential differences in continuous demographic variables between groups of patients with or without mortality and with or without infection. To compare the categorical demographic predictors, presence of inhalation injury and gender for patients with or without mortality and with or without infection, using Chi-Square test or Fisher's exact test. One-way analysis of variance (ANOVA) to test for potential differences in the continuous demographic variables between groups of patients with the first wound excision on different days was applied. Simple logistic regression analyses were performed to test for potential differences in the occurrence of mortality or infection compared to the first PBD wound excision. Indicator variables were used to model PBD as a categorical variable. A Bonferroni's correction was used for the six categories of first PBD wound excision. Results are expressed as mean \pm SD. All tests were two-tailed and a p value of less than 0.05 was considered to indicate statistical significance. Statistical analyses were performed with the use of Stata, v 6.0 software (StataCorp, College Station, TX 1999).

Results

Descriptives

63 patients (51 male, 12 female) who underwent surgery during the first seven post injury days were analyzed. Descriptive statistics of the data set are presented in Table 1 and 2. There were 61 flame (2 com-

bined with electrical), 1 scald and 1 chemical burn. The average length of hospital stay was 60.9 days; patients operated on PBD 7 had the longest hospital stay (71 days) (Table 3). Most patients (86%) underwent the first burn wound excision between PBD 3 - 6 (Fig. 1). Five patients (7.9%) were operated on within 2 days of

thermal injury. Three of these patients had full thickness circumferential chest burn with decreased ventilation; two patients underwent excision on PBD 2 because of operating room availability. No patients underwent burn excision within the first 24 hours of thermal injury.

Table 1. Demographics of the patients and the results of univariate analyses of factors associated with infection. Descriptive data of the patients demonstrate typical demographics for patients with large burns. There were no differences of characteristic data between patients with and without infection ($p > 0.05$)

	All Patients (N = 63)	Patients without infection (N = 11)	Patients with infection (N = 52)
Mortality	19.0%	18.2%	19.2%
Age (yr)	34.9±18.2	29.0±16.3	36.2±18.5
Gender	51 males, 12 females	7 males, 4 females	44 males, 8 females
Inhalation injury	12.7%	9.0%	13.4%
TBSA (%)*	49.2±9.8	46.9±9.2	49.6±9.9
Deep partial or full thickness burn (%)*	45.0±12.0	44.8±9.6	45.1±12.5
Size of first excision (cm ²)*	4288±1926	4566±2182	4228±1887
Mechanical Ventilation time (days)*	16.5±15.6	20.0±23.7	15.8±13.6
Intensive care unit LOS (days)*	35.7±17.4	35.3±21.4	35.7±16.7
LOS (days)*	60.9±29	67.7±39.9	59.4±26.5

* values represent means ± SD
 Percentage of patients
 Number of patients
 Fisher's two-tailed exact test
 Ω Two-sample Mann-Whitney U-test

Table 2. Demographics of the patients and the results of univariate analyses of factors associated with mortality. Descriptive data of the patients demonstrate typical demographics for patients with large burns*

	All Patients (N = 63)	Patients who survived (N = 51)	Patients who died (N = 12)	p-value
Infection occurred	82.5%	82.3%	83.3%	1.0
Age (yr)	34.9±18.2	33.0±17.9	43.2±18.0	0.12Ω
Gender	51 male, 12 female	41 male, 10 female	10 male, 2 female	1.0
Inhalation injury	12.7%	9.8%	25.0%	0.66
TBSA (%)*	49.2±9.8	47.8±9.5	54.9±9.2	0.01Ω
Deep partial or full thickness burn (%)*	45.0±12.0	43.3±12.2	52.6±7.5	0.003Ω
Size of first excision (cm ²)*	4288±1926	4274±1956	4351±1882	0.83Ω
Mechanical Ventilation time (days)*	16.5±15.6	14.1±12.7	26.4±22.4	0.05Ω
Intensive care ICU LOS (days)*	35.7±17.4	37.8±15.6	26.8±22.2	0.02Ω
LOS (days)*	60.9±29.0	67.1±26.3	34.3±25.4	<0.001Ω

* values represent means ± SD
 Percentage of patients
 Number of patients
 Fisher's two-tailed exact test
 Ω Two-sample Mann-Whitney U-test

Table 3. Demographics of the patients and the results of analyses comparing day of first burn wound excision to outcome and descriptive variables. No significant differences were found when comparing outcome and descriptive variables to the day of excision. The incidence of infection was higher than 60% in all patients regardless of day of first excision*

Patient Data	PBD2 n = 5	PBD3 n = 9	PBD4 n = 18	PBD5 n = 14	PBD6 n = 13	PBD7 n = 4	p-value
Infection (%)	60	67	83	79	100	100	0.65
Mortality (%)	60	11	11	21	23	0	0.25
Age (year)*	27±18	44±23	27±13	33±16	39±19	44±12	0.13
TBSA (%)*	56±7	48±9	50±10	47±8	45±8	49±26	0.38
Deep partial or full thickness burn (%)*	52±6	43±10	48±10	45±6	37±13	38±26	0.23
Size of 1st excision (cm ²)*	4473±1397	4377±2462	4128±1997	4219±1951	4297±1867	4674±2343	0.99
Ventilator (days)*	24±33	9.2±12	12.4±13.7	18.2±12.5	18.7±14.1	22.5±12	0.49
ICU stay (days)*	43.6±29.6	34.3±12.7	32±17.9	37.4±14.8	36.4±16.8	34±19.8	0.86
LOS (days)*	58±7	59±9	54±10	63±8	65±8	71±18	0.87

* values represent means ± SD
 Percentage of patients
 Simple logistic regression
 One way analysis of variance

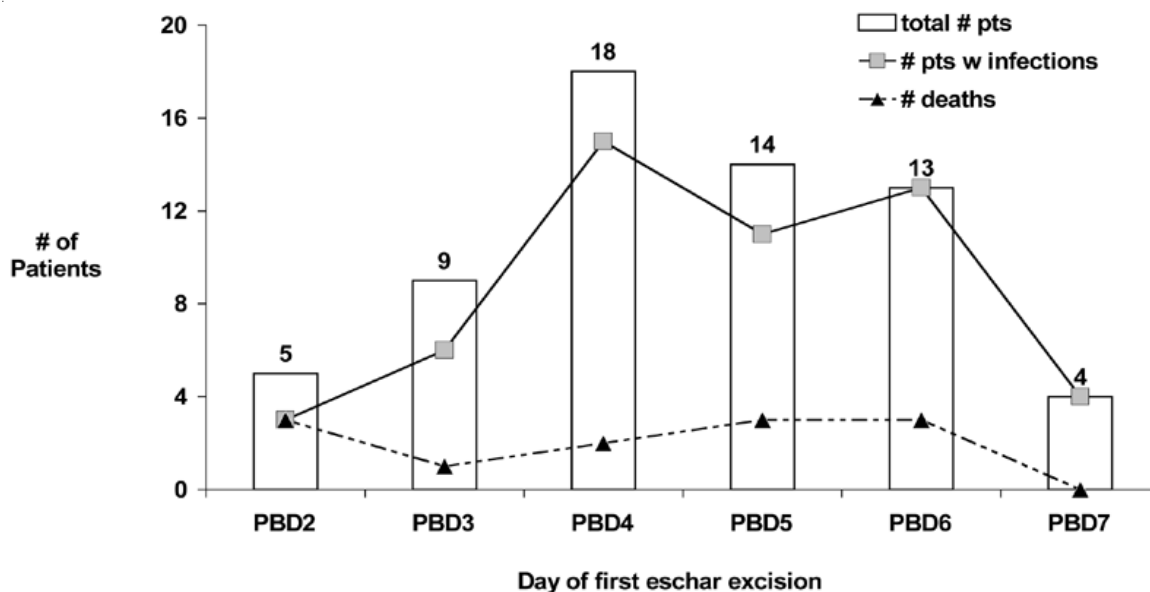


Fig. 1 Most of the presented patients (86%) were operated on 3-6 post burn injury, The number of patients with infection was high for all surgery time points within the first week. The % of infection ranged from 60-100% of all patients. But there was no statistical difference between infection rates at any surgical time-point within the first 7 days ($p > 0.2$)

Demographics

Demographic data including infection (%), mortality (%), age (year), TBSA (%), deep partial or full thickness burn (%), size of first time excision (cm²), ventilator (days), ICU stay (days) and LOS (days) in

each group were compared based on day to first burn wound excision between PBD 2-7 (Table 3). There were no differences in extent of area excised (cm²), operative time, intra-operative blood loss for patients undergoing excision at various times during the first post-burn

week ($p > 0.05$). No peri-operative complications were identified during the first post-burn week.

Infection

Fifty-two patients (82.5%) developed 121 infections including 32 wound infections, 31 bacteremic episodes, 26 pneumonias, 20 UTIs, 11 IV catheter infections and 1 bacterial endocarditis. Wound infections included cellulitis, purulent drainage, positive cultures (qualitative or quantitative), and 'melting graft.(8)' Forty percent of the patients operated on PBD 2 developed compared to 34% on PBD 3, 18% on PBD 4, 40% on PBD 5 (Table 3); all patients that underwent their first excision on PBD 6 or 7 developed an infection during their hospital stay.

Continuous demographic predictors were compared between groups of patients with or without infection (Table 1). The authors found no significant differences in age, TBSA(%), deep partial or full thickness burn (%), size of first excision, days on ventilator, days in ICU or LOS between those patients that had or did not have infection.

Mortality

Twelve patients (19.0%) died (4 ARDS, 1 bacteria endocarditis, 3 pneumonia, 4 bacteremia - including 3 (25%) with severe inhalation injury). Continuous demographic predictors were compared between groups of patients with or without mortality (Table 2). When the continuous demographic predictors between the groups were compared the authors found significant differences. Those patients who died had a larger mean burn size (54.9%) than patients who survived (47.8%; $p < 0.05$); the full thickness burn size was 9.3% larger in those who died compared to patients who survived ($p = 0.003$). The number of days from time of burn to first excision was not associated with mortality ($p = 0.25$). The authors found no differences in size of first excision or presence of inhalation injury between the groups of patients who survived or died. However, 3 of 5 patients (60%) operated within the first 48 hours following injury died (Figure 1.) All patients that underwent the first excision on PBD 7 survived.

Discussion

The gold-standard treatment for deep partial or full thickness burn wounds in the past two decades has been early excision and grafting⁽¹⁾. Early elimination of the burn wound eschar decreases bacteremia, endotoxin production, septic episodes, release of inflammatory mediators with improved patient progn-

sis^(1,2). Previous studies suggest that early excision decreases morbidity^(2,3), blood loss⁽⁹⁾, mortality^(10,11), and length of hospital stay^(3,7,12,13) compared to non-operative therapy^(2,3,7).

Burke et al showed that early excision improved survival in massively burned children with burns $> 80\%$ TBSA^(4,7). Engrav et al showed that tangential burn wound excision of deep second-degree burns (20% TBSA) resulted in shorter hospitalization and less hypertrophic scar formation⁽³⁾ compared to non-operative treatment of burn wounds. Herndon et al reported decreased mortality in young adults with massive third-degree burns without inhalation treated by early total burn wound excision⁽⁵⁾.

Early excision was originally defined to mean operative excision and grafting earlier than would be achieved by natural separation of burn wound eschar by proteolytic enzymes released from proliferating pathogens within the wound, which might take several weeks. The term was gradually redefined to indicate excision earlier than 2 weeks after injury and eventually included surgery within 1 day of admission⁽¹⁴⁻¹⁶⁾. Studies have suggested that total burn wound excision within the first 3 days after injury has decreased hospital LOS^(5,16), blood loss⁽⁹⁾ and mortality^(5,10,16) compared to excision later than 72 hours after burn injury. Total burn wound excision and grafting within first 24 hours post-injury has been reported to be a safe and effective technique in severe burn injuries^(9,15,17). Whereas studies have suggested that total burn wound excision in the first 24 h post-injury in massive pediatric burns may successfully prevent septicemia⁽¹⁷⁾, decrease length of hospital stay⁽¹⁶⁾ and blood loss^(9,16), and incidence of multi-organ dysfunction⁽¹⁸⁾ compared to excision after 24 hours, these studies do not demonstrate improved survival compared to later excision⁽¹⁹⁾.

The authors found no significant differences in mortality or infection for patients who underwent initial burn wound excision within the first 7 days following injury. Our clinical experience has suggested that burn depth estimations for indeterminate burns can be misleading within 24 hours following injury. Hence, the authors typically excise burn wound on post burn day 3-5 after the resuscitation phase is complete. The present analysis suggests that burn wound excision in the first 48 hours following injury had a higher mortality (60%) but there is no significant difference between groups; there was no difference in age, preexisting co-morbid conditions, the extent and/or depth of burn or incidence of inhalation injury in

patients operated on within 48 hours compared to patients who underwent burn wound excision after 48 hours. In contrast, the authors found that all patients who underwent their first excision on PBD 7 survived. Unfortunately, all patients who underwent the first burn excision on PBD 6 or 7 developed an infection. Seventeen percent of the infections were intravenous catheter infections which correlates with published catheter infection rates ranging from 8-57%⁽²⁰⁻²²⁾.

The lack of significant differences in infection and mortality between days of first excision may be a type II error due to limited power from a small sample. The authors had only 63 patients in the present study and calculated that 554 patients would be needed in the mortality group to detect at least a 2 day difference in time to first burn wound excision between those who live and those who die; 54 patients would be needed to detect a 2 day difference in time to first burn wound excision between those who developed or did not develop an infection, given a two-tailed alpha level of 5 percent and a statistical power of 80 percent. Data from a multi-center review may answer this question.

Time until first excision in the present study did not significantly affect other outcomes measures such as ICU length of stay or total hospital length of stay. Factors that impact infection and mortality of massively burned patients may not depend just on time to early excision. Other improvements in the total burn care including highly skilled critical care nursing, nutrition, and respiratory care have also contributed to improved survival of these patients⁽¹⁰⁾.

An important caveat in the present data analysis is the strict limitation to excision within 7 days from the time of injury. The presented data in no way support traditional non-operative management of deep partial or full thickness burn wounds. The overall high infection rate regardless of day of first excision reinforces the potential morbidity related to infection in burn patients and the need to remove the eschar expeditiously.

Conclusion

In patients with a major burn $\geq 40\%$ TBSA, the authors found no statistically significant association between infection or mortality rates and the timing of the first excision within seven days following injury. Since infection rate increased as time to initial excision and grafting approached 6-7 days following injury, the present data support eschar excision as soon as resuscitation is complete and the burn depth has been definitively declared.

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เวลาที่เหมาะสมของการตัดผิวหนังตายจากไฟไหม้แต่เนิ่น ๆ ตามด้วยการปลูกถ่ายผิวหนังเป็นบนบาดแผลผู้ป่วยไฟไหม้รุนแรง

พรพรหม เมืองแมน, สตีเฟ่น ซัลลิแวน, ซาลี ฮอนารี, ลอเรนซ์ เอนกราฟ, เดวิด ไฮม์บัค, นิโคล จิบราน

บทนำ: การตัดเนื้อตายในผู้ป่วยบาดแผลไฟไหม้รุนแรงแต่เนิ่น ๆ ตามด้วยการปลูกถ่ายผิวหนังบนบาดแผลไฟไหม้นั้นพบว่าเพิ่มประสิทธิภาพการดูแลรักษาผู้ป่วยไฟไหม้ในประเทศสหรัฐอเมริกาเป็นอย่างมากโดยสามารถลดภาวะทุพพลภาพ การตาย และเวลาการพักรักษาตัวในโรงพยาบาล การศึกษานี้มีจุดประสงค์เพื่อค้นหาว่ามีวันเวลาที่เหมาะสมที่สุดในการเอาเนื้อตายออกเป็นครั้งแรกหลังได้รับบาดแผลไฟไหม้ตามด้วยการปลูกถ่ายผิวหนังเป็นบนบาดแผลไฟไหม้รุนแรงหรือไม่ โดยช่วงเวลาที่ทำการตัดเนื้อตายนี้ควรเป็นหลังจากผู้ป่วยได้รับการปฏิบัติกรช่วยเหลือฟื้นคืนชีพ และก่อนเกิดการติดเชื้อในกระแสเลือด

วัสดุและวิธีการ: ทำการเก็บข้อมูลย้อนหลังในผู้ป่วยที่เข้ารับการรักษารักษาในโรงพยาบาลระหว่างเดือนมกราคม พ.ศ. 2537 ถึง ธันวาคม ปี พ.ศ. 2543 โดยผู้ป่วยแต่ละรายได้รับบาดแผลไฟไหม้ \geq ร้อยละ 40 ของพื้นที่ผิวร่างกาย และได้รับการผ่าตัดตัดเนื้อตายออกตามด้วยการปลูกถ่ายผิวหนังเป็นบนบาดแผลไฟไหม้มาแล้วอย่างน้อย 1 ครั้ง ผู้ป่วยถูกแบ่งกลุ่มเพื่อการศึกษาตามวันที่ได้รับการผ่าตัดครั้งแรก ผู้ป่วยที่อนุญาตให้แผลไฟไหม้หายเองเพราะได้รับการวินิจฉัยครั้งแรกว่าบาดแผลไฟไหม้ไม่ลึกมากและในเวลาต่อมาต้องได้รับการผ่าตัดเพราะจริง ๆ แล้วบาดแผลไฟไหม้นั้นค่อนข้างลึกเกินกว่าที่จะหายเองได้ ในกลุ่มนี้ถูกจัดอยู่ในกลุ่มที่ได้รับการผ่าตัดหลังจากได้รับบาดแผลไฟไหม้มาแล้วนานกว่า 1 สัปดาห์ ซึ่งในที่สุดผู้ป่วยกลุ่มนี้ถูกคัดออกจากการศึกษานี้ ทีมงานวิจัยได้ทำการค้นหาความสัมพันธ์ระหว่างระยะเวลาการทำหัตถการตัดเนื้อตายตามด้วยการปลูกถ่ายผิวหนังเป็นบนบาดแผลไฟไหม้ครั้งแรกที่มีความสัมพันธ์กับการติดเชื้อ, การตาย, และระยะเวลาในการเข้ารับการรักษารักษาตัวในโรงพยาบาลหรือไม่

ผลการศึกษา: ในจำนวนผู้ป่วย 75 ราย พบว่า 12 รายนั้นครั้งแรกที่ผู้รักษาอนุญาตให้แผลไฟไหม้ที่มีดีกรีไม่ลึกมากหายเอง ก่อนที่จะตัดสินใจทำการผ่าตัดเอาเนื้อตายออกตามด้วยการปลูกถ่ายผิวหนังเป็นบนบาดแผลไฟไหม้ในภายหลังเพราะจริง ๆ แล้วบาดแผลนั้นค่อนข้างลึกและบาดแผลไม่สามารถหายเองได้ ผู้ป่วยกลุ่มนี้ถูกคัดออกจากการศึกษานี้ 63 รายที่ยังเหลือในการศึกษานี้พบว่า 51 รายเป็นชาย, 12 ราย เป็นหญิง, ค่าเฉลี่ยแผลไฟไหม้ร้อยละ 49 ของพื้นที่ผิวร่างกาย โดยพบว่าร้อยละ 44 เป็นบาดแผลไฟไหม้ที่มีความลึกมากหรือเป็นบาดแผลไฟไหม้ ที่ทำลายทุกชั้นของผิวหนัง ผู้ป่วยโดยเฉลี่ยอายุ 36 ปี พบว่าผู้ป่วย 61 ราย นั้นเป็นบาดแผลไฟไหม้สาเหตุจากเปลวเพลิง (2 รายได้รับบาดแผลใหม่จากกระแสไฟฟ้าช็อตรวมด้วย), 1 รายเป็นบาดแผลจากน้ำร้อนลวก, 1 รายเป็นบาดแผลใหม่จากสารเคมี 12 รายเสียชีวิต(ร้อยละ19%) และ 52 รายมีบาดแผลติดเชื้อ ไม่พบค่าความแตกต่างอย่างมีนัยสำคัญทางสถิติในการตายกับวันเวลาที่ผู้ป่วยได้รับการผ่าตัด ไม่ว่าจะผู้ป่วยได้รับการผ่าตัดเริ่มต้นในวันใดตั้งแต่วันที่ 2 ถึงวันที่ 7 หลังได้รับบาดเจ็บไฟไหม้ ($p > 0.2$); ร้อยละ 60 ของผู้ป่วยที่ผ่าตัดภายใน 48 ชั่วโมงหลังได้รับบาดเจ็บ ไฟไหม้เสียชีวิต

สรุป: จากข้อมูลในการศึกษานี้พบว่า ไม่มีความแตกต่างในเรื่องการติดเชื้อ หรือ อัตราตายในผู้ป่วยที่ได้รับการผ่าตัดเอาผิวหนังตายจากไฟไหม้ตามด้วยการปลูกถ่ายผิวหนังเป็นบนบาดแผลไฟไหม้ ภายใน 7 วันหลังได้รับบาดเจ็บไฟไหม้ \geq ร้อยละ 40 ของพื้นที่ผิวร่างกาย โดยพบว่าไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ไม่ว่าจะเริ่มต้นทำการผ่าตัดครั้งแรก ในวันใดก็ตามตั้งแต่วันที่ 2 ถึง 7 หลังไฟไหม้ ($p > 0.2$)
