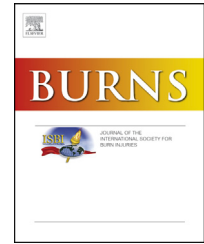




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Estimation of blood loss during adult burn surgery

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ABSTRACT

Introduction: Large burns excision and graft can produce major blood loss. The main objective of this study is to evaluate the blood loss in relation with the excision size in square centimeters (cm²) in adults.

Patients and methods: We conducted a monocentric, observational, prospective and open study in a burn intensive care unit. Patients aged-over 18 with burn wounds excision and autografting covering at least 5% of total body surface area (TBS) were enrolled. Blood loss was evaluated with Mercuriali formula.

Results: 139 procedures were evaluated: median graft size was 1637 cm², median blood loss was 0.8ml/cm² excised and grafted skin and median total blood loss was 1444ml. 84 procedures (i.e. 60.4%) required transfusion. 66 procedures concerned upper limbs, 75 lower limbs, 17 head and 72 trunk. 126 procedures used tangential excision, 10 used fascia excision and 3 used the two techniques. Patients with comorbidities (ASA score 3 or 4) had more bleeding (p=0.001).

Conclusion: The results that were obtained, i.e. approximately 0.8ml/cm² of excised and grafted skin, are similar to those of other published studies, which concerned specific populations such as pediatrics. Determining blood loss in one centre can help physicians to calculate the excisable area without any transfusion. However, blood loss can vary widely between patients and one must consider individual clinical situation to provide safe surgery.

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1. Introduction

Burn surgery is highly hemorrhagic [1]. In order to improve blood sparing strategies in burn surgery [2], we evaluated blood loss in the burn intensive care unit of Saint Joseph Saint Luc hospital (Lyon-France).

Blood loss during skin grafting procedures is difficult to assess and is frequently underestimated by observers [3]. This problem is not unique to burn surgery [4,5]. Most authors rely on the measurement of hemoglobin and hematocrit rates pre and post surgery to calculate blood

loss, using to the formula developed by Mercuriali for orthopedic surgery [6].

It is very difficult to find accurate and usable data to evaluate the perioperative blood loss for burned patients. Most available studies are old, related to specific populations, such as the pediatric population [7-9], and are difficult to apply in clinical practice. Moreover, surgical techniques, such as tourniquet, tangential excision, can modify blood loss.

A meta-analysis of 10 studies designed to assess the effect of local vasoconstrictors on blood loss in skin grafting procedures was unable to compare blood loss, due to a lack

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of data. It compared rates of transfusion, which are an indirect and imprecise estimation of blood loss [10].

Yet, many authors are interested in the transfusion needs of these patients as it is usually very high [2,11-13]. We find that there is an increasing number of researches done on blood saving strategies for burned patients [2,10,12,14-19].

The main objective of this study is to evaluate blood loss that results from the excised and grafted surface area in square centimetres (cm²) in our burn unit.

2. Material and methods

We conducted a monocentric, observational, prospective and open study in a burn intensive care unit. This study is done on patients aged over 18 with burn wounds excision and autografting covering at least 5% of the TBS (total body surface area). Exclusion criteria are patients aged under 18 and less than 5% TBS skin excision and autografting.

Informed consent was collected from patients once they were interviewed and received a written informative document. This study has received a favourable opinion from ethics committee.

The initial burned area is estimated using a specialized free software [20]. Excised and grafted surface area is assessed by surgeons as a percentage of TBS and in cm², by direct measurement of wound size or compare to a paper sheet with known area (A3 paper sheet 1250cm², A4 paper sheet 625cm², A5 paper sheet 313cm²). For less than 313cm², it was a direct measurement.

Epinephrine-soaked gauzes are used for hemostasis (epinephrine concentration of 100mg/ml). Pressure is applied to all sites for a minimum of 10-15min. Electrocautery is used to coagulate individual punctate hemorrhage and pressure reapplied as necessary. Hemostasis is achieved before grafting. For extensive or deep burns, excision is essentially performed tangentially by excising the skin down to the fascia. No tourniquets are used in the burn unit.

Anaesthesia could be general or locoregional. Temperature of the operative room is kept at an average of 24°C, and hypothermia is prevented by forced-air warming (Bair Hugger®). Low molecular weight heparins used for venous thromboembolism prophylaxis are stopped the day before surgery. Transfusion is decided by the anaesthetist during the surgery. Hemoglobin threshold use for transfusion in our unit is approximately 70-80g/l for patient with no comorbidities and approximately 90-100g/l in case of vascular disease or hemodynamic instability. To help the anaesthetist to decide transfusion, capillary hemoglobin measurement (HemoCue®) is used, as per-operative estimation of bleeding.

Blood loss is evaluated with the Mercuriali formula [6], using pre-operative and post-operative rates of hemoglobin and hematocrit (Hte), and transfused blood volume. The calculation that resulted from this study is as follows:

$$\text{Blood loss} = [\text{EBV} * (\text{pre-op Hte} - \text{post-op Hte})] / \text{pre-op Hte}$$

EBV: estimated blood volume, approximately 70ml/kg in men and 65ml/kg in women [21]. Transfused volume = (number of PRBC*57)/post-op Hb

PRBC: packed red blood cells. Total blood loss = blood loss + transfused volume

We use 57 as the average amount of hemoglobin per PRBC in grams, according to the data provided by the EFS Rhône-Alpes (regional blood bank) for 2014-2016.

Total blood loss, expressed in millilitres (ml) of whole blood, is compared to the excised and grafted surface area in cm² to establish an average loss per cm². We also take into account surgery time and laps of time in days between initial injury and surgery.

Baseline characteristics of patients, pre and post-operative rates of hemoglobin and results of other studies are described using medians with interquartile ranges (IQR) and security end-points with frequencies and associated percentages.

3. Results

From January 2014 to September 2016, 139 skin grafting procedures were included in the study that involved 112 patients, 65 male patients and 47 female patients (some of whom were enrolled several times for different skin grafting procedures). The median age was 58 (41-74) (Table 1). The average time between burn and surgery was 12 days (9-15). The initial median burn area was 15% TBS, and the median excised and grafted surface area was 9.5% TBS, corresponding to 1637cm² of excised and grafted skin.

The median total blood loss was 1444ml, corresponding to 0.8ml for 1cm² of excised and grafted skin (Fig. 1). 84 procedures required red blood cell transfusion (60.4%) and the median number of transfused PRBC transfused was 2 units (Table 2). 66 procedures concerned upper limbs, 75 lower limbs, 17 head and 72 trunk. 126 procedures used tangential excision, 10 used fascia excision and 3 used the two techniques.

We found a positive correlation between the length of procedure (time between anaesthesia induction and recovery) and blood loss in ml/cm², with a cut off at 240min (0.70 versus 1.01ml/cm² if the procedure was over 240min, p=0.0002, Table 3). Fig. 2 shows the relation between procedure duration and blood loss in ml/cm². We found a positive correlation between initial area burn and blood loss in ml/cm² (p=0.0318, Fig. 3), and between ASA score and blood loss in ml/cm² (p=0.0001, Table 4).

There was no correlation between blood loss and the delay between burn and surgery in our study (Table 5). There is a correlation between size of the operation and procedure length

Table 1 – Demographics and baseline characteristics of patients.

Number of patients	n=112
Number of procedures	n=139
Male, no. (%)	65 (58%)
Age, median years (Q1-Q3)	58 (41-74)
ASA score, median (Q1-Q3)	2 (2-3)
Weight (kg), median (Q1-Q3)	70 (57-80)
Height (cm), median (Q1-Q3)	170 (162-175)
Estimated blood volume (ml), median (Q1-Q3)	4875 (3900-5600)
Initial area burn (%), median (Q1-Q3)	15 (10-24)

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