

A New Method for Determining the Volume Of Blood Loss During Necrectomy in Patients with Deep Burns

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ABSTRACT

OBJECTIVES: Most surgery manuals indicate that, for excisions of a burn scab on an area of 1 cm² with skin plasty, blood loss, taking into account donor zones, is about 1 mL. This volume of alleged blood loss plays an essential role in planning surgical treatment of patients with burn injuries. To date, when volume of lost blood is calculated with the use of existing methods for determining intraoperative blood loss, it is not recommended to excise necrotic tissues on an area of more than 15% of the body surface. In this study, our aim was to develop a new formula for determining intraoperative blood loss during necrectomy in patients with deep burns.

MATERIALS AND METHODS: We developed and proposed our own, original method for determining the volume of intraoperative blood loss, based on taking into account hemoglobin and hematocrit indicators, as well as differentiated calculation of the volume of circulating blood. This technique was tested on 109 patients with deep burns (per ICD-10), who were admitted to our department from January 2022 to December 2022 because of thermal lesions. We processed obtained data using Microsoft Office Excel and used generally accepted methods of nonparametric statistics.

RESULTS: With the new formula, we determined blood loss of 0.52 mL per 1 cm² of excised tissue, which is 2 times less than predicted by traditional methods.

CONCLUSIONS: Our results showed that the expected intraoperative blood loss may not be 1 mL/1 cm², as currently prescribed in clinical guidelines, but 0.5 mL/1 cm² of the excised tissue. Our results allow for possible expansion of the removal of the burn eschar before the development of infectious complications.

KEY WORDS: *Burn injury, Circulating blood, Excised tissue*

INTRODUCTION

Active surgical tactics, which rely on early excision of dead tissues with simultaneous or delayed skin grafting, are recognized as the most rational in the field of combustiology. Early excision leads to a rapid reduction in the area of burn wounds, decreases the potential for the development of infectious complications, and improves functional and cosmetic results.^{1,2} Early necrectomy, however, is a traumatic operation, accompanied by significant blood loss and can lead to a deterioration in the general condition of patients. In this regard, the primary task facing the surgeon is to reduce intraoperative blood loss. For this purpose, a whole complex of surgical and therapeutic techniques is used, as well as other pathogenetically based methods for correcting anemia.

To date, excision of necrotic tissues in a viable layer is one of the most common methods of necrectomy. However, when volume of lost blood is calculated with the use of existing methods for determining intraoperative blood loss, it is not recommended to excise necrotic tissues on an area of more than 15% of the body surface.³ Vikhriev and colleagues⁴ reported that, when a scab is excised with a scalpel in a single block on an area of 100 cm², blood loss averages about 76 mL or is about 0.76 mL per 1 cm². If surgical intervention is performed on the hands and feet, then blood loss may increase by 2 to 3 times. Aryev reported that blood loss during excision of the scab on an area of 15% of the body area reaches 2 to 2.5 liters.⁵ Less blood loss leads to 0.5 mL of blood per 1 cm² of excised scab.⁶ Chmyrev used a more differentiated approach; during intervention,

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blood loss was 0.67 mL/cm² in the upper extremities, 0.91 mL/cm² in the lower extremities, 0.94 mL/cm² in the head and neck, and 1.24 mL/cm² in the trunk. With early necrectomy for 20% body area and auto-dermoplasty, the volume of lost blood reaches 3 liters.^{7,8}

Housinger and colleagues determined the volume of blood loss after surgery by counting red blood cells in the spilled blood relative to the volume of circulating blood (VCB).⁹ When the scab is excised on an area of 1% with skin grafting, the investigators reported that blood loss can reach 2.8% of the volume of circulating blood.¹⁰ Formulas based on the indicators of circulating blood volume and pre- and postoperative hemoglobin or hematocrit are most often used when calculating intraoperative blood loss. Gross suggested the following method: blood loss = VCB × (preHb – postHb/meHb), where preHb is the hemoglobin concentration 24 hours before surgery, postHb is the hemoglobin concentration 24 to 48 hours after surgery, and meHb is the arithmetic mean of preoperative and postoperative values.¹¹

Budny and colleagues complemented the method proposed by Gross.¹² They took into account the volume of postoperative transfusion (in mL) and used the preoperative hemoglobin concentration value instead of the arithmetic mean as follows: blood loss = VCB × (preHb – postHb/preHb) + Tx, where Tx is the volume of blood transfusion per day.

Using the above formulas, investigators can calculate the volume of circulating blood using various initial data from 55 to 75 mL/kg of body weight. That is, the results obtained will differ significantly depending on arbitrarily selected values, which reduces the accuracy of these methods.⁹

Warden and colleagues published the following formula to determine the volume of blood loss: blood loss = pre-RBCV + Tx-RBCV – post-RBCV/post-Hct × 0.01, where pre-RBCV is the preoperative volume of red blood cells, Tx-RBCV is the volume of red blood cells transfused in the perioperative period (based on the calculation that the hematocrit of the erythrocyte mass is 80%), post-RBCV is the postoperative volume of red blood cells, and post-Hct is the hematocrit value (in %) 24 hours after the end of the operation.

The calculation of the volume of red blood cells in the pre- and postoperative period is performed as follows: RBCV = TBW × k × Hct, where TBW is the weight of the patient (in kg; total body weight), k is a coefficient (0.07 for men and 0.08 for women), and Hct is the preoperative or postoperative (after 24 hours) hematocrit value (in %).¹³

Thus, there are a number of ways to estimate the volume of intraoperative blood loss, based on different initial data

and having different results. To compare the effectiveness of existing methods for reducing blood loss, it is necessary to determine the most effective of these or develop new methods. Our aim was to develop a new formula for determining intraoperative blood loss during necrectomy in patients with deep burns.

MATERIALS AND METHODS

The study was conducted from January 2022 to December 2022 in the Department of Thermal Injuries of the Saint-Petersburg I.I. Dzhanlidze (Russia).

We had previously developed and proposed our own, original method for determining the volume of intraoperative blood loss (Patent of the Russian Federation for the invention “Method for determining intraoperative blood loss in the surgical treatment of victims with deep burns” No. RU 2750843, dated May 18, 2023). The formula is as follows:

The abbreviation V is the volume of intraoperative blood loss (in mL), m is body weight (in kg), k1 is the coefficient corresponding to the Gilcher rule (with 75 mL of blood per kg of weight for athletic men, 70 mL for slender men, 65 mL for asthenic men, 60 mL for obese men, 70 mL/kg of weight for women: with an athletic physique, 65 mL for slender women, 60 mL for with asthenic women, and 55 mL for obese women), preHb is the concentration of hemoglobin in the blood for 6 to 12 hours before surgery (in g/L), and postHb is the concentration of hemoglobin in the blood 24 hours after surgery (in g/L). Finally, TrHb is the hemoglobin of the transfused transfusion medium, calculated by the formula:

The abbreviation Vtr is the volume of transfusion (in L), k2 is the hematocrit of the transfusion medium (the hematocrit is 0.7 in the erythrocyte mass, 0.6 in the erythrocyte suspension, and 0.5 in the thawed washed erythrocytes), preHct is hematocrit of blood for 6 to 12 hours before surgery (in %), and postHct is blood hematocrit 24 hours after surgery (in %).

The department of thermal injuries at Saint-Petersburg I.I. Dzhanlidze has actively used this technique since 2022. Before use, the technique was tested in 82 patients (53 men and 29 women) with stage II and stage III deep burns (ICD-10). The average age of the patients was 54 years. Necrectomy with auto-dermoplasty was performed in all patients from day 1 to day 5 after the burn injury.

The volume of blood loss was determined in all the patients using the formulas from Gross, Budny, and Warden, with also use of the developed methodology. Obtained results were recalculated into relative values (in milliliters of 1% of the body surface of the excised scab). Median values and interquartile ranges of blood loss during necrectomy

on an area of 1% body surface were also determined. Data were analyzed with SPSS version 20.0 and Microsoft Office Excel.

RESULTS

The obtained results of determining the volume of blood loss are shown in Table 1. Blood loss during necrectomy on an area of 1% body surface ranged from 150 to 270 mL. Clinical experience makes us doubt such significant figures. According to the results of the most “subjective” visual method, intraoperative blood loss during such interventions is usually significantly less.

We suggest that the “overestimated” results of computational methods for determining blood loss in combustioly are associated with the peculiarities of the surgical technique. Unlike most other surgical specialties, during necrectomy, up to 3 to 5 liters or more of saline solution can be injected into the soft tissues of burned patients, that is, more than half of the volume of circulating blood. In the postoperative

period, such patients will naturally experience a gradual decrease in hemoglobin and hematocrit due to hemodilution, even in the complete absence of blood loss.

The only method to neutralize the rheological effect of the tumescent technique is the simultaneous use of hemoglobin and hematocrit indicators. This was indirectly confirmed by the indicators of the results (Figure 1). For example, when calculated using the Warden formula, the interquartile interval (that is, the spread of indicators) exceeds the median value. This indicates a significant heterogeneity of the data, with influence from unaccounted external factors. When blood loss was calculated according to our proposed method, we observed a relatively small interquartile range of about 50% of the median value, indicating a greater uniformity of data.

We next evaluated the relationship between the area of surgical intervention and the absolute values of blood loss, which we obtained using the existing calculation methods and our new technique (Figures 2-5).

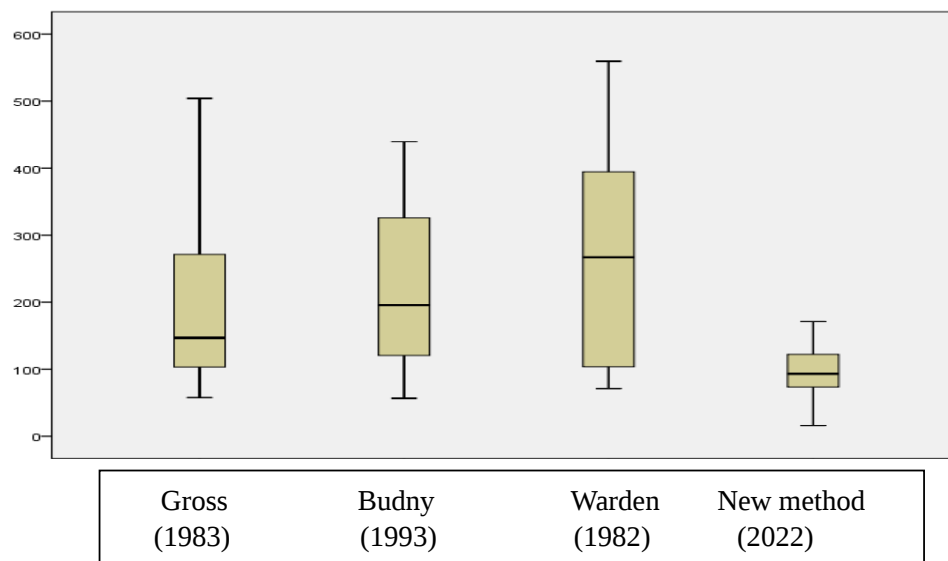
We found that the methods currently available have a large variability when performing the same intervention. The use of the Gross, Budny, Warden formulas did not allow us to conclude a stable direct correlation between the area of necrectomy and the volume of blood loss. To some extent, this result does not correspond to the generally accepted ideas about burn surgery.

Our results also showed a large number of so-called “drop-down” values (Figures 2-5), the number of which can reach up to 20% of observations. For example, when calculating according to the Warden formula (Figure 4), we had cases with blood loss of up to 2 liters with necrectomy on an

TABLE 1. Comparison of the Variance of Relative Volume of Blood Loss (mL/% body surfaces) Obtained Using Various Computational Methods for Determining Blood Loss

Method	Q1	Man (average value)	Q3	Interquartile Range
Gross (1983) ¹¹	103.3	146.8	271.2	167.9
Budny et al (1993) ¹²	120.6	195.6	325.7	205.1
Warden et al (1982) ¹³	103.6	266.9	394.5	290.9
New method, 2022	73.4	93.1	122.2	48.8

FIGURE 1. Comparison of Different Methods for Determining the Relative Volume of Blood Loss (mL/1% body surface area)



area of 2% body surface and blood loss of 200 mL with an excision volume of 8% body surface.

Our technique showed a stable relationship between the volume of blood loss and the area of the excised scab. In

FIGURE 2. Connection Between Excision Area and Blood Loss Volume According to Gross Formula

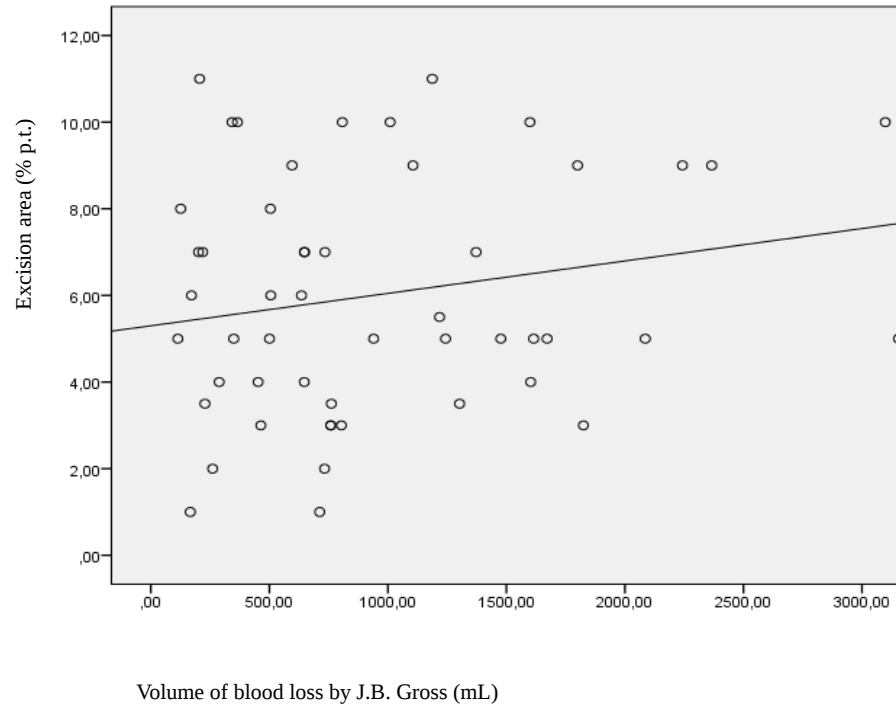
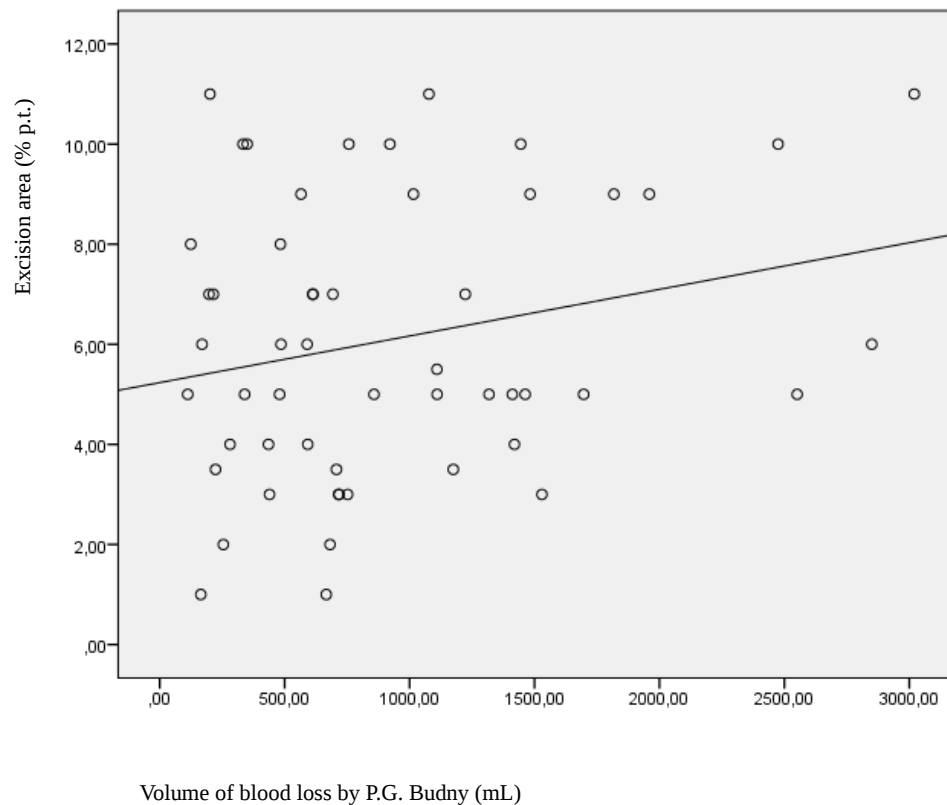


FIGURE 3. Connection Between Excision Area and Blood Loss Volume According to Budny Formula



addition, we did not observe many extreme values that would contradict the main trend (Figure 5).

DISCUSSION

Our new method for determining blood loss in patients with severe burn injuries appears to be a simple and effective

FIGURE 4. Connection Between Excision Area and Blood Loss Volume According to Warden Formula

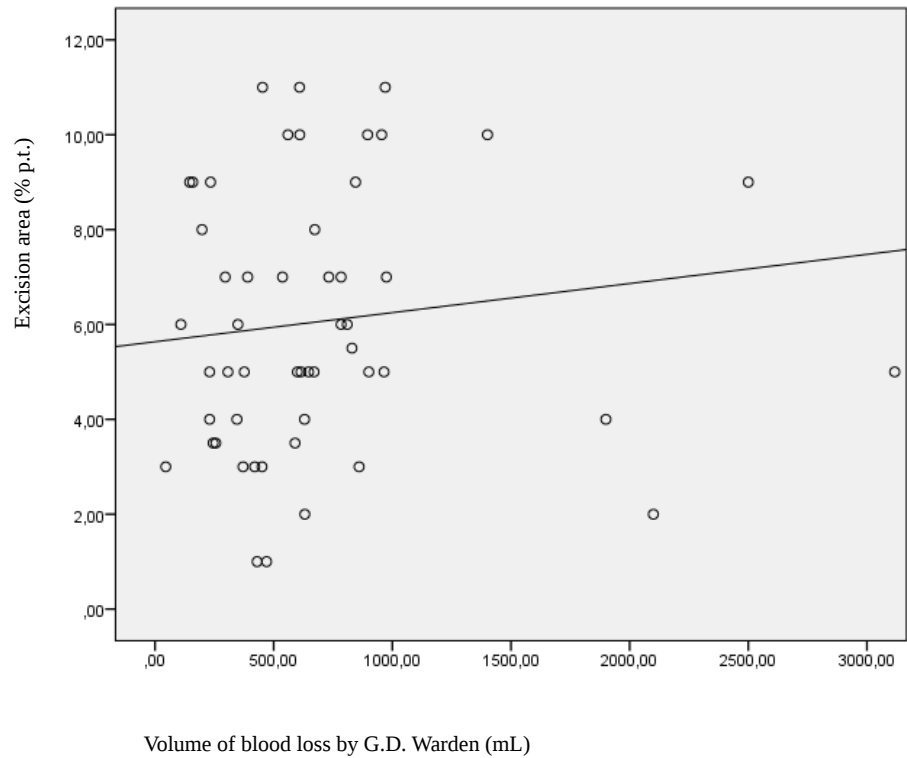
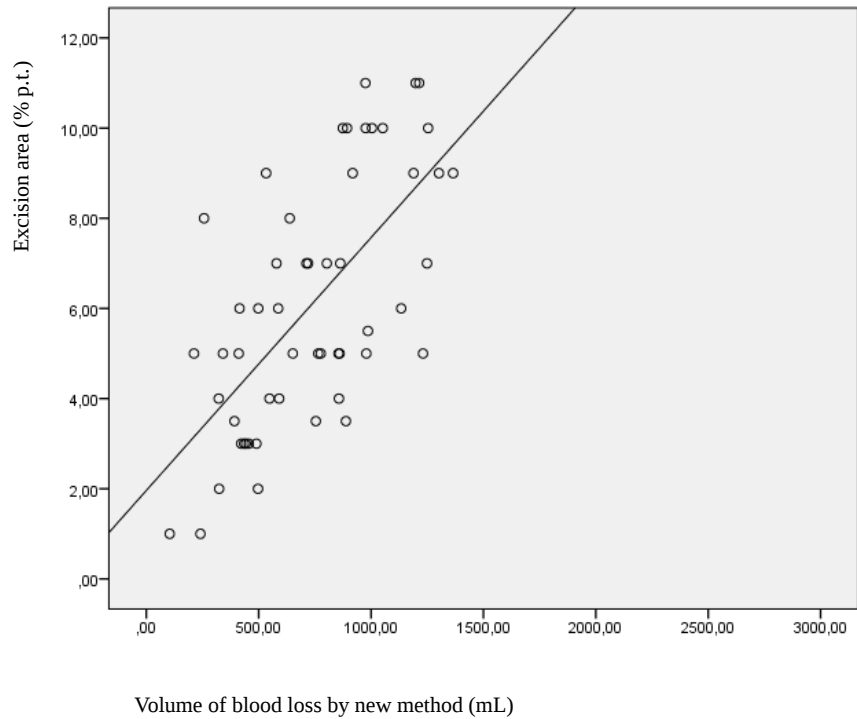


FIGURE 5. Connection Between Excision Area and Volume of Blood Loss According to the Our New Method



method. Its use does not require the use of special equipment. After the development of a computer program for personal computers and mobile devices, the time required for calculations has significantly decreased. Having the results of a general blood test before and after surgery, as well as an installed calculator program to determine the volume of intraoperative blood loss, no more than 1 or 2 minutes is needed to calculate blood loss. This technique allows us to find the most effective methods of minimizing blood loss during surgical necrectomies, which will reduce the need for additional hemotransfusions and promote earlier rehabilitation of patients with burn injuries.

CONCLUSIONS

Our new method for determining blood loss in patients with burn injuries appears to be a simple and effective method. Using the new formula, we determined that 0.52 mL of blood is lost per 1 cm² of excised tissue, which is 2 times less than what is predicted by traditional methods.

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