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Review Article

Assessment of Coagulation Activity and Hemoben Application in Patients with Extensive Burns

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Abstract

Acute burn trauma is accompanied by numerous systemic pathological alterations, among which dysfunctions of the hemostatic system play a crucial role. Burn injuries lead to profound disturbances in coagulation and fibrinolytic mechanisms as a result of vascular endothelial damage, microcirculatory disorders, and excessive production of inflammatory mediators. These changes significantly increase the likelihood of thrombotic events as well as hemorrhagic complications. The severity of hemostatic abnormalities varies with the extent of the burn: minor injuries are associated primarily with laboratory-detected alterations, whereas extensive burns may progress to disseminated intravascular coagulation. Consequently, continuous assessment of hemostatic parameters is a key component in evaluating the clinical status of burn patients. Contemporary research highlights the clinical value of coagulation profiling, platelet function monitoring, and the rational application of anticoagulant or procoagulant therapies. Early identification of hemostatic dysfunctions, implementation of pathogenetically justified treatment strategies, and effective prevention of complications make it possible to markedly reduce mortality associated with burn injuries. This review discusses the principal alterations of the hemostatic system in acute burns, their clinical relevance, and current challenges in diagnosis and management.

Keywords: Hemoben, coagulation hemostasis, cellulose derivatives, blood clotting time, hemostatic implant.

Introduction

Burn injuries and burn disease constitute a significant proportion of all traumatic injuries worldwide. In many cases, dysfunctions of the hemostatic system markedly aggravate the course of burn disease and represent one of the leading causes of mortality. In particular, deep burns involving a large body surface area substantially increase the risk of early development of sepsis and septic toxemia. According to available data, burns account for approximately 10–12% of all types of injuries. At the same time, mortality among patients with severe burns remains high even in specialized medical centers and varies considerably depending on the stage of the disease [1, 2].

The highest mortality rates are observed during the toxemic and septic-toxemic stages, reaching 65–95% according to some reports. The primary direct causes of death in burn disease include sepsis, pneumonia, disseminated intravascular coagulation (DIC syndrome), and the subsequent development of multiple organ failure (MOF) [4, 5, 6].

Despite the substantial clinical experience accumulated in the field of combustiology, a considerable number of patients suffer from long-term disability after treatment. Therefore, burn disease remains not only a major medical concern but also a serious social problem. In modern medical practice, particular importance is attached to the development and implementation of affordable, locally produced, import-substituting agents with minimal side effects that possess hemostatic properties and promote wound healing [7- 9].

Furthermore, mortality in severe burn injuries can be reduced through the introduction of pathogenetically oriented therapies aimed at stabilizing the hemostatic system, regular monitoring of coagulation parameters, and effective prevention of complications. Research in this area enhances the clinical significance of effective therapeutic agents developed from locally available raw materials [10–14].

Materials and Methods

The study was based on the clinical data of 102 patients with deep burn injuries involving 10% to 45% of the total body surface area (TBSA) who were treated in the combustiology department of the Samarkand branch of the Republican Specialized Scientific and Practical Medical Center during the period from 2023 to 2024. To achieve the objectives of the study, all patients were divided into two groups.

The control group consisted of 47 patients (46.1%) with deep burns who underwent early surgical intervention following correction of homeostasis, without the use of composite polymer materials.

The main group included 55 patients (53.9%) with deep burns in whom homeostasis correction was combined with early necrectomy and autodermoplasty performed using the Hemoben composite polymer material during surgery.

Among the 47 patients in the control group, 28 (59.6%) were male and 19 (40.4%) were female (Table 2.1). The age of patients in this group ranged from 18 to 65 years, with a mean age of 38.05 ± 1.5 years. The average total area of skin damage was 25.65 ± 1.45% TBSA, while the mean area of deep burns accounted for 9.85 ± 1.10%.

In the main group, 31 patients (56.4%) were male and 24 (43.6%) were female. Their ages ranged from 18 to 71 years, with a mean age of 44.35 ± 1.5 years. The extent of total thermal skin injury in this group was comparable to that of the control group and indicated severe burn trauma, occupying an average of 30.02 ± 1.35% TBSA. The integral indices of thermal injury severity in this group were also comparable.

To determine the volume of blood loss, a gravimetric method was used. Intraoperative blood loss was calculated based on the difference in weight between dry and blood-soaked surgical materials, including gauze pads, tampons, cotton balls, sheets, and gowns. The obtained value was increased by 50% and added to the volume of blood collected in the suction container. The methodological error of this approach is estimated at 10–12%. According to data reported by various authors, blood loss during early necrectomy ranges from 1 to 3 ml per 1 cm² of excised tissue; approximately 40 ml of blood is lost from a donor site measuring 100 cm², while removal of granulation tissue from an area of the same size results in blood loss of up to 64 ml. Intraoperative blood loss is considered one of the main factors limiting the feasibility of early surgical treatment of deep burns. In all examined patients, hematocrit levels were monitored upon hospital admission and during subsequent days of follow-up.

Characteristics of the “Hemoben” Preparation

Product name: Hemoben — a hemostatic preparation derived from cellulose derivatives.

General description: Hemoben is a biologically resorbable polymer implant possessing pronounced hemostatic properties.

Dosage form: Powder.

Field of application: Medicine, surgery.

Physicochemical characteristics of the finished product: The preparation is a white to grayish powder. It is readily soluble in water and physiological saline solution. The melting temperature is approximately 220 °C. The compound remains stable within a pH range of 5–7. It undergoes rapid hydrolysis in alkaline environments, while maintaining stability under acidic conditions.

Active components

Sodium carboxymethylcellulose (the sodium salt of cellulose glycolic acid, CMC, purified sodium carboxymethylcellulose);

Oxidized cellulose powder (viscose-based);

Calcium chloride.

Empirical and structural formula of sodium carboxymethylcellulose:

$([C_8H_{11} NaO_8])n$

Results

Patient Characteristics and Burn Etiology

A total of 102 patients with burn injuries were examined. The mean age differed significantly between the groups: 38.05 ± 1.5 years in Group 1 and 44.35 ± 1.5 years in Group 2 ($p < 0.05$). The total burn surface area was significantly greater in Group 2 (30.02%), and deep burns were more extensive (15.35%, $p < 0.05$). The Frank index, reflecting burn severity, was also higher in Group 2 (56.28 units), indicating more severe clinical conditions (Table 1).

Burn injuries were most frequently localized on the trunk and extremities (49%), followed by isolated upper limb burns (24.5%), lower limb burns (18.6%), head and extremities (17.6%), and trunk combined with extremities (18.9%). Isolated burns of the face and hands were primarily associated with contact-type thermal injuries.

The main etiological factors included scalds from boiling water (32.3%), clothing ignition (32.3%), open flame (19.6%), and explosions (15.7%). These distributions were similar between the groups, although scald injuries were slightly more frequent in Group 2 (Table 2). Burns of the right upper and lower limbs occurred more often than those on the left side. In 18.6% of patients, burns involved multiple anatomical regions simultaneously, and inhalation injuries were noted in 10.8% of patients, which was associated with a more severe course of burn shock.

Parameter	Total (n=102)	Group 1 (n=47)	Group 2 (n=55)
Age (years)	40.15 ± 1.1	38.05 ± 1.5*	44.35 ± 1.5*
Female	45 (44.1%)	21 (44.7%)	24 (43.6%)
Male	57 (55.9%)	26 (55.3%)	31 (56.3%)
Total burn surface (%)	25.33 ± 1.2	25.65 ± 1.45*	30.02 ± 1.35*
Superficial burn (%)	15.7 ± 1.03	14.00 ± 1.01	17.41 ± 1.8
Deep burn (%)	12.35 ± 1.10	9.85 ± 1.10*	15.35 ± 1.70*
Frank index (units)	46.50 ± 2.1	36.08 ± 1.8*	56.28 ± 3.3*

Note: * indicates statistically significant difference between groups ($p < 0.05$).

Table 1. General characteristics of examined patients (M ± m)

Cause of injury	Total (n=102)	Group 1 (n=47)	Group 2 (n=55)
Scalds (boiling water)	33 (32.3%)	14 (29.8%)	19 (34.5%)
Open flame	20 (19.6%)	9 (19.1%)	11 (20%)
Explosion	16 (15.7%)	7 (14.9%)	9 (16.4%)
Clothing ignition	33 (32.3%)	17 (34.1%)	16 (29.1%)

Table 2. Distribution of patients by cause of injury

Anatomical Distribution of Burns

The anatomical distribution of burn injuries was similar between the groups. The trunk combined with extremities was the most common localization, followed by isolated upper and lower limb burns (Table 3).

Location	Group 1 (n=47)	Group 2 (n=55)	Total (n=102)
Upper limbs	8 (17%)	7 (12.7%)	25 (24.5%)
Lower limbs	10 (21.3%)	9 (16.4%)	19 (18.6%)
Head and extremities	7 (14.9%)	11 (20%)	18 (17.6%)
Trunk and extremities	22 (46.8%)	28 (50.9%)	50 (49%)

Table 3. Anatomical distribution of burns

Comorbidities

Chronic comorbid conditions were observed across all age groups and varied with the severity of burns. The incidence and type of comorbidities were similar between the groups (Table 4). Hypertension was the most frequent comorbidity (11.7%), followed by ischemic heart disease (8.8%) and generalized atherosclerosis with coronary cardiosclerosis (6.9%).

Comorbidity	Group 1 (n=47)	Group 2 (n=55)	Total (n=102)
Generalized atherosclerosis, coronary cardiosclerosis	4 (8.5%)	3 (5.4%)	7 (6.9%)
Hypertension	5 (10.6%)	7 (12.7%)	12 (11.7%)
Ischemic heart disease	4 (8.5%)	5 (9.1%)	9 (8.8%)
Diabetes mellitus	2 (4.2%)	1 (1.8%)	3 (2.9%)
Chronic bronchitis, emphysema, pneumosclerosis	1 (2.1%)	2 (3.6%)	3 (2.9%)
Gastrointestinal disorders	2 (4.2%)	3 (5.5%)	5 (4.9%)
Total	18 (38.3%)	21 (38.1%)	39 (38.2%)

Table 4. Frequency and characteristics of comorbidities

Burn Shock Assessment

Burn shock severity was assessed using the Frank index (Table 5). Mild shock (I degree) corresponded to a Frank index of 30–70 without respiratory involvement and 20–55 with respiratory injury. Moderate shock (II degree) ranged from 71–130 and 56–100, while severe shock (III degree) exceeded 130 and 100, respectively.

Severity	Without respiratory injury	With respiratory injury
I – mild shock	30–70	20–55
II – moderate shock	71–130	56–100
III – severe shock	>130	>100

Table 5. Burn shock severity according to Frank index

Burn area was determined using the “Rule of Nines” and the “palm method.” Burn depth was assessed visually and using diagnostic tests (pain sensitivity, vascular reaction, and the “hair pull” test). According to the USSR surgeons’ 1960 classification, IIIA burns were superficial, while IIIB–IV were deep.

Hemostasis Assessment and Effects of Hemoben

Hemostasis was evaluated using platelet count, soluble fibrin-monomer complex (SFMC), antithrombin III, protein C activity, prothrombin time (PT), partially activated thromboplastin time (PTTa), plasma recalcification, Lee-White clotting time, plasminogen, hematocrit, fibrinogen, and fibrinolytic activity.

The addition of Hemoben significantly shortened PTTa (1.9-fold) and PT (2.8-fold), indicating enhanced coagulation via intrinsic (VIII, IX, XI) and extrinsic (VII) pathways. The effect is likely mediated by calcium ions, present both in plasma and bound within Hemoben. Lee-White clotting time decreased 2.1-fold (2.4 ± 0.6 min).

The composition of fibrinogen in plasma with Hemoben was similar to control, suggesting accelerated coagulation without altering fibrinogen levels. Overall, Hemoben increased whole blood coagulation activity in vitro, confirming its hemostatic properties and supporting its potential use as a surgical hemostatic implant.

Conclusions

The study demonstrates that burn injuries affecting 10–45% of total body surface area are associated with significant hemostatic disturbances, particularly in patients with deep burns and higher Frank index scores. Group 2 patients, with larger burn areas and deeper injuries, exhibited more severe clinical conditions, confirming the correlation between burn extent and shock severity.

The etiology and anatomical distribution of burns were similar between groups, with scalds, clothing ignition, and flame-related injuries being the most common. Multisite burns and inhalation injuries were observed in a subset of patients and were associated with a more severe course of burn shock.

Comorbidities such as hypertension, ischemic heart disease, and atherosclerosis were prevalent but evenly distributed across both groups, suggesting that these conditions did not significantly affect burn localization or etiology in this cohort. Hemostasis assessment revealed that the addition of Hemoben significantly enhances coagulation activity in vitro. Hemoben accelerated clot formation by shortening both partially activated thromboplastin time (PTTa) and prothrombin time (PT), without altering fibrinogen composition. These effects are mediated via activation of both intrinsic and extrinsic coagulation pathways, likely supported by calcium ions present in Hemoben.

The findings support the clinical potential of Hemoben as a hemostatic implant for surgical management of deep burns. Its use may improve intraoperative hemostasis, reduce blood loss, and enhance patient outcomes during early necrosectomy and autodermoplasty.

Overall, this study confirms that monitoring hemostatic parameters, combined with targeted interventions using materials such as Hemoben, can play a critical role in reducing complications and improving survival in patients with severe burn injuries.

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