Review

Burn Debridement - Approach and Review

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ABSTRACT: Between January 2020 and December 2024, a significant number of burn patients were admitted to the Plastic Surgery Clinic of the Craiova Emergency Clinical Hospital. Due to the high incidence of burns requiring hospitalization and the limited number of beds available for such patients, it became essential to identify optimal treatment methods that could reduce hospital stay while ensuring favorable functional and aesthetic outcomes. Early debridement is considered a vital first step in the treatment of burn patients, ideally performed within the first few days post-injury. Burn treatment involves both surgical and systemic approaches. Surgical management includes debridement, skin grafting, and reconstruction. Tangential surgical debridement remains the gold standard for deep burns, allowing precise removal of necrotic tissue while preserving viable skin. However, it may be associated with disadvantages such as intraoperative blood loss and incomplete excision. Alternative methods have evolved, such as hydrodissection, which uses a high-pressure saline jet for selective debridement, particularly useful in partial thickness burns. Larval therapy (using sterile *Lucilia sericata* maggots) is another option, especially effective in infected or necrotic wounds, offering antimicrobial benefits as well. Enzymatic debridement, particularly with bromelain-based products, is a modern, selective, and less invasive method that promotes healing with minimal bleeding and often reduces the need for grafting. A clinical case from Craiova highlights the success of enzymatic debridement: a 75-year-old patient with extensive burns showed significant improvement and near-complete epithelialization after 24 days, without requiring grafts. These outcomes support the growing use of enzymatic agents as a valuable tool in modern burn management, offering rapid, effective treatment and better patient recovery.

KEYWORDS: *Enzymatic debridement, burn, hydrodissection, larval therapy.*

Introduction

The treatment of burn patients is a complex and multidisciplinary process that involves both surgical and systemic interventions.

Among these, timely and effective debridement plays a crucial role in promoting wound healing.

Scar quality is considered to be one of the most important outcomes in burn surgery today [1].

The first therapeutic gesture indicated is early debridement, a vital gesture for the representation of the entire treatment, but also for its success [2].

Historically, debridement techniques have evolved from rudimentary practices to highly specialized procedures.

Each method offers distinct advantages depending on the burn depth, wound characteristics, and patient profile.

This article explores the principles, techniques, and comparative benefits of current debridement strategies in burn care.

Treatment of the burn patient

The treatment of the burn patient includes several stages, both surgical and systemic treatment.

Surgical treatment is represented by burn debridement, grafting and reconstruction.

In the case of grade IIB and III burns, early and correct debridement is what leads to the successful development of subsequent treatment, ideally being carried out in the first days, up to a maximum of one week after the burn [3].

Brief history

Early debridement in the treatment of burns dates back to antiquity, with the first reference being noted by the encyclopedist Aulus Cornelius Celsus in 25 AD [4].

During World War II, the large number of victims led to the need to expedite treatment, and burn debridement was performed with pyruvic acid and starch, and grafting was performed after 6 days [5].

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In the 1970s, Zora Janzekovic introduced tangential excision debridement to reduce mortality rates [6].

In addition to surgical debridement, modern medicine has developed new debridement methods, using hydrotherapy or enzymes [2].

Surgical debridement

Surgical debridement is the gold standard in the treatment of deep burns.

It can be performed using different types of scalpels, such as Weck/Goulian or Blair [2].

Surgical debridement aims to remove as much of the burn scar tissue and devitalized tissue as possible, thus preparing the affected area for grafting.

Surgical débridement is the quickest and most efficient way of getting the wound ready for healing [7].

For large areas of burn damage of varying depths, scalpel debridement has been shown to be a rapid and effective method.

It is a fairly precise method, which manages to preserve as much healthy tissue as possible around the lesion, so that the final healing can be of good quality, the most used excision being tangential [8].

The advantage of tangential excision, compared to excision up to the fascia, is that it is done from close to close to healthy tissue, the final result being one of better quality from an aesthetic point of view, but also faster [2].

However, the method also has disadvantages, such as incomplete removal of the burned tissue and an uneven excision, but also a long time of the intervention itself [8].

Another important disadvantage that should not be lost sight of is intraoperative blood loss, which can lead to hemodynamic instability and anemia and which requires multiple measures to reduce bleeding, such as the use of local hemostatic agents, tourniquets, compression dressings, intraoperative blood transfusion and plasma administration and even grafting of the patient at the same stage [9,10].

Early surgical debridement, typically within 48 hours post-injury, is considered the standard of care for deep dermal and full-thickness burns [11].

Adequate anesthesia is essential to ensure the patient's comfort and pain management during the procedure.

The patient is positioned to provide easy access to the burn areas, and in some cases, this positioning might also facilitate the harvesting of skin grafts from donor sites if required.

Strategies has been shown to improve both morbidity as well as mortality, albeit at the expense of creating new donor wounds [12].

Understanding the burn’s depth is essential to determine how aggressively the debridement should be carried out.

A detailed examination helps the surgeon identify the boundary between necrotic, non-viable tissue and the healthy tissue underneath.

Once the wound is prepared, the surgeon begins the debridement process using a scalpel.

This is typically done through a technique called tangential excision [13].

In this method, the surgeon removes the necrotic tissue layer by layer, starting at the surface and gradually progressing deeper [2].

The goal is to excise tissue until healthy, viable tissue with good blood flow is exposed.

The surgeon uses a back-and-forth motion with the scalpel to carefully remove the burn tissue without disturbing the underlying healthy skin.

This method allows for a more precise debridement, as it minimizes the removal of viable tissue while effectively eliminating the necrotic areas.

In cases of very deep burns, fascial excision may be required.

This technique involves excising tissue all the way down to the deep fascia, ensuring that all layers of necrotic tissue are removed [11].

Hydrodissection

Hydrodissection is a recent technology that uses water flow and the Venturi effect to cut [2,14].

Burn specialists widely use hydrosurgery as an alternative for conventional tangential debridement [15].

This method uses a device that uses sterile saline in a jet with adjustable and focused pressure, which will act as a scalpel with selectivity for burned tissues [14].

It is frequently used for debridement of partial thickness burns, as well as for debridement of fascia or tendons [16,17].

However, it is not effective for debridement of full thickness burns or old burns that have formed hard eschars [2].

An important aspect of this method is the rigorous removal of bacteria from the burn wound, but also the fact that it reduces the risk of contamination of the wound during the intervention [18].

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The efficiency of hydrodissection can be compared to that of classical surgical debridement, but hydrodissection leads to a more accurate and rapid debridement and to the achievement of satisfactory bleeding in the healthy tissue [2].

It is also a procedure that significantly reduces the number of excisions required per patient, thus decreasing the costs of treating the burn patient [2].

Another aspect that can be taken into account for the use of hydrodissection is the learning curve of using the necessary device, which is relatively easy for a surgeon who has mastered classical debridement [2].

However, hydrodissection has limited uses, only for partial thickness burns, full thickness burns requiring a more aggressive classical debridement [2].

The system operates by generating a focused, adjustable-pressure stream of sterile saline, which is emitted through a handpiece nozzle.

This high-velocity jet effectively dissects necrotic tissue, and the Venturi effect creates a localized vacuum that aspirates the dislodged tissue into a collection canister, simultaneously debriding, irrigating, and removing non-viable tissue [19].

When applied at water pressures between 3000 and 5000 psi, hydrosurgery debrides burn wounds more effectively minimizing damage to healthy tissue, promoting better healing outcomes.

Although dermal preservation may be a factor in reducing subsequent hypertrophic scarring, there were no significant differences found between scarring at 3 or 6 months after injury [20].

While some studies suggest that hydrosurgery may not provide significant advantages in healing time, infection rates, or operative time compared to traditional techniques [21], other studies suggest that the hydrosurgery system did offer advantages in terms of operative times and intraoperative blood loss and was cost-neutral, despite the handpiece cost [22].

Sterile larval debridement

The treatment of human wounds with fly larvae is an ancient procedure recently reintroduced into medical practice under the term of biosurgery [23].

Larval debridement is a method that involves the application of sterile larvae of the Dipteran species (most commonly *Lucilia sericata*).

In addition to debridement itself, this can disinfect the affected area and help heal wounds that do not respond favorably to antimicrobial therapy [24].

Throughout history, larval debridement has been used in various cultures, such as the Australian Aboriginal culture, the Chinese culture, and the Mayan culture [25].

Ambroise Paré, the chief surgeon to Charles IX and Henry III, in 1557 described the presence of myiasis in the suppurating wounds of the wounded on the battlefield of St. Quentin [26].

Baron Dominique-Jean Larrey, chief surgeon in the Napoleonic army, observed in 1829 the ability of maggots to provide better quality granulation tissue and shorten healing time in infected wounds [26].

The first clinical application was carried out by J.K. Zacharias and J. Jones during the American Civil War, and William Baer, professor of orthopedic surgery and founder of modern maggot therapy, improved the technique by using sterile maggots, after observing its benefits in abdominal and scrotal wounds, as well as in complex wounds with fractures [26].

Although popular in the 1930s, with the introduction of antibiotics in the 1940s, the method lost its popularity [26].

Debridement using sterile maggots is recommended in necrotic and/or infected lesions, in which a classical technique cannot be applied [27].

Larvae can both physically remove necrotic tissue from the wound site and stimulate wound healing by activating molecular processes in the wound area through the enzymes they secrete [28].

It may be particularly useful for venous or diabetic foot ulcers or for deep pressure ulcers [27].

This type of debridement is not feasible for hard, dry pressure ulcers.

Larval therapy is not significantly increasing the rate of healing of the ulcers [29].

If maggots are required for this type of pressure ulcer and other methods are not effective, the pressure ulcer should be soaked in 0.9% saline and surgically removed before applying maggots [27].

Maggots are also contraindicated for clean, non-necrosis wounds or for wounds that are in the process of granulating [27].

Recent clinical studies have demonstrated the effectiveness of Maggot debridement therapy (MDT) in treating full-thickness (grade-III) burn injuries [30].

The application of MDT involves placing sterile larvae directly onto the wound bed, typically within a specialized dressing that confines them to the treatment area.

Larvae actively move within the wound, ingesting necrotic tissue and debris, thereby cleansing the wound bed.

Larval secretions contain proteolytic enzymes that break down dead tissue, facilitating its removal.

Larvae secrete substances that combat bacterial infections, reducing the microbial load and lowering the risk of sepsis [19].

Recent studies have shown that maggot therapy was able to remove microbial contamination from burns comparable to that seen in the conventional group who have been given antibacterial agents [31].

The application of MDT involves placing sterile larvae directly onto the wound bed, typically within a specialized dressing that confines them to the treatment area.

The number of larvae, duration of application, and frequency of dressing changes can vary based on clinical protocols and the severity of the wound [30].

Enzymatic Debridement

Treatment of burns using herbal preparations dates back to 1600 BC [3].

However, in the modern era, preparations based on plant-derived enzymes began to be frequently used for the treatment of burns in the 1970s.

The first such preparation based on papain was prepared in 1940, later being combined with proteolytic enzymes derived from Bacillus subtilis in the late 1960s and early 1970s.

Although this preparation was very popular in the 1970s and 1980s, in the 1990s it was withdrawn from the market [3].

Over the years, various preparations based on enzymes obtained from Ficus carica or enzymes extracted from various bacteria have been developed: Bacillus subtilis, Streptococcus hemolyticus, Clostridium histolyticum [3].

Following these preparations, a product based on an enzyme extracted from pineapple, bromelain, was developed, which was approved by the European Medicines Agency in 2012 [32].

The bromelain-based preparation contains proteolytic enzymes-anacaulase-bcdb, such as thiol-endopeptidases, glucosidases, phosphatases, peroxidases, cellulases [33].

This product has proven its effectiveness in debridement of deep partial thickness burns, but also in full thickness burns [34].

Bromelain has anti-edema, anti-thrombotic, anti-inflammatory and exfoliative effects due to arachidonic acid and kallikrein-kinin, but also effects on cell-mediated immunity [32].

Patients treated with bromelain-based enzymatic debridement showed significantly faster wound healing, reduced infection rates, and lower pain levels during debridement.

Improved cosmetic outcomes, such as reduced scarring and better skin texture, were also observed [35].

The advantages of using enzyme debridement are low bleeding, faster and selective removal of eschar from the burn lesion, reduction of areas requiring the use of skin grafts [3].

In the last decade, numerous protocols and guidelines for the use of this product have been developed, both at European level [36] and by countries such as: Spain [37], Italy [38], Romania [39] and Poland [40], these protocols and guidelines being updated periodically.

Currently, the use of bromelain-based preparations in the treatment of burns is approved in 40 countries worldwide, most recently in the United States of America [41].

Enzymatic debridment can be used safely in any adult patient and that the indications for its use do not need to vary among younger and geriatric burn patients [42].

A randomized controlled trial comparing bromelain-based enzymatic debridement with conventional excision found that the enzymatic approach led to a shorter time to eschar removal and reduced the need for autografting, without significant differences in scar quality or healing time [19].

Enzymatic debridement prevents damage to the viable dermis due to the procedure's selectivity and has become an option for obtaining an accurate depth assessment and enabling wound re-epithelialization [43].

To begin, the wound is cleaned using sterile saline to remove any debris or contaminants.

Once prepared, the enzymatic agent is applied to the affected area under sterile conditions and it may be left on the wound for a specified period-typically about 3 to 4 hours-during which the enzymes gradually break down the necrotic tissue.

The treated area is covered with an occlusive dressing to maintain a moist environment and enhance enzyme activity [11].

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Collagenase selectively targets and digests denatured collagen in necrotic tissue, promoting its breakdown.

Healthy tissue, particularly epithelial cells and fibroblasts, is generally unaffected by the enzymatic activity, which allows the wound to heal more efficiently [44].

After the incubation period, the dressing is removed and the necrotic tissue is gently removed using sterile spatulas.

Adequate analgesia and, if necessary, local, regional or general anesthesia is ensured.

All advantages of the new enzymatic debridement had led to extend its use at the face area, although it was not tested in this area during pre-registration studies [45].

Selective bromelain-based enzymatic debridement (BED) has emerged as a valid alternative for the treatment of extensive burns, with Total Body Surface Area (TBSA)>20% [46].

The experience of the Plastic Surgery Clinic-Burns of the Craiova County Emergency Hospital with enzymatic debridement-example

During the period January 2020-December 2024, 514 burned patients were admitted to the Plastic Surgery Clinic of the Craiova Emergency Clinical Hospital, with an average of 8,6 per month.

The frequency of burns requiring hospitalization, as well as the low number of beds allocated to burn patients both locally and nationally, led to the need to find an optimal treatment formula to reduce the period of hospitalization of patients, with the best possible functional and aesthetic results.

75-year-old female patient presents for burns of the lower limbs, grade 3, partially 2B (Figure 1) and of the upper limbs and lower abdomen, grade 2A, with a body surface area of 25%.

The patient has associated comorbidities: hypertension, stroke and grade 3 obesity.

During hospitalization, the patient benefited from systemic treatment aimed at hydroelectrolytic rebalancing according to the Parkland formula, gastric and hepatic protection, pulmonary thromboembolism prophylaxis, and combating pain and post-burn edema.

She also continued her pre-existing cardiological treatment, to which vitamin therapy was added, as well as hyperprotein nutritional support.

It is decided to use enzymatic debridement, using a bromelamine-based product.

Figure 1. Patient at admission.

In order to obtain the best possible result, the pre-application preparation protocol was initiated, which consisted of rigorous cleaning of the burns on the lower limbs with a chloramine-based antiseptic solution and the application of compresses soaked in saline, to ensure adequate hydration of the wound before applying the enzymatic debridement compound.

24 hours after the patient's admission to the Plastic Surgery Clinic-Burns, enzymatic debridement was performed on the lower limbs, under spinal anesthesia, and the protection of the intact skin was achieved using a petroleum jelly barrier.

The enzymatic debridement compound was allowed to act under occlusive film for 4 hours.

During this period, analgesia was provided by the spinal anesthesia performed at the beginning of the procedure, supplemented with systemic analgesics.

After the action time had elapsed, the product was removed under intravenous analgesia (Figure 2).

Figure 2. Appearance after enzymatic debridement.

After enzymatic debridement, tulle gras dressings and biosynthetic cellulose dressings were applied to the lower limbs to avoid dehydration of the lesions and to promote epithelialization (Figure 3).

Figure 3. Dressings after enzymatic debridement.

During the next 3 weeks, tulle gras dressings were changed every 2 days and biosynthetic cellulose dressings were reapplied in areas where they had degraded and did not adhere to the tissues.

Also, the initial systemic treatment, appropriate oral hydration with 3000ml of water and enteral hyperprotein nutrition were continued.

In addition to surgical and systemic treatment, the patient benefited from psychoemotional support and psychological counseling throughout the hospitalization period.

24 days after enzymatic debridement, spontaneous, almost complete epithelialization was observed in the lower limbs, and the patient did not require skin grafts (Figure 4).

Figure 4. Appearance on 24th day after enzymatic debridement.

During the hospitalization, the patient did not require antibiotic administration.

The challenges of the case were represented by the patient's weight, but also by the low compliance with the treatment, especially related to active mobilization, which she systematically refused.

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For active mobilization, periodic physiotherapy was used.

The patient benefited from treatment according to the management algorithm for enzymatic debridement in the burned patient used within the Plastic Surgery Clinic-Burns Craiova (Figure 5).

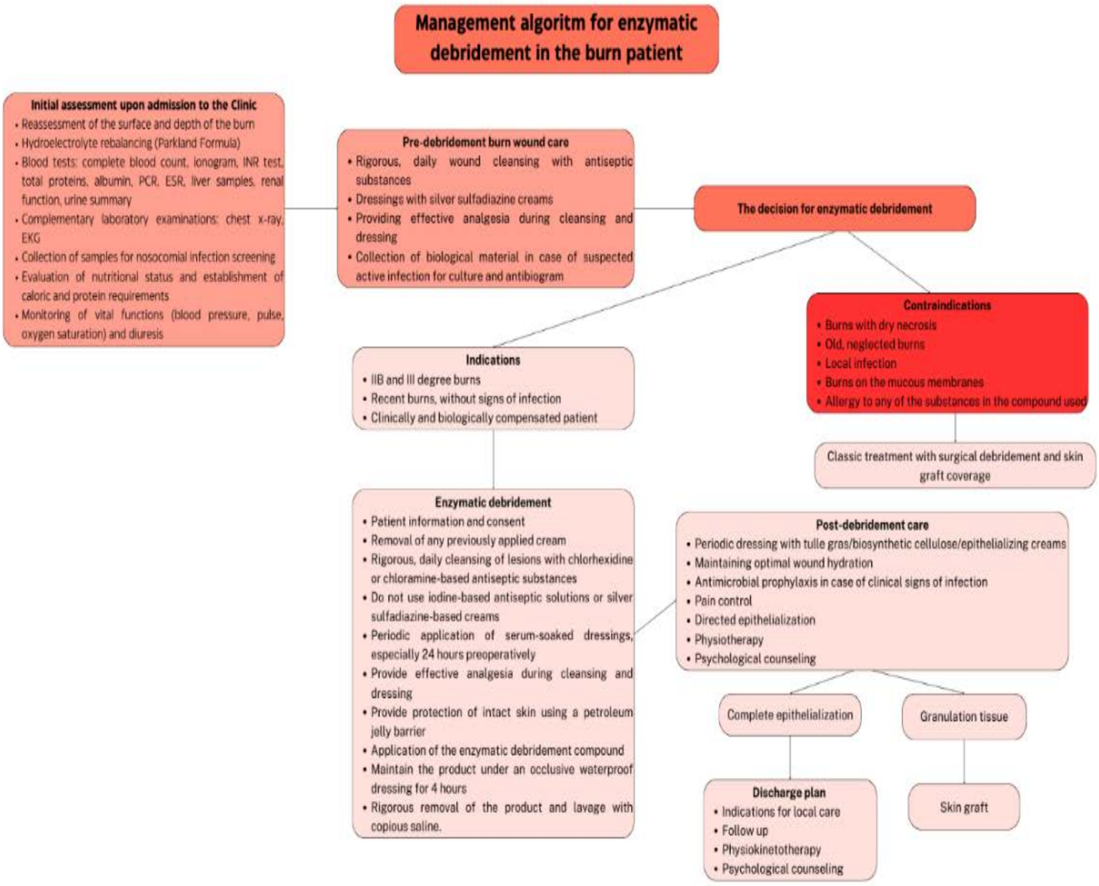

Figure 5. Management algorithm for enzymatic debridement in the burned patient.

The patient agreed and signed the consent for photography, participation in the educational process, and publication of the case.

Conclusions

Over time, mankind has sought different methods of treating burn patients, each of which is beneficial for the patient.

Of the methods developed, the most commonly used remains classical surgical debridement, as it does not require special equipment and is the basis of any plastic surgeon's practice.

Enzymatic debridement is a rapid method of eliminating the burn lesion, but which also provides a favorable ground for rapid and good-quality healing. These attributes may be the premises for a widespread use in the treatment of burns.

Conflict of interest

None to declare.

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