

# Topical Negative Pressure on Burns: An Innovative Method for Wound Exudate Collection

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**Summary:** Burn wound exudate is an important source of information on the wound-healing process and systemic improvement of burn patients. Identification of biomarkers for the prediagnosis of local or systemic complications in patients will have a great impact on adapting personalized procedures in burn treatment. No efficient exudate collection method exists that offers a direct and continuous collection over time. We developed an innovative system based on the negative pressure wound therapy technique to directly collect exudate from burn wounds over several days after burn. This method did not cause any complication or pain for patients, and positive influence on wound healing was seen. Exudate samples were further used in different projects for studying biochemical profile, trace element content, kinetics of bacterial growth, and cell cytotoxicity. (*Plast Reconstr Surg Glob Open* 2016;4:e1117; doi: 10.1097/GOX.0000000000001117; Published online 10 November 2016.)

## INTRODUCTION

Mortality and morbidity in burns are significantly decreased because of improvement in reanimation, specialized critical care, and surgical wound treatment.<sup>1,2</sup> Severe burns, however, still cause acute organ failure, infection, and sepsis requiring extended intensive care unit stays and specialized multidisciplinary care.<sup>3-5</sup> One of the main aims of burn research is to improve the wound closure time. In this regard, burn wound exudate is an appropriate and valuable source of information to monitor wound-healing processes in burn patients. In the last decades, burn wound exudate has been considered as either beneficial or damaging to the wound healing, depending on the mechanisms investigated.<sup>6-8</sup> Recent studies demonstrated that it offers a far more accurate reflection of the burn wound

pathophysiology than the traditional blood/serum investigations undertaken in the past. Meanwhile, this potential diagnostic tool has not gained the deserved attention in the burn research field.<sup>9</sup> One reason could be the lack of an easy and appropriate method for the collection of exudate from burn wounds. Different techniques have been used over the years to collect the exudate with different advantages and disadvantages observed (Table 1). However, a simple, affordable, painless, and sterile procedure to collect burn exudate is still to be designed. We have therefore developed an exudate collection system, assuring no biocontaminants in the equipment chosen, by modifying the conventional negative pressure wound therapy method.<sup>16</sup> We began using this method as part of a global research project that involved extensive analysis of burn wound exudate. In this article, we describe our innovative, low-cost, and easily applicable exudate collection system, which can be used for several consecutive days on the burn wound and ensure a noninvasive sample collection.

## MATERIALS AND METHODS

Following the standard of care protocol in our burn center, after the primary stabilization and resuscitation process, the patients were showered for cleaning, estimation of the total body surface area and the depth of the wounds. The exudate collection system was applied at the

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**Table 1. Different Methods of Burn Wound Exudate Collection**

Methods for Exudate Collection	Advantages	Disadvantages	Reference
Aseptic aspiration from intact blisters	Simple and quick procedure; low risk of contamination; frequently used and tested	Limited to blistering wounds; short period of sample collection; pain	Pan et al, <sup>10</sup> Wilson et al <sup>11</sup>
Elution from dressings (gauze/textile) covering the burn wound	Painless; collection over long time	Long procedure; indirect; high risk of contamination; elution step necessary	Berger et al <sup>12</sup>
Aspiration beneath temporary dressing (occlusive film) placed over the wound	Direct collection; low risk of contamination	Complicated procedure; short period of sample collection	Grinnell et al, <sup>7</sup> Yager et al <sup>13</sup>
Elution from Integra dressing (collagen layer) temporarily placed over the wound	High patient compliance; painless; collection over long time	Expensive; indirect; short period of sample collection; not applicable for highly exudative wounds	Caulfield et al <sup>14</sup>
Elution from porous, inert hydrophilic dextranomer beads placed under occlusive dressing covering the wound	Painless; collection over long time	Expensive; indirect; special device and elution step necessary	Ladwig et al <sup>15</sup>

end of shower with the following procedure. The wound was disinfected with chlorhexidine solution 0.05% and abundantly rinsed with sterile NaCl 0.9%. The wound bed was then partially covered with a silicon film (Adaptic Touch, 12.7×15 cm, Systagenix; North Yorkshire, United Kingdom) folded in 2 onto which a silicon drain (Blake; Ethicon, N.J.) was placed. The exudate collection area was sealed with an occlusive plastic dressing (Steri-drape 2, 60×60 cm, 3M Health Care; Neuss, Germany). The drain was connected to a sterile reservoir (Redovac bottle, B. Braun; Melsungen, Germany) and was connected to mural suction, and a continuous negative pressure was applied at 125 mmHg. The wound exudate was aspirated continuously and collected in the reservoir. (**See video, Supplemental Digital Content 1**, which demonstrates the application of exudate collection dressing system. This video is available in the Related Videos section of the Full-Text article on PRSGlobalOpen.com or available at <http://links.lww.com/PRSGO/A285>.) Reservoirs were collected twice per day, and the dressing was changed at each patient shower (every 48–72 h). All components of the dressing were CE-marked and used in standard of care protocols for burn patients (Fig. 1).



**Video Graphic 1.** See video, Supplemental Digital Content 1, which demonstrates the application of exudate collection dressing system. This video is available in the Related Videos section of the Full-Text article on PRSGlobalOpen.com or available at <http://links.lww.com/PRSGO/A285>.

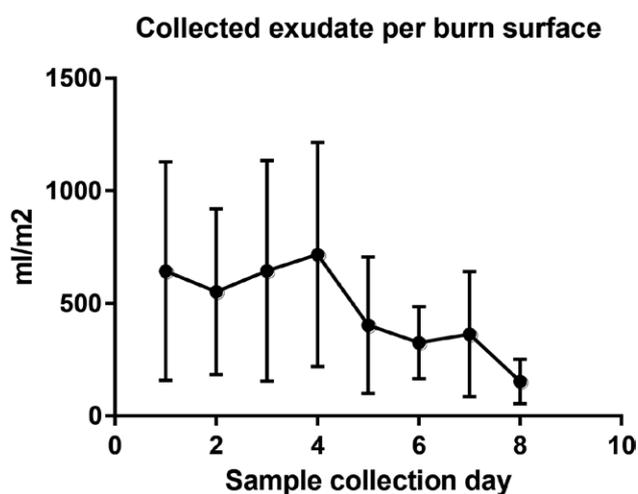
## RESULTS AND DISCUSSION

We included 22 patients with an average TBSA of 28% from December, 2013, to May, 2015. This study was approved by the Institutional Review Board of the Centre Hospitalier Universitaire Vaudois and the Ethics Committee of the State of Vaud, Switzerland (Ethics No. 488/13). Wound exudate was collected from second-degree superficial or deep burns on a surface area of 3% to 12% depending on the TBSA. Second-degree wounds were chosen because of the more exudative and dynamic nature of the wound. We performed exudate collection from 1 or maximum 2 wounds localized on (preferably) limbs to not interfere with nursing care and excluded burns on the head and neck area. We observed an average exudation period of 5.5 days (range: 3–8 d) with maximum levels at day 1 and 4 after trauma (Fig. 2). Sample collection was discontinued upon grafting of the wound site or natural arrest of exudation. Implementation of the system was done during the first hydrotherapy and therefore caused no pain (the patients were under anesthesia). No complications for the application of the system or interfering with routine treatment protocols and nursing care were reported.

The exudate collection system was adapted from the conventional vacuum-assisted wound therapy and thus we applied a mean pressure of –125 mmHg, which was already reported safe and not invasive for the tissues.<sup>16</sup> With this method, we could obtain sufficient amounts of wound exudate to run biological analytical assays. The exudate samples were analyzed for bacterial culture growth. The results were negative for the majority of samples. In a few cases, we had positive results for normal skin flora (coagulase negative *Staphylococcus* including *S. epidermidis*) and in 1, a positive result for *Streptococcus mitis*. This suggests that our collection and aliquoting procedure does not contaminate the exudate samples. The collected samples were used in different research projects, all aiming to make a detailed characterization of biochemical, immunological, microbiological, and toxicological properties of the burn wound exudate. The ultimate goal of this project was to gain an overall knowledge on the microenvironment of the burn wound with perspective of developing new biologically active dressings for the burn patients. The biochemical profile of the exudates was



**Fig. 1.** Dressing components for exudate collection. Tubing and recipient choice that did not produce TE contaminants.



**Fig. 2.** Exudate yield per day post burn. Exudate collected at several days after burn was normalized to sample collection surface area and illustrated in collected liquid (in ml) per burned area (in m<sup>2</sup>).

used to design an in vitro formulation of burn wound exudate to test new biological wound dressings for their behavior in an artificial wound medium. Exudative loss of trace elements (TEs) was determined during the first week after trauma, which is the most critical period for burn care. Control tests did not reveal any TE contamination of all the tubing and reservoir of our system, and we did not observe any TE release into exudates in the sample collection conditions. We observed a very high loss of all essential TEs during the first 2 days of hospitalization in the burn center despite continuous micronutritional supplementation. This suggested us to revise the dosing of these elements in preparation that were prescribed to patients early after trauma.

### CONCLUSIONS

We have shown that this system is easily implemented and causes no complications or pain. Other studies have report-

ed the use of negative pressure for wound exudate sampling, but a continuous exudate collection for large quantities from large burn surfaces was only achieved by our method to date.<sup>17,18</sup> The samples collected by this method produce adequate quantities to undergo different analytical procedures and provide reliable results. Determining the balances between prohealing and antihealing factors in the wound exudate could help assess wound healing in each patient and personalize the surgical treatment protocol accordingly.

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