Effectiveness of Beta-Glucan Collagen for Treatment of Partial-Thickness Burns in Children

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Background/Purpose: Beta glucan collagen matrix (BGC), which combines the carbohydrate beta-glucan with collagen, has been used as a temporary coverage for adult partial thickness burns with reported good results. Observed advantages of BGC coverage include reduction of pain, improved healing, and better scar appearance. Potentially even more important in children is the elimination of painful daily dressing changes to the burned epithelial surface, as well as decreased fluid loss. This report details the authors’ 2-year experience with BGC in a pediatric burn center. 1

Methods: Retrospective chart review of 265 consecutive pediatric patients treated at our institution between 1997 and 1999. 43 patients (19%) with suspected partial thickness burns treated with BGC as the primary wound dressing. BGC was applied to a debrided burn wound and secured with steri-strips, karlix, and an ace wrap. After 24 hours, adherence of the BGC was confirmed and then left open to air.

Results: The most common cause of burn injury was scald (61%), followed by flame (37%), and contact (2%). The average age of patients was 5.5 years (range, 6 weeks to 16 years) and mean percent total body surface area burned was 9.3% (1% to 35%). Thirty-four patients (79%) had the BGC remain intact while the wound healed underneath, with excellent cosmetic results, minimal analgesic requirements, and no need for repetitive dressing changes. Nine patients (21%) had the BGC removed before wound healing. Six patients lost the BGC because of progression of the burn to full thickness, 2 had BGC nonadherence over a joint, and 1 had an unexplained nonadherence.

Conclusions: Partial-thickness burns in children can be effectively treated with BGC with good results, even in infants and toddlers. BGC markedly simplifies wound care for the patient and family and seems to significantly decrease postinjury pain.


INDEX WORDS: Partial thickness burns, beta glucan collagen, pediatric burns.

Burn injuries present a major public health problem for children. Annually, 250,000 children under the age of 18 suffer serious burns that require medical attention. 1 Approximately 30,000 American children are hospitalized for serious burns each year with a large number suffering permanent disfigurement and disability. 2 Significant pain is suffered by these children during their burn wound convalescence. Treatment regimens designed to decrease the morbidity of burn care are needed.

Most burns occur in children under 5 years of age with a peak incidence seen in infants and toddlers under the age of 3. 3 Of the injuries requiring medical attention, the majority are partial thickness burns typically the result of flame exposure, scalding, or direct contact with hot surfaces. The frequent occurrence of burn injuries in the very young reflects a combination of factors including a decreased awareness of potential dangers and a limited ability of the child to respond to a prompt, appropriate manner. In addition, a child’s thinner skin tolerates less heat at a shorter duration before full-thickness injury occurs. 4

Partial thickness burns can be superficial or deep and involve both the epidermis and dermis. They are characterized by moist blisters, redness, edema, and pain. Unlike the more extensive full-thickness burn, a deep partial-thickness burn has the capacity for healing if properly treated. Crucial in the care of partial thickness wounds is the maintenance of a moist wound bed, adequate circulation, and protection from infection to avoid conversion of a partial thickness injury into a full-thickness wound. 5 Optimal wound conditions must be maintained in partial-thickness burns to preserve the uninjured dermal and epidermal appendages. 6 A large or infected partial-thickness burn may take longer to heal and may require skin grafting to maintain function or preserve cosmesis.

Several treatment options are available for the management of partial-thickness burns depending on the

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location of the injury. Before the 1980s, treatment at most centers entailed cleansing, debridement, and dressing changes using antimicrobial agents such as silver sulfadiazine, sulfamylon, or bacitracin. On a daily and sometimes twice-daily basis, dressings are changed until the underlying wound is healed usually between 10 days and 3 weeks. Another option included the placement of dressings of various degrees of occlusion (Duoderm, Opsite, Xeroform) depending on the preference and experience of the surgeon. In addition to the significant financial costs, these treatments generate a great deal of pain and anxiety for the young patient.

The development of synthetic skin substitutes such as Biobrane®dates back to the late 1970s. These materials were developed as alternatives to the available biological temporary skin substitutes (pig skin, amnion, and cadaver skin) for the management of deep partial and full-thickness burns, and for coverage of autograft harvest sites. It was discovered that when used on superficial partial-thickness burns and on donor harvest sites, epithelialization occurred beneath the adherent synthetic material without the need for painful daily dressing changes. An ideal approach to the care of partial-thickness wounds in children would provide optimal conditions for wound protection and repair while minimizing the amount of pain suffered by the child. In the adult population, different collagen-based products have been developed and used effectively in wound management including Biobrane, Integra, and beta glucan collagen matrix (BGC).

BGC matrix (Brennan Medical, Inc, St. Paul, MN) combines beta glucan with collagen in a meshed reinforced wound dressing. Beta glucan, a complex carbohydrate, is known to stimulate macrophages. Macrophages are vital in the inflammatory phase of healing, providing phagocytosis and secretion of chemokines that promote the formation of new tissue. Collagen is a natural component of the dermal matrix produced by fibroblasts that function as a protective scaffolding for migrating epithelial cells in the regenerating skin. BGC is a temporary wound dressing intended for the management of partial-thickness burns, donor sites, and other shallow wounds. It is applied to the wound immediately after cleansing and debridement. If well adhered to the burn surface without signs of infection, the BGC matrix may remain on the wound as a barrier or protective dressing until healing is complete. Daily dressing changes are eliminated.

The pediatric burn center at the Medical University of South Carolina (MUSC) began using BGC on selected partial-thickness burns in 1997. Before this, partial-thickness wounds were managed using standard techniques, which included cleansing and debridement, followed by daily dressing changes with silver sulfadiazine cream or bacitracin ointment depending on the location of the injury. This report describes our experience to date with the use of BGC for primary coverage of partial-thickness burns in children.

MATERIALS AND METHODS

Retrospective chart review of 225 consecutive pediatric burn patients treated at our institution between September 1, 1997 and September 30, 1999 was conducted. All new burn patients were entered into a pediatric burn registry maintained by the perioperative clinical nurse specialist. Age, sex, patient length of stay, and number of transfers and deaths were obtained from the registry. Primary cause of burn injury, percent body surface area burned, and depth of burn were extracted from the patient's admission history and physical. Number of outpatient visits, days to healing, noncompliance (history of greater than 2 missed appointments), and follow-up information were obtained from the outpatient chart and review of clinic notes.

Candidates for BGC placement were those patients with new, clean, suspected partial-thickness burns not involving the face, fingers, toes, genitalia, or major joints. Some patients had a combination of partial- and full-thickness burns, and these patients were included in this review. BGC also is our primary dressing for donor sites 156 of 58 patients requiring skin grafting had BGC placed at their donor site dressing. These patients were not considered in the study.

BGC was applied to a clean debrided burn wound and in some cases premoistened with normal saline to provide easier manageability. Total wound coverage was assured by extension of the BGC over a margin of nonburned skin around the wound. The BGC was secured with sterile strips, covered with fluffed gauze wrap, and held in place with an elastic bandage. The dressing was left undisturbed overnight, after which time the outer wrap and gauze dressings were removed. If BGC adhered to the burn surface, the wound was left open and a layer of gauze wrap was applied to the BGC dressing on those children whose age or site of injury dictated further protection of the BGC from mechanical disturbance.

In the absence of mechanical disruption, the BGC became very adherent once allowed to dry (Fig 1). Accumulation of a serous exudate and slight odor was common within the first 24 to 48 hours and was not necessarily associated with infection. Exposure to air usually hastened disappearance of both the exudate and odor. Six to 8 days after application, the well-adhered and dry BGC was coated with a petroleum jelly or antibiotic ointment to begin softening the dressing. This process facilitated removal of the BGC. Both the parents and the patient, if age appropriate, were instructed on the goals of managing the wound with BGC. Verbal and written instructions on the care of the dressing were provided.

For patients whose injuries required hospital admission, standard protocols for pain management were followed. Our standard practice includes the use of scheduled acetaminophen and either oral or intravenous narcotics given as needed and with dressing changes, if necessary. In addition, anxiolytics were used as needed for dressing changes. Patients with smaller burns not requiring hospitalization were given prescription narcotics only if home dressing changes were indicated (ie, BGC not used). Otherwise, acetaminophen alone was prescribed.

RESULTS

Of the 225 charts reviewed, 43 (19%) patients with suspected partial-thickness burns treated with BGC as the primary wound dressing were identified. An additional 130 patients (58%) had partial-thickness burns and were treated in a standard fashion without the use of
BGC or split-thickness skin grafting (STSG). The majority of partial-thickness burns not treated with BGC were located on the face, hands or feet, joints, or other areas unsuitable for BGC placement and adherence. Almost 10% of burns deemed unsuitable for BGC were several days old at presentation and considered contaminated. Fifty-two patients (23%) were treated with debridement and early skin grafting.

Table 1 summarizes the data collected in this series and is divided into 3 treatment groups. The 3 groups include patients treated with BGC, patients treated according to our standard protocol without the use of BGC and not requiring subsequent skin grafting, and those treated with STSG either primarily or after failed BGC. The patients treated without BGC received daily dressing changes using either topical silver sulfadiazene or bacitraclin as previously mentioned.

Within the BGC group, the most common cause of injury was scald (61%), followed by flame (37%) and contact (2%). The average age of patients was 5.5 years (range, 6 weeks to 16 years). Mean percent total body surface area burned (TBSAB) was 9.3% (range, 1% to 35%). In 34 patients (79%) the BGC remained adherent to the burn surface, while the wound healed underneath (Fig. 2). Nine patients (21%) had the BGC removed before wound healing. Six of these lost BGC adherence because of progression of wounds to full thickness, 2 had BGC nonadherence over a joint, and 1 had an unexplained nonadherence. Treatment after BGC removal of these 9 patients included subsequent skin grafting in 5 patients, daily topical silver sulfadiazene dressings in 3 patients, and application of a bioengineered skin substitute in 1 patient.

Of the 43 patients treated with BGC, 10 patients (23%) did not require hospitalization. Twelve of the remaining patients were hospitalized for 24 hours or less. The average length of stay in the BGC population was 4.1 days. In those patients in whom the BGC adhered tightly to the burn surface, the average length of hospital stay was 1.8 days. These patients did not require daily dressing changes to the BGC site. For those patients whose BGC was removed before complete wound healing, the average length of stay increased to 13 days. The major reason for BGC removal was nonadherence, whether from mechanical shear or progression of the underlying wound to full-thickness injury. The average number of outpatient visits was 3.9 for patients with BGC. Only 1 patient was lost to follow-up.

Patients with partial-thickness burns not treated with BGC received a standardized treatment of daily dressing changes with silver sulfadiazene or bacitraclin ointment (for facial wounds). The majority of burns in this group were the result of a scalding injury involving less than 5% of the total body surface area (TBSA). Many of these burns were in locations unsuitable for BGC placement because of poor adherence over a mobile surface. The average length of hospital stay was 1.4 days, and the

Table 1. Treatment of Partial-Thickness Burns

<table>
<thead>
<tr>
<th>Treatment</th>
<th>BGC (n = 43)</th>
<th>Standard Treatment, No STSG* (n = 138)</th>
<th>STSG† (n = 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age (yrs)</td>
<td>5.5</td>
<td>5.6</td>
<td>4.8</td>
</tr>
<tr>
<td>Primary cause of burn</td>
<td>Scald</td>
<td>Scald</td>
<td>Flame</td>
</tr>
<tr>
<td>TBSA injured (mean)</td>
<td>3.3%</td>
<td>4.5%</td>
<td>13.3%</td>
</tr>
<tr>
<td>Days to heal</td>
<td>15</td>
<td>15</td>
<td>33.9</td>
</tr>
<tr>
<td>BGC intact</td>
<td>12.4</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>nonadherent</td>
<td>24</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Length of stay</td>
<td>4.1</td>
<td>1.4</td>
<td>18.2†</td>
</tr>
<tr>
<td>BGC intact</td>
<td>1.8</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>nonadherent</td>
<td>13</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Outpatient visits (mean)</td>
<td>3.9</td>
<td>2.3</td>
<td>6.6†</td>
</tr>
</tbody>
</table>

NOTE. Patients categorized by groups of treatment. Data are descriptive. No significant differences are seen between BGC and Standard Treatment groups in terms of types of burn injury and days to healing.

* Standard treatment with silver sulfadiazene/antibiotic ointment
† Includes 8 patients with failed BGC requiring STSG
# As determined by evaluation in clinic follow-up.
average number of days to complete wound healing was 15.

For the patients treated with STSG, the majority of burns were more severe, more likely to be related to flame exposure, and involved an average of 14% of the TBSA. The total length of stay in this group was 18.2 days. The time to complete wound healing was an average of 33.9 days. In addition, the number of outpatient visits averaged 6.8 for the STSG group, whereas those treated without BGC or grafting underwent follow-up an average of 2.3 times.

DISCUSSION

A primary concern to both patient and family is the pain associated with both the initial injury and the necessary daily care that follows. One study asked 44 pediatric burn patients to identify 7 painful experiences, rank them in order from most to least painful, and report a worst possible pain imaginable. Eighteen of the 44 patients (40.9%) listed their burn as the most painful experience imaginable, whereas 8 children (18.2%) identified being burned again as the worst possible pain. Of the other children who did not list their burn injury as the most pain imaginable, many identified painful experiences associated with treatment, including dressing changes, surgical procedures, staple removal, intravenous sticks, and physical and occupational therapy. For many patients, the pain incurred in the care of the daily dressing changes of the burn wound provides the greatest source of morbidity.

The purpose of this study was to report our experience using BGC as the primary wound dressing on partial-thickness burns over the past 25 months through retrospective review. Data are presented as descriptive. Statistical comparison of the treatment groups does not favor one method of nonoperative treatment over another when comparing wound healing. The extent and nature of the injuries were most similar for the 2 groups of patients treated without the use of STSG. A similarity between those patients treated with BGC and those with standard, nonoperative therapy was evident in the mechanism of the injury, the percent TBSA affected, the day to healing, and the length of hospital stay. Given the similarities of injuries in these groups, outcome of burn injuries was not affected adversely by the choice of BGC or standard treatment with silver sulfadiazine as a primary wound dressing. What deserves emphasis is the lack of daily wound care required by the BGC group. Patients treated with BGC appeared to have simila
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results without the need for daily painful dressing changes and the accompanying narcotics that are required (Fig 2).

BCG matrix offers several advantages when utilized as a primary wound dressing on partial-thickness burns. By providing a semiocclusive wound covering, BCG decreases evaporative water and heat loss from the wound. Sensory nerve terminals are covered and, as a result, pain associated with the wound is decreased. If the BCG remains adherent to the wound surface, daily dressing changes are eliminated. Furthermore, the adherent protective wound covering of BCG may allow improved physical and occupational therapy with earlier return to activities of daily living. The BCG also acts as an effective barrier to bacterial contamination.

In this descriptive study, 5 patients lost BCG adherence and required subsequent skin grafting because of progression to full-thickness injury. It is possible that the full extent of the burn went unrecognized at the time of the initial survey. Initial coverage with BCG, even if it becomes nonadherent, still provides effective coverage and barrier to infection in those cases when it is unclear if partial or full-thickness injury has occurred. In evaluating the potential success of BCG dressing, the location of the wound must be considered. Our greatest success has been in the application of BCG to partial-thickness burns over a relatively flat, immobile skin surface, such as the trunk or extremities. As the BCG becomes adherent and dries, the matrix becomes quite stiff, thereby limiting its use over joints and on the face and neck.

In addition to eliminating the need for daily painful dressing changes and their accompanying psychological toll, treatment of partial-thickness burns with BCG reduces the overall financial expense incurred. Cumulative material costs of treating a 5- x 6-inch partial-thickness burn for 15 days with antimicrobial agents applied once daily approaches $350. This excludes the time involved in changing the dressing for the caregiver, whether it is a family member or, more importantly, a home health nurse. To treat a similar-size injury with BCG, assuming adherence, the costs is approximately $120 and requires only daily assessment.

Patient and family education is vital to the successful treatment of burns with BCG. Verbal and written instructions reviewing the goals of treatment, appearance of the dressing, and importance of compliance with follow-up are a necessity. Particularly in the outpatient setting, it is imperative that parents have a clear understanding of expectations and potential problems. We have found it helpful to offer caregivers photographs of the BCG on wounds at different stages of healing (initial placement, midtreatment, and before and after removal). In the hospital and clinic settings, meetings are coordinated between patients and family members with similar injuries and treatment, creating opportunities for education about burn wound healing and providing an added benefit of psychosocial support.

Building from our use of BCG on STSG donor sites, our initial experience with BCG as a primary wound dressing for partial-thickness burns in children has been favorable. Reduction in the number of daily painful dressing changes alone has proved to be a significant improvement over previous methods without a negative impact on healing. Currently, our efforts are focused on improving initial assessment of depth of burn injury to avoid use of BCG on wounds to which it will not adhere. Newer preparations of beta glucan may broaden the applications of BCG biotechnology to include injured skin over articular and facial surfaces. BCG matrix dressing is effective in reduction of the pain experienced in burn wound care. The particular needs of the burned child, especially in the area of pain management, demand even further improvements along this direction to decrease the morbidity of burn wound care.

REFERENCES

Discussion

W. Hardin (Birmingham, AL): We are starting to use more of these synthetic-type products in these burn patients. Did you do anything in terms of pain analysis in these children to find out whether subjectively it worked out better than the Hubbard tank torture treatment that we have done in the past?

E.P. Tagge (response): We did not do anything specifically other than realizing that none of these patients required any kind of narcotics after the first 24 hours. Now we did not analyze pain scales, etc., and I think this information has stimulated us to be more prospective in our data acquisition for sure.

C. Priebe (Stony Brook, NY): I raise somewhat to convince our other pediatric colleagues that maybe they should play a little larger role in the management of children's burns, because I see in institutions that are surrounding us that our adult colleagues do not pay as much attention to the scald burn, which is of course the common problem that we see. A number of years ago I presented a poster at this meeting showing a pain scale actually indicating the advantages at that time of a silver-impregnated xenograft, pig skin, and there was a great decrease in pain compared with the traditional methods. And I am sure you would find the same thing had you done it. Again, I think it is important that we think about burns in our young children and that more of us take an interest in this and be involved and treat them.

E.P. Tagge (response): I would agree with that wholeheartedly. When you look in the data there are very few if any reports by pediatric surgeons on the management of pediatric burns. This is something that is done by adult surgeons or burn surgeons, and I think pediatric surgeons have a major part to play in treating these children.

A. Winthrop (Milwaukee, WI): Could you comment on the difference in cost between the BGC and Biobrane. We have had very good success with Biobrane, which is applied in a very similar population of patients, and they often go home in 14 to 48 hours with good pain control.

E.P. Tagge (response): I cannot comment on Biobrane versus BGC. I know Biobrane is probably a little bit less expensive. There are a variety of skin substitutes. We are not saying that BGC is the best way to go. When we looked at a 5 x 6 burn that would require 2 weeks of dressing changes with Silvadene, pain medicine, etc. the cost is about $350 for the standard therapy and $150 for BGC. That is just one comparison but certainly not to Biobrane or some of the other products.