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A Comparison of Biobrane™ and Cadaveric Allograft for Temporizing the Acute Burn Wound: Cost and Procedural Time

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Abstract

Introduction—In many circumstances early burn excision and autografting is unsafe or even impossible. In these situations, skin substitute dressings can be utilized for temporary wound coverage. Two commonly used dressings for this purpose are cadaveric allograft and Biobrane™.

Materials and Methods—Five year retrospective cohort study evaluating upper extremity burns treated with temporary wound coverage (Biobrane™ or allograft). The primary outcome was to determine the impact choice of wound coverage had on operative time and cost. The secondary outcome was the need for revision of upper extremity debridement prior to definitive autografting.

Results—45 patients were included in this study: 15 treated with cadaveric allograft and 30 treated with Biobrane™ skin substitute. Biobrane™ had a significantly lower procedure time (21.12 vs. 54.78 minutes per %TBSA excised, p=0.02) and cost (1.30 vs. 2.35 dollars per minute per %TBSA excised, p=0.002). Both techniques resulted in 2 revisions due to complications.

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Author Contribution

Ryan E. Austin was involved in the literature search, data collection, data analysis, data interpretation, and writing of this manuscript.

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Conclusion—Biobrane™ is superior to cadaveric allograft as a temporizing skin substitute in the acute burn wound, both in terms of procedure time and associated cost. We believe that this is largely due to the relative ease of application of Biobrane™. Furthermore, given its unique characteristics, Biobrane™ may serve as a triage and transport option for severe burns in the military and mass casualty settings.

Keywords

Allograft; Biobrane; Burn; Cost; Skin Substitute

Introduction

Early excision and autografting of thermally injured patients is one of the fundamental principles of acute burn care. [1-3] Despite the known benefits of early autografting, there are situations where the placement of autograft is unsafe (e.g. unstable patient, lack of donor sites) or even impossible (e.g. military, trauma, mass casualty, insufficient operating room resources). In these circumstances, alternate treatment options must be explored to allow for excision of the burned tissue, as unexcised burn helps drive a significant hypermetabolic inflammatory state that can lead to poor clinical outcomes.[3-5] The ideal skin substitute in these situations would be cost-efficient, easy to use, non-antigenic, and provide permanent wound coverage.[6-8] Unfortunately, to date there is no commercially available skin substitute that has been able to achieve all of these ideal properties.[7,8] Instead, the clinician must select from a variety of dressing and skin substitute options available, each of which has its own limitations. When a temporizing dressing is needed, it would ideally be rapidly applied, provide an effective barrier layer, and be inexpensive given the extensive costs associated with acute thermal injury care.[7,9]

Though the ideal temporizing dressing does not exist at present time, the options currently available can be classified according to their composition. Biological dressings are derived from naturally occurring components (e.g. cadaveric allograft), whereas synthetic dressings are a micro-engineered biocompatible polymer matrix.[8] Allograft plays an essential role in burn wound coverage, as it is relatively inexpensive and serves as an effective option for temporary burn wound coverage following excision. The allograft tissue is non-immunogenic and is tolerant of questionable wound beds. It can serve as an indicator as to whether the wound bed is adequate and ready for autografting, because in large burns autograft coverage is a necessity for survival. However, despite all the advantages cadaver skin also has disadvantages; it can take longer to apply, it must be stored and handled according to stringent guidelines, and it must be held in an adequate enough supply to allow for full wound coverage.

Synthetic dressings, the current alternative category of temporary dressing, biosynthetic dressings, which specifically combine synthetic polymers with cellular and/or extracellular components.[8] Biobrane™ (Mylan Bertek Pharmaceuticals Incorporated, Canonsburg, PA) is a biosynthetic temporary skin substitute composed of a silicone membrane and nylon mesh impregnated with porcine dermal collagen.[8,10] It can be easily and quickly applied to the excised burn wound, however, it is intolerant of contaminated wound beds and is

limited by its cost.[11] Advantages of Biobrane™ include its rapid application, the ability to visualize wounds, and its potential for temporary coverage. We therefore asked several questions in this study; first, whether use of a Biobrane™ dressing offset the extra time required to apply a cadaveric allograft dressing. Second, are the differences in time, cost and outcome between the two dressing options significant? Finally, is it safe to use Biobrane™ as a temporary dressing in the acute burn wound? The aim of this study was to determine the answers to these aforementioned questions, as we believe this knowledge could significantly impact the management of acute thermal injuries, both within the civilian population and in the triage process for thermal injuries associated with military conflict and mass casualty scenarios.

Methods

A review of the NTRACS Burn Database® was performed for all patients admitted to the regional burn unit at a single tertiary trauma center between January 1, 2008 and December 31, 2012. Patients were identified who had undergone treatment for isolated upper extremity burns, either unilateral or bilateral. The upper extremity was selected for analysis, as it is one of the few anatomic locations treated in an isolated fashion with standardized positioning in the operating room. The upper extremity also has many intricacies, specifically the hand, which influences the excision and dressing application unlike other anatomic regions.

The major inclusion criterion for this study was patients who had undergone primary excision of the burned upper extremity in the operating room, with application of either cadaveric allograft or Biobrane™ skin substitute. Any patient who had undergone autografting during the same procedure, received more than one type of skin substitute, or underwent another simultaneous procedures to the same extremity (e.g. amputation of digit) or elsewhere on the body was excluded.

Demographic information for all included patients was collected from the ABA NTRACS database®. %TBSA was documented from the Lund-Browder charts completed by the attending physician at the time of admission. Procedure time was defined as the length of the operative procedure itself, and excluded time required for anesthesia and patient transportation to or from the OR.

Costs for these procedures were determined based on unit costs provided by the operating room manager, and are calculated and expressed in Canadian Dollars (CAD). Total cost was based on skin substitute materials, as well as materials used to secure these dressings (e.g. suture, stapler, fibrin sealant). Costs for operating room time, surgeon, anesthesia and nursing staff were excluded from these calculations as these are fixed costs at our institution. Cadaveric allograft was made available through our hospital's tissue bank. Biobrane™ dressing materials included the Biobrane™ glove (cost based on size) and the Biobrane™ 10×15” sheet dressing. For patients treated with the Biobrane™ glove but who were missing sizing information, the unit cost of a medium sized glove was used for the purpose of data analysis.

Patients included in this retrospective cohort study were compared based on whether their upper extremity burn has been treated with cadaveric allograft or Biobrane™. The primary outcome of this study was to determine what impact the choice of dressing had on operative time and operating room cost. The secondary outcome was the need for revision of upper extremity debridement prior to definitive autografting. Data points were analyzed using the student t-test, with $p < 0.05$ considered significant.

All patients included in the study had provided consent to participate in research studies during their admission. Research ethics approval for this study was obtained through the local institutional Research Ethics Board.

Results

In total, forty-five patients were identified who underwent operative debridement of upper extremity burn injuries with temporary wound coverage (see Table I). Fifteen of these patients were treated with cadaveric allograft while the remaining thirty patients were treated with Biobrane™. The groups were comparable in regards to age, gender, length of hospital stay, and average upper extremity percentage total body surface area (%TBSA) involved. Comparing %TBSA involvement of the upper extremities by region, the only significant difference was a greater involvement of the right forearm in the Biobrane™ group. All of the patients in the cadaveric allograft group had involvement of at least one hand, compared twenty-seven of thirty in the Biobrane™ group.

Overall cost and procedure time showed no statistically significant difference between cadaveric allograft and Biobrane™. The absolute difference in cost between the procedures was $311.96, with cadaveric allograft the more expensive dressing. There was no difference observed in operative temperature change between the two groups. Both techniques resulted in two revisions due to complications. In the allograft group, one patient had extensive soft tissue necrosis on the hand with no allograft incorporation. The wound was treated with a VAC dressing, but eventually required the amputation of three digits. Another patient developed a fungal infection in one of his upper extremities alongside underlying muscle necrosis; this required redebridement and replacement of allograft. In the Biobrane™ group, one patient was found to have inadequate debridement of the underlying burn wound requiring re-debridement and coverage with allograft. Unfortunately the patient died two days later of multi-organ failure. Another patient developed infection in a part of the wound bed covered with Biobrane™ requiring re-debridement and coverage with allograft (see Table I).

Significant differences were identified in the cost and procedure time of each treatment modality when standardized by %TBSA treated. The average cost per minute per %TBSA excised with cadaveric allograft was $2.35±1.26 compared to just $1.30±0.88 for Biobrane™ ($p=0.002$) (see Table I). This did not significantly change when only patients with involvement of the hand(s) were included in the analysis ($1.39±0.88, $p=0.007$).

Discussion

When treating patients with thermal injuries, many aspects of the acute burn management can directly influence patient outcomes. Following the initial burn resuscitation, early excision and grafting of the burn wound is the goal, as this has been shown to improve outcomes in burn patients.[2,12] Burned tissue is one of the major driving forces behind the systemic inflammatory response and hypermetabolism seen in thermally injured patients.[4,5] Early excision of the burn wound has been shown to modulate this hypermetabolic response, with beneficial effects on overall patient morbidity.[3,5,13] Early autografting of the burn wound provides stable coverage of the wound with the patient's native skin. Unfortunately, circumstances arise wherein it is not feasible to accomplish early autografting. There may be a lack of available donor skin to harvest, question of infection or contamination of the burn wound, or the patient may be systemically unstable and thereby unfit to undergo autografting. Furthermore, in the combat or mass casualty scenario, the sheer number of patients requiring excision and autografting may lead to delay in treatment for some individuals. In response to these dilemmas, a multitude of dressing options have been developed to serve as skin substitutes. The goal of these dressings is to temporize the excised burn wound until autografting is possible.[7]

Two of the more commonly used skin substitutes for temporizing excised burn wounds are cadaveric allograft and Biobrane™. In the setting of a clean burn wound with no concern of contamination, both cadaveric allograft and Biobrane™ have been shown to function well for short-term coverage/[14,15] Furthermore, a study by Al-Hashimi et al. showed that Biobrane™ can also be safely and effectively used to cover burn wounds following full-thickness debridement, with low intraoperative and postoperative complication rates.[16] These skin substitutes can safely remain in place up to ten days in the case of Biobrane™ and up to two-weeks for cadaveric allograft.[14] Based on the results of our study, there was no difference in revision or complication rates between the two dressings. This finding is consistent with the results of a systematic review by Pham et al., which found that Biobrane™ was at least as efficacious as cadaveric allograft, though no studies to date have performed a direct comparison of the two skin substitutes.[17]

So how is the clinician to choose between these two dressing options when both are known to be effective? The answer, we believe, comes down to two main factors: time and cost. In the current era of healthcare, there is constant pressure to provide treatment more quickly and at lesser cost, provided that patient outcomes are not adversely affected. As technology advances, we as clinicians must determine whether these advancements are worth the added costs that are invariably associated with them. Nowhere are the effects of time and cost as tangible as in the operating room, where costs can be calculated on a minute-to-minute basis and expenses for supplies increase exponentially.[18,19]

Based on the results of our study, Biobrane™ is the superior skin substitute for temporizing the excised burn wound, both in terms of time and cost. Although there was no statistically significant difference between cadaveric allograft and Biobrane™ in terms of time (148.53 vs. 149.17 minutes, p=0.972) and total cost ($1,533.30 vs. $1,221.34, p=0.184), the average size of burn treated with cadaveric allograft was much smaller than those treated with

Biobrane™ (6.56 vs. 8.51 %TBSA, p=0.155). When time and cost are adjusted based on %TBSA, it becomes clear that Biobrane™ can be used to cover a larger area of excised burn, in less time, and with less associated cost.

The reason, we believe, that Biobrane™ is more cost-effective and time-efficient is its relative ease of application. A sheet of Biobrane™ can rapidly be placed over an excised wound bed and stapled in place, whereas sheets of allograft must be aligned and adjusted before being individually secured. The Biobrane™ glove, which is pre-fabricated to fit multiple hand sizes, is another major source of time saving.[20] Although these gloves are rather expensive in terms of unit cost, they are easily applied over the excised burn wounds on hands and digits, which saves significant time-associated cost.[20,21] Placing and securing cadaveric allograft over each digit is a time consuming process that uses additional supplies, thus increasing total cost. Although our study looked at isolated upper extremity debridement and coverage only, it is not unreasonable to believe these results would apply to other anatomical regions, including the torso or lower extremity.

The ability to rapidly excise and cover a large burn wound can have a significant impact on patient outcome.[2,12] The more time that the thermally injured patient spends exposed in the operating room, the more likely they are to lose core body heat and risk the deleterious effects of hypothermia. Another danger associated with early burn excision and autografting is that these patients are often systemically unstable and requiring vasopressor or inotropic support, which is not optimal for skin graft take. The use of a temporizing skin substitute allows preservation of invaluable donor skin, which can then be autografted when the patient is more stable. Finally, less time spent on the application of the skin substitute means that more burn tissue can be excised in a single stage, which can potentially save the time and cost associated with additional visits to the operating room.

Biobrane™ has other features that can be taken advantage of in the post-operative period. When treating isolated hand burns where sheet grafts are to be placed, Biobrane™ can be used in a serial manner to avoid hematoma formation. This not only saves time during the initial procedure, but may even improve graft take in the final procedure.[22] Furthermore, our collective experience has shown that wounds treated with Biobrane™ tend to be associated with less hyper-granulation tissue, which allows for a softer and smoother autograft appearance postoperatively. Another advantage of the use of Biobrane™ is that it allows for commencement of physical therapy in the immediate post-operative period. While cadaveric allograft requires immobilization for a period of several days to facilitate graft take, range of motion can be started immediately with Biobrane™. Therefore, patients treated with Biobrane™ could have fewer days of immobilization, which should lead to improved overall outcomes.[21]

Not only do the findings of this study impact the care of individual civilians with thermal injuries, they could affect how patients are triaged in the mass casualty setting. When multiple patients simultaneously arrive with thermal injuries, the critical step is excision of the burned tissue as early as possible. This minimizes the systemic hypermetabolic inflammatory reaction and its sequelae. Biobrane™ serves a safe, simple, and reliable skin substitute that can be rapidly applied, meaning that a greater number of patients can be

treated than would be possible with cadaveric allograft given the same amount of time. In combat situations where military personnel may be injured in remote locations, Biobrane™ can allow for early burn wound excision and coverage in the field until transport can be arranged for more definitive coverage. Furthermore, Biobrane™ is easily stored, readily available and has a prolonged shelf life, which is ideal for the aforementioned circumstances. The act of procuring, transporting and maintaining cadaveric allograft is a complex procedure; it is a limited resource that requires a pre-existing infrastructure to be readily available.

The major limitations of this study are that the cohort groups were unequal in size and the population sizes were relatively small. Larger studies are needed to verify the findings of this study in the burn population. Also, the cost structure at our institution may be different from other facilities, as our annual operating room costs are fixed and not tied to actual time spent using the theater. However, the effects seen in this study would likely be magnified at institutions where costs are based on facility usage.

Conclusion

For thermally injured patients requiring temporary coverage of the excised burn wound, our findings suggest that Biobrane™ is the more time efficient and cost effective skin substitute. Due to its relative ease of application, Biobrane™ can be used to safely cover large areas of excised burn in a short period of time. This not only saves operating room time and associated costs, but also spares the patient the risks of a prolonged operation. Based on this study, Biobrane™ may also be the ideal temporizing skin substitute for mass casualty and conflict situations. Military personnel who sustain thermal injuries in remote locations could have their burn wounds rapidly excised and safely covered in the field, pending transfer for definitive care.

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Table I

Patient demographics for the treatment modalities of cadaveric allograft and Biobrane™.

	Allograft	Biobrane™	p-Value
Gender (male/ total)	9/15	23/30	
Age	50.24 ± 15.23	48.43 ± 17.12	0.736
Total TBSA	17.55 ± 21.68	24.23 ± 13.78	0.218
3rd Degree UE TBSA	4.32 ± 4.53	4.44 ± 4.88	0.935
Total UE TBSA	6.56 ± 5.06	8.51 ± 3.96	0.175
Length of Stay (days)	39.3 ± 34.4	36.5 ± 27.3	0.776
Burn Involving Hand(s)	15/15	27/30	
Revision Procedures	2	2	0.470
Procedure Time (minutes)	148.53 ± 65.51	149.17 ± 50.00	0.972
Change in Body Temperature (°C)	0.00 ± 0.67	0.10 ± 0.47	0.854
Cost (Canadian Dollars)	1533.30 ± 957.44	1221.34 ± 552.34	0.184
Cost (dollars) per %TBSA	301.03 ± 141.42	166.09 ± 80.24	**0.0003**[a]
Procedure Time (minutes) per %TBSA	54.78 ± 74.59	21.12 ± 10.66	**0.022**[a]
Cost (dollars) per minute per %TBSA	2.35±1.26	1.30±0.88	**0.002**[a]

[a] denotes statistically significant results ($p < 0.05$).