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A Case Study of Necrotizing Fasciitis in the Neonate Treated With Cultured Epidermal Autografts

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ABSTRACT

Background: Necrotizing fasciitis (NF) is a rare but often fatal bacterial infection of the skin and the soft tissue.

Clinical Findings: Necrotizing fasciitis occurs mainly in adults and remains relatively uncommon in the neonate. Because the presenting skin and laboratory findings are variable, prompt diagnosis is often difficult. The risk of mortality increases with time to intervention.

Primary Diagnosis: This case presents a 4-day old full-term female neonate with NF resulting in a significant scalp defect.

Interventions: The neonate was successfully treated using a novel approach with a cultured epidermal autograft.

Outcomes: The treatment period was effective, and the neonate had an excellent clinical outcome. The neonate was discharged home 21 days post graft application.

Purpose: This case study will highlight the influence of the clinical nurse specialist on care coordination, innovative treatment plans, and resource development for a neonate with NF.

Practice Recommendations: Because of the rare but fatal nature of NF, innovative therapies must be considered. Offering a nontraditional treatment can help improve patient recovery and long-term outcomes. The use of cultured epidermal autograft now provides a new treatment option for neonatal patients in the future.

Key Words: case study, Epicel, necrotizing fasciitis, neonate, skin graft

Necrotizing fasciitis (NF) is a severe and often fatal bacterial infection of the skin, subcutaneous tissue, superficial fascia, and deep fascia.[1] Necrotizing fasciitis is primarily an adult disorder and remains rare in neonates. Laboratory studies are often nonspecific in the early stages, and the presentation is variable, making prompt diagnosis difficult.

Patients often suffer significant tissue loss once disease progression is made. Antimicrobial therapy has limited effectiveness in salvaging the affected tissue bed. Surgical debridement continues to be a mainstay of current therapeutic interventions, leaving patients with full-thickness skin loss over what may be a significant surface area. Disruptions of the skin surface in infancy impede thermoregulation, photoprotection, cutaneous circulation, and immune functions.[2]

This neonatal case reviews the importance of early serial surgical debridement, repeated wound management, and multidisciplinary cooperation. The adoption of adult and pediatric care practices was necessary due to the rarity of NF and the lack of established evidence in neonates. This led to the development of a novel treatment regimen using a cultured skin graft for the treatment of NF in a neonate. To our knowledge, this process has not been done before.

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Epicel product discussed; not labeled for the use in the treatment of necrotizing fasciitis.

The author declares no conflicts of interest.

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CLINICAL FINDINGS

The infant was born full term via spontaneous vaginal delivery without complications. She had a nuchal cord × 2 that was easily and quickly reduced manually. A scalp electrode was used during labor to monitor fetal heart rate. No additional instrumentation was used. The infant was discharged home from the well-baby nursery on day of life 2. On day of life 4, the infant presented to an outside hospital with lethargy and hypoglycemia. Parents reported increased sleepiness, poor feeding, and difficulty waking the infant before the patient's admission. The parents also noted scalp erythema at home. Intravenous fluids and broad-spectrum antibiotic therapies were initiated and then narrowed for confirmed group A *Streptococcus* sepsis. The patient's status declined rapidly, and transfer to the neonatal intensive care unit (NICU) of a large quaternary care children's hospital was deemed imperative to her survival.

Upon admission to the NICU, the infant presented with clinical signs consistent with septic shock. The clinical team began immediate interventions to stabilize the infant's cardiopulmonary condition as well as prevent multisystem organ failure. On continued

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physical assessments of the scalp, the care team noted progressive erythema that evolved into localized purple discolorations with oozing. The appearance of the scalp continued to rapidly deteriorate, with increased edema and areas of epidermal necrosis, prompting consultation with the general surgery service (Figure 1).

INTERVENTIONS

After evaluation, the neonate was immediately taken to the operating room (OR) for debridement, including wide excision of necrotic tissue over the patient's anterior, posterior, and lateral scalp. On hospital day 2, the patient required additional debridement to ensure adequate removal of all devitalized tissue. Plastic surgery was consulted at this point seeking guidance regarding future reconstruction (Figure 2).

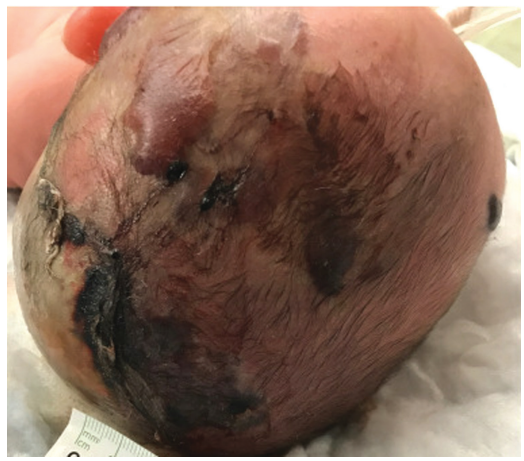
Because of the patient's size, the vast area of exposure, and the severity of illness, treatment options were limited. The head of a neonate represents 18% of the total body surface area. Consequently, a full-thickness injury to the entire scalp carries significant associated morbidity and can be life-threatening.

Cadaveric skin grafts are often used to treat similar injuries in adults, but due to the high likelihood of rejection, they were not considered further in this case. Another option considered after a review of the literature was autologous skin graft from an uninjured donor site on the same patient.[3] Such grafting provides sufficient coverage without the risk of rejection. However, autologous skin grafts seemed unfeasible due to the large surface area required to harvest the patient's tissue.

In consultation with expert colleagues, the plastic surgery team decided on the use of dermal grafting, followed by reconstruction with Epicel, an autologous cultured epidermis. This culture-based option uses a small biopsy of the patient's skin, which is then expanded over 2 to 3 weeks, in vitro, into a confluent epidermal autograft. The advantages of the cultured epidermal autograft include the provision of permanent wound coverage,[4] rapid coverage of the wound, faster pain relief, and a better functional and cosmetic outcome.[5] The disadvantages are the requirement for a skin biopsy, a 2- to 3-week delay for graft cultivation, the lack of a dermal component, and high cost.[5] Epicel is not labeled for use in NF treatment and is currently authorized for use in adults and pediatric patients who have deep dermal or full-thickness burns. Despite there being no previous mention in the literature of this novel approach to skin grafting in neonates, it was chosen as the one most likely to provide a permanent skin barrier.

Before placement of the epidermal autograft, a rebuilding of the dermal elements needed to take place. On hospital day 5, the patient returned to the OR for a washout and debridement. At this time, the plastic surgeon placed an Integra wound dressing over the exposed cranial bone. Integra is a bilayer artificial skin, comprising a noncellular matrix. The outer silicone layer simulates the functions of the epidermis and controls moisture loss and microorganism growth. The inner layer, derived from bovine, acts as a template for dermal regeneration.[6] Integra helps facilitate the blood vessels and other cells to regrow a new layer of dermis.[5] A negative pressure wound vacuum-assisted closure (VAC) device was

FIGURE 1



Status of scalp prior to surgical intervention.

FIGURE 2

Scalp after initial debridement.

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placed to promote fluid drainage, reduce swelling, and enhance perfusion in preparation for the skin graft. The plastic surgery team managed the wound VAC device settings and frequency of dressing changes. Because of the concern for maintaining the integrity of the wound VAC device seal and Integra, the patient was not allowed out of bed.

The patient was taken back to the OR on hospital day 10 for another washout, wound VAC device change, and a full-thickness 2 cm × 4 cm skin biopsy, from the patient's left upper thigh, to be sent for skin expansion. The cultured skin growth was projected to take multiple weeks. During this time, the patient would continue to require medical management and weekly wound VAC device changes (Table 1).

CARE COORDINATION

Training

Before the reconstruction process, the clinical nurse specialist (CNS) organized and led a large interdisciplinary team to help coordinate the care of the novel therapy application. The interprofessional team included registered nurses, frontline clinicians, attending physicians, pharmacists, plastic surgeons, general surgeons, OR staff, physical therapists, respiratory therapists, a wound/ostomy/continence nurse, a burn therapy specialist, and staff from the departments of environmental services, materials distribution, and infection prevention and control. The full team met to address the patient's preoperative and postoperative care needs.

The patient's clinical team received in-depth training on the intricacies of the entire procedure from applying the skin graft to postoperative care. The CNS focused on preparing the clinical team and supporting the work of the bedside nurses to influence the patient's outcome. The burn therapy specialist with autograft expertise aided the CNS in developing patient-specific wound care and dressing-change guidelines.

Nursing Care

It was evident that this therapy would require close attention to detail and focused interventions. There was an early decision to provide 1:1 nursing care. Thus, a small core team of nurses received training for the care following the graft application. The CNS provided training that included environmental considerations, protective precautions and equipment, dressing application, dressing removal, supplies for treatment, and patient care guidelines.

After approximately 3 weeks of waiting for the epidermal graft to grow at an outside facility, the autologous skin cells had proliferated, ranging from 2 to 8 cell layers thick, and the grafts were ready for use. The patient was intubated and started on continuous morphine and dexmedetomidine infusions in anticipation of pain management needs. Versed boluses were on hold for breakthrough agitation. The patient went to the OR, and the grafts were meticulously placed on the scalp. To ensure that the skin graft would successfully adhere to the wound bed with minimal shearing, the grafts were stapled together and then stapled to the healthy tissue surrounding the wound bed, locking them in place. A layer of Vaseline gauze and a mesh veil protected the new skin layers. Before transfer back to the NICU, a firm, multilayer dressing was applied on top of the mesh to ensure that shearing did not occur.

Infection Prevention

Because of the increased risk of infection, strict infection prevention procedures were imposed. Minimal foot traffic was recommended in the patient care area, and anyone entering the patient room was required to wear protective equipment from head to toe. Signs were placed on the room entrance to alert staff of the unique precautions necessary to enter the patient room. The patient's family visited each day but spent minimal time in physical contact with the patient to minimize the risk of bacterial exposure.

Dressing Changes

In adherence with Epicel post graft care recommendations, all dressing layers, with the exception of the sterile nylon net, were changed daily to prevent the accumulation of fluid and bacteria and dry out the grafts. Each dressing change included a sterile takedown to the mesh layer, a 4-hour open-to-air period, and a sterile dressing reapplication. To

FIGURE 3

Post-Epicel placement during a "dry out" period.

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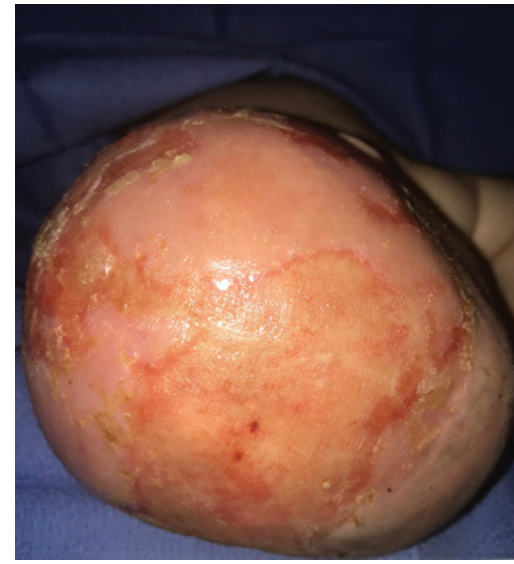
FIGURE 4

Epicel graft, day 7, after dressing and mesh veil takedown.

promote consistency and standardization, photographs were taken of each step of the dressing takedown and reapplication process. The CNS used the photographs to create a wound care document, including necessary supplies and step-by-step guidance for dressing management. These resources were kept at the patient's bedside for reference by all care team members. Often, when providers were unfamiliar with the patient's treatment plan, these resources were referenced for continuity of care.

A standardized time for dressing changes was critical to the patient's ability to heal and for tissue to epithelialize. The CNS, nurse, and respiratory therapist performed the daily dressing takedown. The dressing was removed each morning, prior to patient rounds. This time was determined to be the most convenient for the interdisciplinary team and the family and ensured that the fewest number of people would need to enter the room while the patient's scalp was open to air. It was essential to remove the dressing slowly, as some of the layers would firmly adhere to the graft and would need to be soaked away. Once the dressing was removed, the patient would remain open to air, with minimal movement allowed. The patient was positioned to lie prone with her entire scalp exposed and under an overhead warmer. The nurses increased the room temperature to 88° during the open-to-air periods each day to promote wound healing and

FIGURE 5

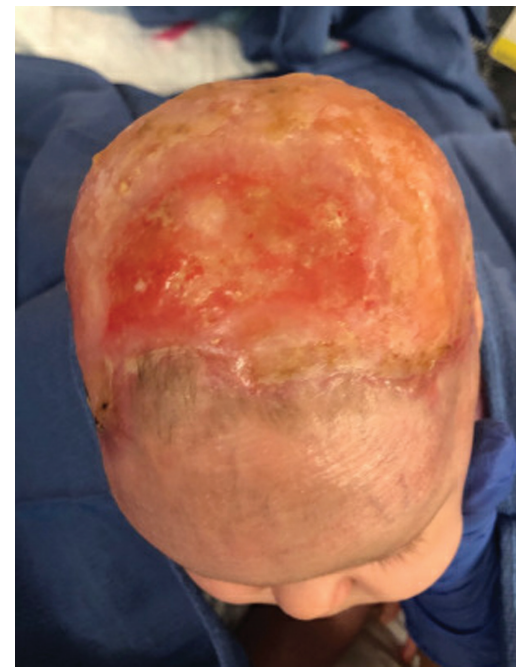


Epicel graft, day 14.

vascularization. Each nurse was deeply invested in the meticulous care of the patient; management of the wound and the need to minimize movement during this vulnerable time often required the nurse to sit next to the patient for hours.

The CNS took daily photographs of the anterior, posterior, and lateral views of the wound and placed them in the electronic health record. The

FIGURE 6



Epicel graft at discharge.

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photographs allowed all care team members to track progress without needing to enter the room. After a 3- to 5-hour "dry out" time, the CNS and the nurse on duty would reapply the multilayered dressing using a sterile technique, while the respiratory therapist supported the patient's endotracheal tube. This dressing included gentamicin antibiotic–soaked gauze, rung out until mostly dry, multiple layers of dry absorptive burn gauze, and elastic netting to hold the dressing in place. The dressing was not intended to be occlusive. The combination of dressings ensured that fluid would be absorbed away from the graft and minimize the risk of maceration of the fragile cell layers (Figure 3).

Removal of Staples

After 1 week, the grafts appeared dry with no evidence of infection and the patient was ready to be taken back to the OR for removal of the dressing, including the mesh, Vaseline gauze, and staples. Upon removal of the Vaseline-impregnated gauze, the underlying graft was exposed, revealing near-total adherence to the autograft sheets. A nonadherent wound dressing was applied directly to the newly grafted skin. Upon return from the OR, the patient no longer required continuous sedation, and she was able to be extubated to room air. The nurse and the CNS continued daily dressing changes with 4 hours of open to air periods for an additional 10 days. Each day, healing was taking place, and the grafts became more and more confluent (Figures 4 and 5).

Discharge Readiness

By 21 days after the graft application, the patient had approximately 90% engraftment. The only areas that were slow to epithelialize and did not have complete healing were the occipital and temporal

TABLE 1. Summary of History and Interventions

Relevant Past Medical History and Interventions			
April 1, 2019	Spontaneous vaginal delivery to G2P1 without complication. Discharged home healthy on day of life (DOL) 2. On DOL 4, the patient presented to OSH with lethargy, hypoglycemia, and scalp erythema.		
Date	**Summary From Initial Visit**	**Diagnostic Testing**	**Interventions**
April 5, 2019	Transfer to level IV NICU	• Immediate blood cultures, CBC, BMP, coagulation profile, iSTAT • Babygram • General surgery consulted	• NPO with DL PICC inserted: Antibiotics, epinephrine, dopamine, sedation infusions started • Peripheral arterial line placed • OR for emergent debridement
April 10, 2019	OR procedure—Integra applied		• Washout, debridement, placement of Integra, and wound VAC device placement
April 15, 2019	OR procedure	• Skin cultures obtained	• Weekly washout, wound VAC change • Excisional biopsy from L thigh
May 6, 2019	OR procedure		• Silicone layer of Integra removed, wound VAC device changed
May 10, 2019	OR procedure—Epicel graft applied	• Preoperative laboratory test results sent • Patient on protective precautions	• Intubated for surgery • Sedation infusions initiated • Initiation of daily dressing change
May 17, 2019	OR procedure—removal of mesh veil	• Patient on protective precautions	• Extubated to room air • Sedation weaned • Continuation of daily dressing changes
May 28, 2019 to June 11, 2019	Daily dressing changes	• Thorough assessment of skin graft healing with open to air	• Off sedation • Full oral feeds
June 11, 2019	Discharge to home		• Breastfeeding • Parents independent with care

Abbreviations: BMP, basic metabolic panel; CBC, complete blood count; DL PICC, double lumen peripherally inserted central catheter; NICU, neonatal intensive care unit; NPO, nothing by mouth; OR, operating room; OSH, outside hospital; VAC, vacuum-assisted closure.

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FIGURE 7

Epicel graft 2 months after discharge.

regions, which was expected because of the pressure to those areas generated while the patient was sleeping. Each day, the new skin became more mature appearing, and the protective dressing became less cumbersome.

It was at this time that the parents began learning the dressing changes. The nurse and the CNS began to perform the dressing changes with the parents in order to familiarize them with the steps. The parents took ownership of the daily dressing changes to get more comfortable and practice while still in the hospital setting. They were eager to take her home and continuously demonstrated readiness for discharge.

After a total of 68 days in the hospital, including 3 weeks post skin graft, the patient was ready for discharge. The parents were instructed to continue to protect the areas that remained unhealed, and the neonate was required to wear a thin cap over the dressing to minimize shearing. The parents, while nervous, felt prepared to care for their daughter at home. Despite all odds, the patient was discharged home, without any need for invasive ventilation, and breastfeeding with minimal interventions was required (Figure 6).

FIGURE 8

The patient 2 months after discharge at home with her family.

LONG-TERM OUTCOME

Currently, the infant is meeting all of her milestones as an 8-month-old and no longer needs to wear a dressing at home during the day. She is rolling over, eating solid foods, sitting up independently, and sleeping through the night.

While her outcome is encouraging to the entire care team, there are some known challenges ahead. Because of the loss of the hair follicles, she will have minimal to no hair growth from the cultured epithelial graft. The grafted skin is also sensitive to UV light and will need consistent protection from sun exposure. The patient will continue to be followed by the plastic surgery and dermatology teams in order to ensure continued healing. The family was aware of the complex emotional needs that may accompany the child later on in life. They expressed the desire to build confidence and self-esteem in their daughter, as she matures and recognizes that she may not look like other children of her age. They were open to hair donations, wigs, and support groups as she matures (Figures 7 and 8).

CONCLUSION

The clinical team worked to balance the many factors that affected the neonate's healing; the infection, the time to engraftment, and the overall time to functional recovery. The partnership between the family and the interprofessional team was crucial to this patient's survival. Caring for a patient with this rare, challenging, and complex condition during her NICU admission demanded collaboration, knowledge, confidence, and expertise, as well as a willingness to innovate. A multidisciplinary approach to medical management and treatment is necessary to limit the spread of disease and increase the chance of survival.

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Summary of Recommendations for Practice and Research	
What We Know:	• Necrotizing Fasciitis is seen infrequently but potentially lethal in neonates. • Evolution of the disease is rapid and requires prompt and specialized management. • Surgical debridement is essential to limiting morbidity and mortality related to necrotizing fasciitis. • Multidisciplinary team approach is necessary in improving outcomes. • Risks and benefits of using cultured skin grafts in neonates.
What Needs to Be Studied:	• Comparison of dressing change techniques and their impact on wound healing. • Long-term outcome of cultured skin grafts. • Promote collaboration between care team members.
What We Can Do Today:	• Identify a local expert who can guide and coach a team to ensure collaboration and teamwork. • Create effective communication mechanism to ensure that changes in care are clear and new team members are provided with the information they need to effectively care for the patient.

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