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Dressings and Products in Pediatric Wound Care

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Significance: The increasing complexity of medical and surgical care provided to pediatric patients has resulted in a population at significant risk for complications such as pressure ulcers, nonhealing surgical wounds, and moisture-associated skin damage. Wound care practices for neonatal and pediatric patients, including the choice of specific dressings or other wound care products, are currently based on a combination of provider experience and preference and a small number of published clinical guidelines based on expert opinion; rigorous evidence-based clinical guidelines for wound management in these populations is lacking.

Recent Advances: Advances in the understanding of the pathophysiology of wound healing have contributed to an ever-increasing number of specialized wound care products, most of which are predominantly marketed to adult patients and that have not been evaluated for safety and efficacy in the neonatal and pediatric populations. This review aims to discuss the available data on the use of both more traditional wound care products and newer wound care technologies in these populations, including medical-grade honey, nanocrystalline silver, and soft silicone-based adhesive technology.

Critical Issues: Evidence-based wound care practices and demonstration of the safety, efficacy, and appropriate utilization of available wound care dressings and products in the neonatal and pediatric populations should be established to address specific concerns regarding wound management in these populations.

Future Directions: The creation and implementation of evidence-based guidelines for the treatment of common wounds in the neonatal and pediatric populations is essential. In addition to an evaluation of currently marketed wound care dressings and products used in the adult population, newer wound care technologies should also be evaluated for use in neonates and children. In addition, further investigation of the specific pathophysiology of wound healing in neonates and children is indicated to promote the development of wound care dressings and products with specific applications in these populations.

SCOPE AND SIGNIFICANCE

GIVEN THE LACK of consensus on the optimal strategies for common wound care management issues in the neonatal and pediatric populations and the large number of wound care products on the market today, it can be challenging to make informed decisions regarding wound care in these populations. A comprehensive review of the literature on the following specific areas of focus: pressure ulcers, surgical wounds, epidermal stripping, intravenous extravasation injuries, moisture-associated skin damage (MASD), and use of negative-pressure wound therapy (NPWT) is presented, along with management recommendations based on the clinical experience of the authors.

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TRANSLATIONAL RELEVANCE

Application of continuing advances in the understanding of the pathophysiology of wound healing, in particular in neonates and children, will hopefully result in the development of advanced wound care products and technologies that address the specific needs of these populations.

CLINICAL RELEVANCE

Despite the lack of evidence-based clinical guidelines for wound management in the neonatal and pediatric populations, clinical practice decisions can be aided by a thoughtful consideration of the published literature and of expert opinion. Such information can also guide future clinical investigations into the safety and efficacy of the use of these products in children as part of a comprehensive initiative to develop evidence-based clinical guidelines for the treatment of acute and chronic wounds in the neonatal and pediatric populations.

DISCUSSION OF FINDINGS AND RELEVANT LITERATURE

Prevalence of wounds in pediatrics

Despite rapid advances in medical and nursing care for pediatric and neonatal patients and the increasingly complex level of care provided to these patients, there has been limited formal assessment of the prevalence, type, and management of wounds in this population. The hospitalized neonatal and pediatric population is at significant risk for the development of acute and/or chronic wounds and other skin-related injuries.[1] A series of three hospital-acquired skin injury (HASI) prevalence surveys performed over 2010–2011 at a university-affiliated tertiary-care children's hospital revealed that pressure ulcers, both medical device-related and immobility-related, was the most common type of HASI, with point prevalence rates of 1.7–3.5%; diaper dermatitis/irritant-associated dermatitis was the next most common cause of HASI.[2] In 2005, a one-day skin integrity audit performed on all inpatients hospitalized at another university-affiliated tertiary-care children's hospital revealed that 43% of patients had a wound and/or surgical incision, 16% of patients with urine and/or stool incontinence developed diaper dermatitis, and 6% of patients were felt to be at risk for the development of pressure ulcers as based on Braden Q score assessment.[3] A 2003 multisite study examining the prevalence of pressure ulcers and skin breakdown in the pediatric inpatient population revealed a pressure ulcer prevalence of 4.0% and the prevalence of other forms of skin breakdown of 14.8%; 66% of pressure ulcers were facility associated.[4] A 1998 survey of 215 neonatal intensive care units reported that an average of 21% of extremely low birth weight neonates developed skin breakdown in the first week of life.[5]

A significant number of children will be discharged from the hospital with a chronic wound, a stoma, or a predisposition to impaired skin integrity that will, by necessity, require some form of home management. Among children receiving home care, a study of 13 home care agencies indicated that 17% of children had a wound; most were treated with hydrogen peroxide, household soap, or povidone-iodine and either left uncovered or covered with dry or saline-soaked gauze.[6] These studies further highlight the lack of clinical knowledge and consensus on the most appropriate standards for wound management in children.

Overview of wound care in pediatrics

Fundamentals of wound care in the neonatal and pediatric population are similar to those applicable to adults and include eliminating any identifiable contributing factors when possible, cleansing of the wound, debridement of devitalized tissue where appropriate, providing a moist wound environment to promote wound healing, identifying and treating associated infection, and protecting the intact skin surrounding the wound from maceration and skin breakdown.[7,8] Optimizing patient nutritional status is also a very important factor.[9] As compared to adults, however, there are important age-related and neurodevelopmental considerations that impact wound care in the neonatal and pediatric populations (Table 1).[10]

Specific concerns in the neonatal population, in particular in premature neonates, include an impaired epidermal barrier, immaturity of the developing immune system with increased risk for infection and impaired thermoregulation.[8] By 34 weeks of gestation or usually within 2–3 weeks of life in preterm infants, the epidermal barrier is usually functionally mature, although skin fragility and susceptibility to irritants and increased risk for percutaneous absorption of topical agents persists. Prior studies have documented disparities in clinical practice with regards to basic skin care and wound management in neonatal intensive care units.[11,12] In 2001, the Association of Women's Health, Obstetric, and Neonatal Nurses and the National Association of Neonatal Nurses published evidence-based clinical practice guidelines for general neonatal skin care.[13] In infants and children, wound care recommendations must

Table 1. *Wound care considerations in neonates, infants, and children*

Premature neonate
Impaired epidermal barrier
• Increased transepidermal water loss and electrolyte imbalance
• Skin fragility and increased risk of epidermal stripping
Increased percutaneous absorption of topical agents due to increased body surface area to weight ratio (*e.g.,* alcohols, povidone-iodine)
Susceptibility to irritants
Impaired thermoregulation
Immature immune system
Term neonate
Skin fragility
Increased percutaneous absorption of topical agents due to increased body surface area to weight ratio
Susceptibility to irritants
Impaired thermoregulation
Immature immune system
Infant
Increased percutaneous absorption of topical agents due to increased body surface area to weight ratio
May attempt to remove dressings
May contaminate wound and dressings, including the diaper area
Need to place dressings securely due to crawling, running, and playing
Fear, anxiety, and pain may complicate wound care and dressing changes
Child
May attempt to remove dressings
May contaminate wound and dressings
Need to place dressings securely due to running and playing
Fear, anxiety, and pain may complicate wound care and dressing changes, in particular with removal of adhesive dressings ("tape phobia")
Need for developmentally appropriate preparation for wound care and dressing changes, including use of child life specialists and caregivers to provide psychological support and distraction
Neurodevelopmental delays may further complicate wound care

also include neurodevelopmental and behavioral considerations.

Fortunately, in the majority of otherwise healthy children, wound healing is brisk, uncomplicated, and requires minimal specialized attention. Chronically ill children, however, in particular those with limited mobility, poor nutritional status, immune compromise, neurodevelopmental delays, and/or frequent hospitalization are predisposed to poor wound healing and iatrogenic skin injury.

Wound healing is a complex, dynamic process that involves four basic phases: coagulation and hemostasis; inflammation; proliferation and repair; and wound maturation and remodeling.[14] As such, the use of specific wound care products by necessity may need to be adjusted during the wound healing process (Fig. 1). Optimal product choice is dependent on several factors: the type of wound present; the overall condition of the patient, including any relevant comorbidities; and the condition of the wound bed, including the presence of infection, excessive granulation tissue, or the presence of devitalized tissue (slough or eschar)

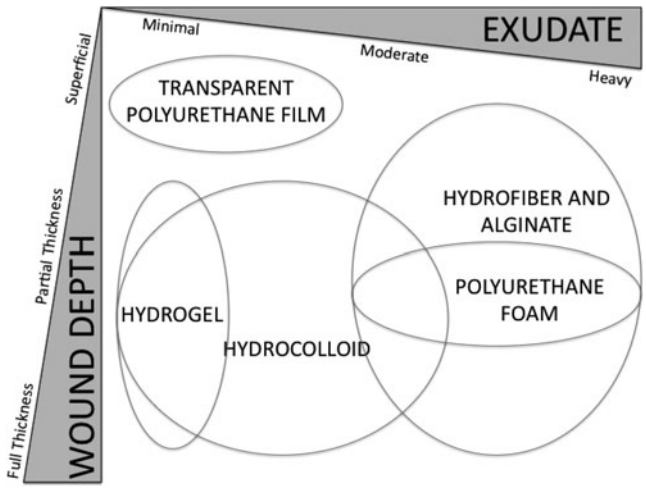

Figure 1. Optimal product choice for local wound care based on depth of injury and amount of exudate.

that may interfere with wound healing. Management of the wound is a dynamic process, and the astute clinician should frequently reassess the wound with regard to wound bed factors, including the depth of injury and amount of exudate, and with regard to the overall patient condition and modify the use of wound care dressings and other products as needed (Fig. 2).

Wound care products and dressings have evolved dramatically from the use of simple wet or dry gauze to highly specialized skin care products (Table 2). Although the use of wet-to-dry gauze dressings is still a common practice in wound care, the use of wet-to-dry gauze has been shown to cause nonselective mechanical debridement of the

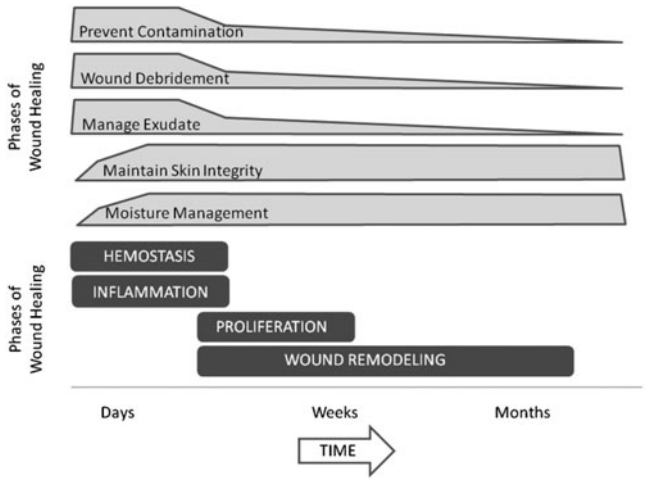

Figure 2. Considerations in dressing and product choice based on the different phases of wound healing.

wound that results in injury to normal tissue, results in desiccation of the wound bed, and is associated with periwound maceration and increased pain during dressing changes; in addition, use of wet-to-dry gauze dressings has been associated with increased cost and labor due to need for more frequent dressing changes and with an increased risk for infection.[15] Alternative, less painful options for selective debridement include use of occlusive dressings to promote autolysis, use of hydrogels, and enzymatic debridement. Use of appropriate wound care products and dressings help to maintain an optimal wound healing environment by maintaining adequate moisture, humidity, pH, and temperature, by minimizing pain, and by preventing damage to the skin surrounding the wound such as epidermal stripping and maceration as well as to address issues such as delayed wound healing due to complications such as bacterial infection, necrotic devitalized tissue, exudate, and slough. Use of specialized wound care dressings may also require less frequent dressing changes. However, overall data on the use of these products even in adults are extremely limited, with a recent assessment of published randomized controlled trials, meta-analyses, and cost-effectiveness studies providing only weak levels of clinical efficacy.[16]

There are currently only a limited number of published clinical guidelines for the evaluation and management of wounds in the neonatal and pediatric populations.[2,13,17–21] None of these have undergone the rigorous assessment required for the generation of evidence-based guidelines. As such, wound care practices and selection of wound care products tend to reflect provider experience and preference.[1] Given these constraints, the authors have utilized a combination of literature review and personal experience on which to base a thoughtful discussion of the use of dressings and other wound care products in the neonatal and pediatric populations with an emphasis on the management of pressure ulcers, epidermal stripping, surgical wounds, MASD, and intravenous extravasation injury and on the use of NPWT. Basic information on types of dressings, examples of specific products often used in neonates and children, indications for use, and special considerations/cautions with use is presented in Table 2. A discussion of other wound care strategies, including use of bioengineered skin substitutes, and of wound care for specialized population such as patients with epidermolysis bullosa, toxic epidermal necrolysis, cutaneous graft versus host disease, or burns, is beyond the scope of this article.

Wound management issues in pediatrics

Pressure ulcers. Pressure ulcers are common in hospitalized neonates, infants, and children, with estimates of point prevalence ranging from 10% to 35%, and they are most common in patients requiring management in an intensive care unit.[18,22,23] The most common sites for the development of pressure ulcers in neonates and children related to immobility are the sacrum/coccyx (most common site in children), occiput (most common site in infants), and heels.[24] More than 50% of pressure ulcers in hospitalized children are related to pressure from devices and equipment, including blood pressure cuffs; tracheostomy cannulas, connectors, and tubing; oxygen delivery devices such as nasal prongs, noninvasive positive pressure ventilation interfaces, and continuous positive airway pressure masks; and cutaneous oximetry probes.[25] In children, pressure ulcers related to medical devices are seen most frequently on the head and neck in association with the presence of a tracheostomy or noninvasive positive pressure ventilation interface, on the torso in association with placement of electrocardiography leads, and on the digits in association with use of pulse oximeter probes.[2,3,26]

The Braden Q Scale and Modified Braden Q Scale were developed to allow for standardized assessment of pressure ulcer risk in pediatric patients. These scales are based on assessment of mobility, activity, sensory perception, moisture, friction/shear, nutrition, and tissue perfusion/oxygenation (Fig. 3B) and help to identify pediatric patients requiring care in a pediatric intensive care unit who are at risk for the development of pressure ulcers.[27,28] Prevention of pressure ulcer development is a major nursing initiative, and is dependent on comprehensive and frequent patient assessment and pressure distribution in at-risk areas through the use of interventions such as appropriate padding of bony prominences and devices that come in contact with the skin; use of age-appropriate specialty mattress such as an alternating pressure mattress, low-air loss, or foam or gel overlay; frequent repositioning; and frequent assessment and rotation, when possible, of medical devices.[1,10,29] Unfortunately, despite use of appropriate preventative measures, pressure ulcers may still occur.

The most commonly used dressings in the management of pressure ulcers in the pediatric population include hydrocolloids, hydrogels (available as amorphous gel and sheets), polyurethane foams, and transparent films.[30,31] In addition, NPWT is also used in the management of Stage III and Stage IV pressure ulcers. Medical device-related pressure ulcers is a challenge in neonates and children

Table 2. *Wound care products commonly used in neonates, infants, and children*

Dressing Class	*Adhesion*	*Indications*	*Function*	*Precautions*	*Examples*
Transparent polyurethane film	May contain adhesive	Skin tears Superficial wounds with little to no exudate Secondary dressing Secure devices to skin	Prevents wound contamination Provides moist wound healing Promotes autolytic debridement Nonabsorptive	Semipermanent; not intended for frequent dressing changes May result in epidermal stripping (if adhesive present)	Tegaderm Opsite
Contact layer	Some contain soft-silicone adhesive	Superficial tears Superficial wounds with little to no exudate First- and second-degree burns Minimal to moderate exudative wounds Pressure ulcers Partial and full-thickness wounds	Prevents wound contamination Provides moist wound healing Allows transfer of exudate into absorbant dressing Nonabsorptive	Requires secondary dressing	Mepitel Mepital-One N-TERFACE Restore Contact Restore Contact Silver Versatel Adaptic Xeroform Conformant Wound Veil
Hydrocolloid (gelatin, pectin, and/or carboxymethyl cellulose)	May contain adhesive	Minimal to moderate exudative wounds Pressure ulcers Partial and full-thickness wounds Promotes autolytic debridement Pressure redistribution	Prevents wound contamination Promotes autolytic debridement Minimal absorption Ease of use	Caution in infected wounds May cause maceration of periwound May result in epidermal stripping (if adhesive present)	Duoderm Tegasorb Medihoney
Polyurethane foam and composite	May contain adhesive	Moderate to heavy exudative wounds Partial and full-thickness wounds Peristomal Pressure redistribution Infected wounds[b]	Ease of removal (only if nonadherent or containing soft silicone adhesive) Ease of use Moderate absorption Pressure redistribution Comfortable	Not for use in dry wounds Requires a secondary dressing (unless compositie)	Polymem[a] Allevyn Lyofoam Mepilex Mepilex-Ag Hydrosorb
Hydrogel	Nonadherent	Minimal exudate or dry wounds Partial and full-thickness wounds Burns	Pressure redistribution Reduce pain Promotes autolytic debridement Promotes epithelialization Adds moisture Minimal to moderate absorption Fills dead space Ease of removal	May over-hydrate wound May macerate periwound; consider applying skin sealant first as protection Requires secondary dressing	Sheet: • Vigilon • Elastogel Amorphous: • Solosite • Intrasite • Normlgel • Hypergel • Carrasyn wound gel
Hydrofiber (sodium carboxymethyl cellulose)	None	Moderate to heavy exudative wounds Partial and full-thickness wounds Wound dehiscence Infected wounds[b] Wounds requiring packing	Promotes autolytic debridement Moderate to marked absorption Ease of removal	Requires secondary dressing	Aquacel Aquacel-Ag
Alginate	None	Moderate to heavy exudative wounds Partial and full-thickness wounds Wound dehiscence Infected wounds[b] Wounds requiring packing	Promotes autolytic debridement Moderate to marked absorption Ease of removal	Requires secondary dressing	Kaltostat Medihoney Maxorb extra Maxorb extra-Ag

(*continued*)

Table 2. *(Continued)*

Dressing Class	*Adhesion*	*Indications*	*Function*	*Precautions*	*Examples*
Barrier	None	Diaper dermatitis Peristomal	Protects against moisture-associated skin damage Protects against epidermal stripping Protects against irritation from adhesives	May be difficult to assess wound with opaque preparations Residual cream or ointment should not be removed prior to reapplication	Stomahesive wafer Stomahesive powder Coloplast wafer Sensicare cream Criticaid ointment White petrolatum Zinc oxide ointment Cavilon No-Sting barrier Marathon

[a]Contains starch co-polymer, glycerol, and surfactant and approved for use in full- and partial-thickness wounds, ulcers, skin tears, surgical wounds, and first- and second-degree burns.
[b]Dressings containing silver.

and strategies to prevent these injuries include protection of underlying skin, frequent assessments of skin located under the device, and frequent rotation of devices, if possible. Prevention of tracheostomy-related pressure ulcers is aided by frequent clinical assessment of the tracheostomy site and by the use of a moisture-reducing and pressure-reducing device interface.[20] Simple use of a thin hydrocolloid or thin polyurethane foam under the tracheostomy cannula, securement ties, and ventilator connector may also be effective.[32] In the authors' experience, use of a polyurethane foam dressing with a gentle adhesive such as soft silicone is preferred to use of a hydrocolloid dressing due to the increased risk of epidermal stripping and skin irritation from the adhesive in the hydrocolloid dressings and use of a dressing with silver is helpful for colonized tracheostomy wounds. Amorphous hydrogels and silver impregnated dressings have been used in the neonates to treat several types of skin injury, including pressure ulcers.[21]

Epidermal stripping. Epidermal stripping is a common form iatrogenic skin injury in neonates and in any pediatric patient with compromised skin integrity, despite the use of an adhesive remover prior to removal of adhesive dressings (Fig. 3C). In addition, adhesive removal is painful and often a source of fear and anxiety in the hospitalized child. An evaluation of several common skin dressings, including one using soft silicone adhesive technology, demonstrated the development of epidermal stripping with use of all dressings except the one using a soft silicone adhesive; the use of the dressing with soft silicone adhesive also minimized transepidermal water loss, a measure of epidermal barrier function.[33] In the authors' experience, use of products with soft silicone adhesive technology is typically better tolerated by neonates and children with skin fragility or impaired epidermal barrier. The use of dressings with soft silicone adhesive technology has also been associated with significantly reduced pain during dressing changes.[34,35]

Choice of an adhesive dressing is dependent on several factors, including the need to manage wound exudate, the need to minimize skin trauma during removal, the need for the dressing to remain in place in areas of high tension, sustained adhesion for the duration of the wear time.[36] Use of a skin barrier product prior to the application of the dressing may also minimize epidermal stripping; however, use of a skin protectant under a product with a soft silicone adhesive may interfere with dressing adherence. Once epidermal stripping has occurred, management strategies to promote re-epithelialization may include application of barrier ointment or cyanoacrylate liquid or application of a transparent film dressing.[37]

Surgical wounds. Surgical wounds are common in the pediatric population, yet there are no clear guidelines for routine postoperative management (Fig. 3D). Complications include wound dehiscence and infection, which are predictors of poor wound healing and other complications. Postoperative wound complications are particularly common after tracheostomy placement, occurring in 29% of patients in one published series.[38] Amorphous hydrogels have been used in the neonatal intensive care unit to treat several types of surgical wounds in the neonatal population, including tracheostomy sites.[21] In the authors' experience, use of a hydrogel is also helpful in maintaining a moist wound environment in neonates with congenital anomalies with exposed mucosa such as cloacal or bladder exstrophy.

Surgical site infections occur in 2.5–6.7% of postoperative wounds and are more common in contaminated and dirty/infected surgical sites.[39–41] Preventing critical colonization and frank infection of wounds is an important component of postoper-

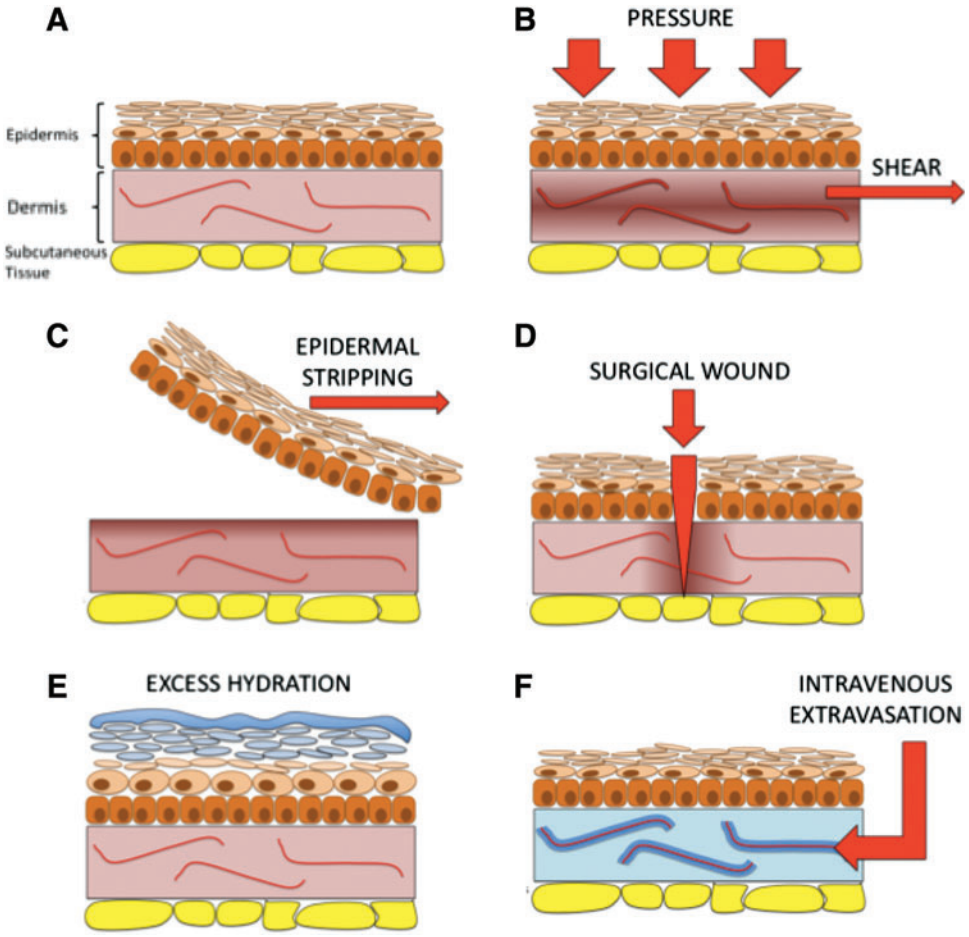

Figure 3. Normal skin with intact epidermis, dermis, and subcutaneous tissue **(A)**. Conditions leading to pressure ulcer development include increased pressure at the surface of the skin in conjunction with shear forces **(B)**. Injury resulting from epidermal stripping **(C)**, surgical wounding **(D)**, moisture-associated skin damage **(E)**, and intravenous extravasation injury **(F)**. To see this illustration in color, the reader is referred to the web version of this article at www.liebertpub.com/wound

ative wound care; however, it has been suggested that routine use of a wound dressing after clean surgery has no impact on the development of post-surgical wound infections in children.[42] In addition to the use of a variety of topical antimicrobial agents, specialized dressings with bacteriostatic or bactericidal properties are also available for the treatment of colonized and/or infected wounds, including surgical wounds. The most commonly used antimicrobial agents incorporated into wound dressings are honey and silver ions.

Honey has been used for centuries in many parts of the world for wound management and has several antimicrobial properties, including high osmotic pressure, low pH, high sugar content, and production of hydrogen peroxide.[43] Several studies have documented the efficacy of medical grade honey in augmenting wound healing and addressing bacterial colonization of wounds in the pediatric population, in particular in oncology patients.[44,45] Although limited, reports on the use of dressings and skin care incorporating use of honey in neonates have also been published.[43] In the authors' experience, some patients may report stinging with use of medical grade honey products, but overall they appear well tolerated and have been successfully used in the treatment of extravasation injury in neonates and in the management of pressure ulcers in neonates and children of all ages.

Use of wound dressings containing silver as an antibacterial agent in the management of critically colonized wounds and in the management of burns has gained popularity in adults; however, use in children has not received rigorous evaluation. There are several different technologies that involve the incorporation of silver into wound dressings, including nanocrystalline silver and ionic silver. Silver ions exert anti-inflammatory and antibacterial effects; although nanocrystalline technology appears to provide the lowest risk of toxicity and the highest level of sustained silver

release to the wound, concerns exist regarding their safety.[46,47] Use in children must take into consideration concerns for silver toxicity as elevated serum silver levels have been documented in children with burns treated with silver-containing dressings.[48] Due to these concerns, the authors advocate for judicious use of silver-containing wound care products in children and for limiting their use to no more than two consecutive weeks when possible. There are several reports in the literature detailing use of silver-impregnated dressings in children, predominantly in burn care.[49–51]

Wound dehiscence is a significant risk factor for postsurgical morbidity and mortality. Risk factors for wound dehiscence after laparotomy in children include age less than 1 year, presence of wound infection, median incision, and emergency surgery.[52] A number of different approaches to the management of wound dehiscence may be considered depending on the size and location of the wound and on the presence of infection. Appropriate wound assessment includes the following: the depth of the wound; the condition of the wound bed including the presence of granulation tissue, slough, and/or eschar; the presence of exposed sutures, hardware, supporting structure (muscle, bone tendon, and muscle/fascia), or internal organs; the amount and type of drainage; the presence of odor; the condition of the wound margins; the presence of associated pain; and the condition of the periwound skin. Commonly used dressings for the management of wound dehiscence include alginates, hydrofibers, hydrogels, hydrocolloids, and foams, depending on the characteristics of the wound. In selected patients, use of NPWT may be considered in the management of chronic and/or otherwise complicated surgical wounds.

Moisture-associated skin damage. MASD results from prolonged skin exposure to factors such as urine, stool, saliva, mucus, and wound exudate, which in combination with other factors such as friction, microorganisms, and chemical irritation, results in skin inflammation (Fig. 3E).[53] Diaper dermatitis is the most common type of MASD observed in the pediatric inpatient population with a point prevalence of 24% in one study; a comprehensive literature review combined with expert opinion and benchmarking with several large pediatric hospitals concluded that the available evidence supports the use of superabsorbent diapers with frequent diaper changes and routine use of skin protectants containing petrolatum and/or zinc oxide in the perineal area.[17]

Skin issues related to MASD are common in children with gastrostomy tubes and include granulation tissue formation, infection, and skin irritation as a result of leakage.[54,55] Use of a hydrocolloid or foam dressing to protect the skin around the gastrostomy site may be helpful in minimizing irritation from leakage, although in the authors' experience use of a hydrofiber dressing around the gastrostomy is more helpful when there is a significant amount of drainage due to the limited absorptive capacity of hydrocolloid dressings. In the experience of one of the authors, use of a hydrofiber dressing around the gastrostomy can also help to prevent the formation of hypergranulation tissue. A barrier ointment such as petrolatum or zinc oxide or a skin-protection powder may be applied to irritated or eroded skin as needed and are also helpful in the management of ileostomy and colostomy site dermatitis.[56] The authors find that the application of Stomahesive Protective Powder combined with a skin barrier product such as 3M Cavilon No Sting Skin Barrier or Coloplast Brave Skin Barrier Wipe ("crusting technique") followed by application of a barrier ointment is a very effective strategy for the management of MASD. Skin protection can also be achieved with use of a cyanoacrylate topical liquid. When dry, these agents create a flexible barrier against moisture, friction, and irritants. In the experience of one the authors, they are particularly useful for protection against highly caustic effluent from high output ostomies, incontinence-associated dermatitis in patients with short bowel syndrome, and for protection around various feeding and surgical tubes such as biliary drains. They are not indicated for use in deep, open wounds; chronic or nonhealing wounds; second- or third-degree burns; or infected wounds.

Intravenous extravasation injury. Extravasation injury associated with use of intravenous catheters is common in hospitalized children, in particular in neonates, and tissue damage and necrosis can result in significant scarring and long-term complications (Fig. 3F). For significant extravasation injury in neonates that results in moderate to severe swelling, blanching, and pain at the site with skin that is cool to the touch, with or without decreased or absent distal pulses and evidence of tissue necrosis, the use of an aqueous gel followed by the application of a hydrofiber sheet covered by a hydrocolloid dressing has been suggested as a reasonable approach to management.[57] Use of a hydrogel dressing or product alone has also been reported to be effective in the management of extravasation injury.[21,58]

TAKE-HOME MESSAGES

- Although general principles of wound healing are similar in children and adults, there are limited clinical guidelines to direct the choice of specific wound care products in the management of wounds in children.
- Developmental and behavioral considerations should be taken into account when choosing wound management strategies in neonates, infants, and children.
- Epidermal stripping of neonatal skin in particular and of compromised skin in pediatric patients of any age is a common form iatrogenic skin injury that can be minimized with the use of dressings with soft silicone-based adhesives.
- The use of medical-grade honey appears to be safe and well tolerated for use in children.
- The use of silver-based technology in wound dressings for use in children to provide antimicrobial properties requires additional evaluation due to concerns regarding silver toxicity, although the use of newer nanocrystalline silver products appears promising.
- Wound care in neonates, infants, and children should also include appropriate neurodevelopmental assessment and modification of the wound care regimen to ensure minimal pain and anxiety and to facilitate wound healing.

Negative-pressure wound therapy. NPWT, also known as vacuum-assisted closure, has been shown to facilitate wound healing for a variety of acute and chronic wounds in adults. NPWT reduces tissue edema, increases tissue perfusion, removes exudate, and facilitates granulation tissue formation. Several retrospective case series provide evidence that use of NPWT in neonates and children can augment wound healing in a variety of acute and chronic wounds, including infected wounds, those with exposed orthopedic hardware, and surgical wound dehiscence, with successful use reported in 92–100% of patients.[19,59–63] Reported complications, including enteric fistula formation, bleeding, pain, and periwound skin breakdown, were uncommon and in the case of fistula formation, related at least in part to the patients' underlying disease process. In addition to facilitating wound healing, benefits of NPWT included decreased frequency of dressing changes, reduced need for use of pain medication, and decreased length of hospital stay.

The safety and efficacy of these devices in neonates, infants, and children, however, has not been established and there are no devices that are approved by the U.S. Food and Drug Administration for use in these populations; serious safety events, including injury and death related to bleeding and infection secondary to retained foam dressing particles, have been reported in adults treated with NPWT. Guidelines for the use of NPWT in neonates, infants, and children have been proposed and include age- and wound-specific recommendations for negative pressure settings and choice of foam dressing.[19] In the experience of several of the authors, negative pressure settings that correlate to – 25 mmHg above the mean arterial blood pressure of the patient in the neonate, infant, and toddler population are initially utilized and adjusted as needed based on comorbidities, perfusion status, wound location, and pain tolerance. Providers should remember that neonates and infants in particular are at risk for fluid loss and dehydration during treatment with NPWT.

FUTURE CONSIDERATIONS

In addition to the promotion of an initiative to develop clinical trials to address the safety and efficacy of the use of currently marketed wound care dressings and products in the neonatal and pediatric populations, the available technologies for advanced wound care continue to evolve; thus, additional wound care products with potential pediatric and/or neonatal applications will hopefully emerge in the future. In addition, further investigation of the specific pathophysiology of wound healing in neonates and children is indicated to promote the development of wound care dressings and products with specific applications in these populations.

CONCLUSIONS

The lack of evidence-based clinical guidelines for the prevention and management of common skin and wound issues in the neonatal and pediatric population is an obstacle to the provision of appropriate and accountable care. The development of evidence-based practice guidelines that address these concerns and incorporate the rational choice of specialized wound care dressings and products should be a priority for wound care specialists with pediatric and neonatal expertise with a goal of promoting standardization of clinical practices.

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Abbreviations and Acronyms

HASI = hospital-acquired skin injury
MASD = moisture-associated skin damage
NPWT = negative-pressure wound therapy