Skin Care for ELBW Infants
Control of Transepidermal Water Loss, Use of Emollients and Adhesives, Skin Breakdown and Infection

Carolyn Lund RN, MS, FAAN
Neonatal Clinical Nurse Specialist

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• Funding from Natus, Inc for investigator-initiated study on effect of LED phototherapy on TEWL

Definitions Regarding Birth Weight
• LBW: low birth weight (<2500 grams)
• VLBW: very low birth weight (<1500 grams)
• ELBW: extremely low birth weight (<1000 grams)

Immature Skin

Layers of Stratum Corneum in Premature, Term Newborn and Adult Skin

Measuring TEWL: Evaporimeter
**Premature Infants and TEWL**

- 23 weeks
  - 75 g/m²/hr
- 26 weeks
  - 45 g/m²/hr
- 29 weeks
  - 17 g/m²/hr
- 32-40 weeks:
  - 5-10 g/m²/hr
- Stratum corneum becomes mature at 30-32 weeks PCA

**Development of Skin Barrier Function in Premature Infants**

- 10 infants, 23-32 weeks gestational age, <7 days of age
- Measured barrier function using two methods: TEWL (evaporimeter) and impedance spectroscopy
- Barrier matures at 200-230 days (30-32 weeks)

**TEWL in Infants Born at 24 and 25 Weeks**

<table>
<thead>
<tr>
<th>Day of Life</th>
<th>TEWL [g/m²/hour]</th>
<th>Fluid Loss in 24 hours [ml/kg/day]</th>
<th>Humidity [%]</th>
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<tbody>
<tr>
<td>0,1</td>
<td>58.4</td>
<td>165</td>
<td>50</td>
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<td>50</td>
</tr>
<tr>
<td>28</td>
<td>24.2</td>
<td>66</td>
<td>50</td>
</tr>
</tbody>
</table>

**Thermoregulation and the VLBW Infant**

- Prematures < 30 weeks predominately lose heat via evaporation because stratum corneum is deficient
- Thermoregulation must primarily address heat loss from evaporation

**Strategies to Decrease TEWL and Evaporative Heat Loss**

- Plastic wrap or bags
- Supplemental conductive heat
- Incubator rather than radiant heater
- Humidity >70%
- Transparent adhesive dressings
- Emollients
Polyethylene Bags Prevent Heat, Fluid Loss in ELBW Infants

- Vohra (1999): RCT comparing bag to standard care; bag infants’ temperature 1.9° higher when admitted to NICU; benefit only seen if <28 weeks
- Knobel (2005): bag infants’ temperature 0.5° higher, delivery room kept at higher temperatures
- Vohra (2004): bag infants had higher temperatures when admitted to NICU, but at one hour same as controls
- HELP Trial: enrolling 1600 infants, 24-27 weeks, outcomes: temperature, mortality

Radiant Warmer vs. Incubator

- Kjartansson (1995): TEWL determined by water vapor pressure in air surrounding infant; radiant warmer dries the air more; “microclimate”
- Meyer (2001): better temperature control with radiant warmer, but increased fluid intake, more problems with serum Na levels >150
- Maayan-Metzger (2004): TEWL similar in both warmer and incubator; humidity levels 34% radiant warmer, 38% incubator

Supplemental Conductive Heat Reduces Radiant Heater Output

Heated Mattress with Radiant Warmer

Increasing Humidity Reduces TEWL

Humidified Incubators
Improved Care and Growth Outcomes by Using Hybrid Humidified Incubators in Very Preterm Infants

- Retrospective study of 182 infants <1000g
- Conventional incubator (CI) group (n=87) admitted to RW, moved to CI with no added humidity; 2002-2003
- Hybrid incubator (HI) group (n=95) used radiant heat mode at first, then 70-80% RH for week 1, 50-60% RH week 2 until 30-32 weeks

Results: babies using the Hybrid incubator w/humidity
- Decreased fluid intake, urine output, wght loss, hypernatremia
- Increased hypoaetremia on day 1, improved growth rate
- Decreased incidence severe BPD, duration of assisted ventilation
- Increased sepsis also reported, but not statistically significant

Humidity and Skin Barrier Maturation in Extremely Preterm Infants

- 27 infants, 23-27 weeks
- 85% humidity during the first week
- Randomized to 75% or 50% at 7 days
- Measured TEWL, fluids, serum Na
- At 28 days, infants in 75% humidity had less mature skin barrier compared to infants in 50% humidity

CHO Humidity Guidelines

- High humidity (>70%) for first 7 days
  - 23-26 weeks--85%
  - 27-30 weeks--70-75%
- Avoid flexion (skin-on-skin contact, no diapers) for first week
- Decrease to 50% after first week, d/c added humidity after one month

Transparent Adhesive Dressings and TEWL

- Four studies (1989-1995) studied transparent dressings effect on TEWL
- TEWL decreased by more than half with dressings
- Mancini (1995): transparent dressings accelerate maturation of stratum corneum
- Biggest problem with transparent dressings: skin breakdown when removed!

TEWL Reduction

- Polyethylene bag in delivery room for <28 weeks
- Choose from following techniques:
  - High humidity
  - Transparent adhesive dressings
  - Supplemental conductive heat
- High humidity (>70%) for first 7 days
  - 23-26 weeks, 85%
  - 27-30 weeks, 70-75%
- Decrease to 50% after first week
- D/C added humidity after one month, or at 30-32 weeks
**Phototherapy and TEWL**

- Halogen phototherapy lights increase TEWL by 10% in premature infants <1500 grams; fluorescent phototherapy lights do not increase TEWL (SPR 2003: Lund, Nonato, Kuller, Durand)
- LED phototherapy lights do not increase TEWL in neonates (AAP 2005; Lund, Kuller, Durand)

**Mist and Water Condensation inside Incubators Reduce the Efficacy of Phototherapy**

- Experimental study
- 3 types phototherapy (fluorescent, halogen, LED)
- 3 levels humidity: 60-70%, 80-90%, >90%
- Increased mist, condensation >80%
- Decreased irradiance phototherapy with halogen (by 50%), LED by (10%)
- Fluorescent irradiance extremely low, no change

**Emollients in Premature Infants**

- Lane & Drost (1993): Eucerin cream treated infants had better appearance, no difference in barrier function (TEWL)
- Nopper (1996): Aquaphor treated infants had improved barrier function, appearance; fewer infections (60 infants, not a big enough sample to prove this)
- Pabst (1999): 19 infants, 26-30 weeks, <24 hours old received Aquaphor BID or standard care; no difference in fluid intake, NA levels, weight, skin microflora; skin condition better with Aquaphor

**Effect of Prophylactic Ointment Therapy on Nosocomial Sepsis Rates and Skin Integrity in 501-1000g Infants**

- 1191 subjects, randomized to prophylactic Aquaphor (BID) vs “routine skin care” in first 14 days of life
- No difference in combined outcomes (sepsis or death)
- Prophylactic group had increase sepsis w/CONS (25.8% vs 20.4%), more septic work-ups (highest in <750 g)
- No increase in gram negative or fungal sepsis
- 34% of “routine treatment” group received Aquaphor ointment for 4 days
- Prophylactic group had better skin scores

**Effectiveness of No-Sting Skin Protectant and Aquaphor on Water Loss and Skin Integrity in Premature Infants**

- 69 infants, mean GA 28.5 weeks, birthweight means 1117-1215 g
- Randomized to Aquaphor BID or sprayed with No-Sting once a week for 2 weeks
- Both equally effective in reducing TEWL
- Skin condition score better with Aquaphor
- Used high humidity as well
**Unacceptable Skin Dryness**

- Role of emollients in routine skin care for healthy newborns not clear
- Substantial research on preservative-free, petrolatum-based emollients in premature infants
- Apply sparingly, for dry or cracked skin
- Use single patient tubes or jars to prevent cross contamination
- Prophylactic use in ELBW infants not recommended

**The Effect of Daily Treatment with an Olive Oil/Lanolin Emollient on Skin Integrity in Preterm Infants**

- Kiechl-Kohlendorfer (2008)
- RCT of 173 infants, mean GA 30 weeks, mean BW 1500 g (1/3 were less than 30 wks)
- 2 treatment groups, 1 control
  - Water-in-oil emollient cream
  - Olive oil/lanolin cream (made in the pharmacy)
- BID application for up to 4 weeks
- Treated skin better than untreated skin
- Best skin scores with olive-oil/lanolin
- Blood cultures + in 8 treated infants (6 CONS, 1 MSSA, 1 Klesiella)

**Topical Oils and Skin Barrier Function**

- Darmstadt (2002): used hairless mouse model for skin, stripped with tape to remove stratum corneum
- Sunflower seed oil accelerated skin barrier recovery
- Aquaphor ointment also significantly improves skin barrier recovery
- Mustard oil, olive oil, soybean oil delay skin barrier recovery

**International Skin Science**

- Darmstadt (2008, Peds 121:522-528)
- 497 preterm infants <33 weeks in Bangladesh
- Sunflower seed oil, Aquaphor, control groups
- Treated 3x/day for first 2 weeks, 2x/day for 2 weeks
- Sunflower seed oil decreased mortality 26%
- Aquaphor decreased mortality 32%

**Relaxing after Massage**
Adhesives in the NICU

- Widely used in premature and full term infants
- Attach life support devices such as ETTs, intravenous and arterial catheters, chest tubes, and monitoring sensors, electrodes
- Adhesive removal was primary cause of skin breakdown in AWHONN neonatal skin care project

Other Adhesive Products

- Hydrocolloids, pectin barriers
- Hydrogels
- Transparent adhesive dressings
- Silicone adhesives

Disruption of Barrier Function Associated With Adhesive Removal


- 30 infants, 26-40 weeks, <7 days of age
- Significant alteration in TEWL, color, visual assessment after removal of plastic tape and pectin barrier
- Changes seen in bigger as well as smaller babies
- Hydrogel fell off in 7 infants before 24 hours

Types of Adhesive Skin Damage

- Skin stripping
- Tearing
- Maceration
- Tension blisters
- Chemical irritation
- Sensitization
- Folliculitis

Anetoderma of Prematurity

Concerns with Adhesive Removers

- Solvents contain hydrocarbon derivatives or petroleum distillates
- Toxicity can result from absorption through the skin
- Case report of skin injury and hemorrhage in premature infant after exposure to Detachol
Tips for Safer Adhesive Removal

- Peel adhesive back parallel to skin surface instead of straight up.
- Hold skin surface next to adhesive.
- Use water soaked cotton balls.
- Use mineral oil, petrolatum ointment if no need to reattach appliance.
- Transparent dressings: stretch to release adherence.

Bonding Agents

- Tincture of Benzoin, Mastisol
- Increase adhesive strength
- Used to enhance adhesion of wound closure tapes
- Not recommended in newborns, can increase epidermal stripping

What to Do With Benzoin

Barrier Films

- Plastic polymers sprayed or wiped on skin to protect from trauma
- Alcohol-free products less irritating to skin
- Cavilon is FDA approved in infants >30 days as diaper dermatitis treatment
- Other manufacturers haven’t approached FDA

New Technology: Silicone Adhesives
Silicone Tape in High Humidity

Silicone Tape

Silicone Dressing

Stretchy COBAN

- Attaches to itself without adhesives
- Caution—if too constricting can interfere with blood flow

Redesigning Adhesive Products

Adhesive circles have removable top layer

Snap-on design allows replacing sensor every 4 hours without removing adhesive

Soft material with Velcro Stabilizing band to secure cable

Skin Infections in VLBW Infants

- Previously, most likely suspect was candida
- Also consider other pathogens: MRSA, gram negative bacteria
- Skin cultures, gram stains very helpful

Cutaneous Candida
Invasive Fungal Dermatitis in the <1000 gram neonate

• Series of 16 prematures, 474-855 grams
• Fungal dermatitis in first 2 weeks of life
• Ulcerative, corrosive lesions
• Skin portal of entry: early colonization, immature barrier
• Often associated with systemic involvement

Approach to Fungal Dermatitis

• Culture, gram stain or KOH prep of any skin breakdown
• If yeast present, evaluate for systemic symptoms such as thrombocytopenia, hypotension, acidosis
• Send blood culture, urine for hyphae
• Consider systemic antifungal therapy before blood culture is positive
• Topical antifungal ointment (not cream or powder)
• Some times it isn’t yeast!

Invasive Fungal Dermatitis

Approach to Fungal Dermatitis

Candida +

Ecthyma Gangrenosum from Pseudomonas
Conclusions

• ELBW infants have decreased skin barrier function with increased TEWL and evaporative heat loss
• This must be addressed in their environment of care
• Use of emollients not recommended routinely in this population
• New adhesive technologies are encouraged