Neonatal Skin Care: Understanding Unique Differences in Neonatal Skin and Evidence-based Skin Care

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Skin Layers

- Epidermis
- Dermis
- Subcutaneous tissue
  - Hair follicle
  - Sebaceous gland
  - Sweat gland
- Stratum Corneum
- Basal Layer
What is Skin Barrier Function?

- Ability of skin to protect and function as barrier to toxins, pathogenic organisms
- Can be measured by the skin’s ability to hold on to water (TEWL), stay hydrated (SCH); influenced by pH
- Immaturity, alterations in pH, skin injury or disease can result in impaired barrier function
Measuring Skin Barrier Function

• TEWL
  – Transepidermal Water Loss

• pH
  – acid-base balance

• SCH
  – Surface hydration

Stratum Corneum and TEWL

- 10-20 layers of stratum corneum in term infants and adults
- Far fewer layers in premature infants <30 weeks, increased fluid and heat losses
- Evaporimeter measures skin barrier function—TEWL (transepidermal water loss)
- 5-10 gms H₂O/m²/hr in adults

(Neonatal Skin: Structure and Function, 1982)
Premature Infants and TEWL

- 23 weeks
  - 75 gmH₂O/m²/hr
- 26 weeks
  - 45 gmH₂O/m²/hr
- 29 weeks
  - 17 gmH₂O/m²/hr
- 32-40 weeks:
  - 5-10 gmH₂O/m²/hr
- Stratum corneum becomes mature at 30-32 weeks PCA
Strategies to Decrease TEWL and Evaporative Heat Loss

• Plastic wrap or bags
• Supplemental conductive heat (heated mattress)
• Incubator rather than radiant heater
• Humidity >70%
• Transparent adhesive dressings
• Emollients
Hats and Wraps and Bags
Increasing Humidity Reduces TEWL

Hammarlund K & Sedin G (1979)
Acta Paediatr Scan 68:795-801
High Humidity for ELBW Infants
Improved Care and Growth Outcomes by Using Hybrid Humidified Incubators in ELBW Infants

- 70-80% RH for week 1, 50-60% RH week 2 until 30-32 weeks
- ELBW infants using hybrid incubator w/humidity
  - ↓ fluid intake, urine output, weight loss, hypernatremia
  - Improved growth rate
  - ↓ incidence severe BPD, duration of assisted ventilation
- Trend toward more sepsis, not statistically significant

Cohesion Between Epidermis and Dermis

Top two layers of skin connected by fibrils

Fewer and further apart in premature infants

Adhesives can attach more securely to epidermis than the epidermis is attached to the dermis

(Neonatal Skin: Structure and Function, 1982)
Skin pH

- pH >6.0 at birth, falls to <5.0 in 4 days
- Premature infants--pH 5.5 after one week, 5.1 after one month
- Diapered areas--pH 6.0
- pH of adult skin 4.7 (24 hours after bathing)
- Acid mantle is protective--at pH 4.7:
  - resident flora grow (staph epi, micrococci, coryneforms, propionbacteria)
  - transient flora is inhibited (gram negative such as E. Coli, pseudomonas; gram positive staph; candida)
- Normal tap water increases pH for awhile
Increased Risk of Toxicity from Topical Agents in Newborns

- Newborn dermis is 40-60% the depth of adult dermis
- Larger surface area (compared to body weight) exposed to topical agent
- Stratum corneum maturity and integrity are factors, especially in premature infants
- pH of skin surface: more alkaline pH increases permeability
- Occlusion (ie, wearing a diaper) compromises stratum corneum, skin barrier
Newborn Skin Colonization

What we thought:

After C/S, skin thought to be sterile
In utero, fetal skin not colonized (except PROM, selected organisms such as group B strep, candida)
“..skin flora resembles that of adults after the first few weeks..”

(NEONATAL SKIN: STRUCTURE AND FUNCTION, 2003)

What we are learning:

• Skin, GI, respiratory tract colonized with thousands of microorganism species
• 9/10 cells are microbial
• “Microbiome” based on DNA sequencing (PCR)
• Most are commensal (“good bacteria”)
• Imbalance may lead to disease states
Microbiome Aspects of Perinatal and Neonatal Health¹

• Using PCR technique, previously undetected microbes found in amniotic fluid with intact membranes, possible link to premature labor
• Vaginal birth infant skin colonized differently than C/S birth²
• 64-82% of MRSA infection found in C/S births³
• Intestinal microbiome altered in premature infants — antibiotics, often C/S
• Lack of protective bacteria may be involved in pathogenesis of NEC

2 Dominquez-Bello 2010
3 Malloy, Peds 2008; 122:285
Delivery Mode Shapes Initial Microbiota in Newborns

Dermal Microflora Transmission From Mother to Baby At Birth Correlates With Region of First Maternal Contact

Mother’s Body Habitat or Baby’s Delivery Mode

Diversity of the Human Skin Microbiome Early in Life

Skin swabs from 31 infants

Infant skin:
- **Firmicutes** predominate (staph, strep, propionbacter)

Adult skin:
- **Actinobacteria** predominate (gram + organisms, mycobacteria, corynebacteria)

**Establishment of healthy skin microbiome may have role in denying access to infectious microbes, help to modulate inflammation**

Innate Immunity of Skin

- Symbiotic relationship between skin and skin flora: skin provides sebum (lipids), sweat (minerals), dead skin cells (protein) to resident flora
- Resident flora strengthens the skin’s first defense (acid mantle) by producing anti-bacterials which compete and prevent colonization with harmful bacteria

Antimicrobial defense system in the skin is more than just a mechanical barrier
What is Vernix Caseosa?

- Cheesy substance composed of sebum from sebaceous glands, broken-off lanugo, desquamated cells—unique to humans
- Primarily water (80%), lipids, protein
- Production begins end of 2nd trimester, most accumulated 36-38 wks
- Vernix detaches from skin as levels of pulmonary surfactant rise

Vernix contains LL-37 and lysozymes, have antibacterial effects against pathogens (E. coli)
First Bath

• Studies indicate that newborns bathed as soon as 1 hour after delivery will maintain their temperature if they have a normal temperature to begin with

• AWHONN Guideline:
  – Vital signs, temperature stable 2-4 hours
  – Antiseptic cleaners not currently required by American Academy of Pediatrics, Center for Disease Control
  – Universal precautions until bathed
  – Not necessary to remove all vernix

• WHO: wait at least 6 hours

• Would they, or their mothers, choose to be bathed as early possible?
How to Give the First Bath?

- Sponge bath
- Under the faucet
- Small tub
- Large tub “immersion bath”
- Swaddle bath
Tub Bathing vs. Sponge Bathing

- **Hennigson (1981):** 232 newborns, no infection or colonization problems, better temperature, less crying with tub bathing
- **Hylen (1983):** 618 newborns, rectal temperatures better with tub bathing, no difference in infection
- **Anderson (1995):** axillary temperatures stable with tub bath, better for attachment and bonding
- **Cole (1999):** tub bath maintained temperature better, 70% remained drowsy or quiet alert vs 90% crying with sponge bath
- **Bryanton (2004):** 102 newborns randomized to tub or sponge bath. Tub bath less temperature loss, no differences in umbilical cord healing, behavior more content, mothers rated more pleasurable
- **Loring (2012):** 100 infants (35-36 6/7 weeks) randomized to immersion tub bathing or sponge bathing, tub bathed infants had overall higher and less variability in body temperature
Swaddled Bathing
Water alone vs. Baby Wash Studies

- **Gfatter (1997):** RCT 40 infants; all bathing (water, liquid cleanser, bar cleanser, soap) caused transient $\uparrow$ pH, $\downarrow$ SCH; significant only with soap
- **Hoeger (2002):** 202 neonates, water only bath 2x/week; pH $\downarrow$, $\uparrow$ SCH over first 4 weeks, desquamation on cheeks, forehead
- **Bartels (2010):** RCT 60 neonates (water, gel wash, crème after water, crème after gel wash); TEWL, SCH better when emollients used
- **Lavender (2013):** RCT 307 neonates, water vs liquid baby wash; no difference in TEWL, pH, SCH at 2 and 4 weeks; moms preferred using baby wash
Our “First Bath” Study (2012-13)

• 100 babies randomized to first bath with water alone or water with liquid baby wash
• 50 vaginal birth, 50 C/S
• All babies immersed and swaddled in the bath
• Pre and Post-Bath:
  – pH
  – TEWL
  – stratum corneum hydration
  – Skin microbiome (baby, mom)
  – Baby’s temperature
  – Water pH, hardness
Bathing Premature Infants

• 2013 AWHONN Guideline:
  
  – For preterm infants less than 32 weeks of gestation, gently clean skin surfaces using warm water only during the first week of life.
  
  – Preterm infants should usually not be bathed daily.
Premie Bathing Studies

- **Quinn (2005):** 53 subjects 560-1950 grams; sponge or tub bath with Johnson & Johnson “soap” and gauze bath every 2 vs 4 days; bathing every 4 days does not result in increased skin colonization

- **Da Cunha (2005):** 73 subjects 800-1800 grams; sponge bath with water only or liquid soap and water; both decrease number of colonies of gram + and gram – bacteria

- **Sankar (2009):** 60 subjects 1001-2000 grams; a single skin cleansing with .25% CHG did not adversely affect skin condition or temperatures, reduces bacterial colonization axillary but not groin
Stress of Bathing

• **Peters (1998):** physiologic and behavioral disruption during sponge bathing

• **Tapia-Rombo (2003):** sponge baths cause stress in premies

• **Lee (2002):** sponge bathing causes stress in premies; they should be stable before you start

• **Liaw (2006):** tub bathing causes stress in premies
Should We Reconsider Antimicrobial Bathing?

- Concerns about community-acquired MRSA
- Newborns seen in emergency departments with cellulitis, skin infections due to MRSA
- Hospital-acquired infection
Daily CHG Bathing to Reduce Bacteraemia in Critically Ill Children

- PICU patients > 2 months of age in 5 US units
- Randomized by unit type (cardiac, medical, surgical)
- Daily bath with CHG vs soap/water or bath cloth
- 4947 pts enrolled (ITT group); 4072 received the full protocol (PP group)
- Significant reduction bacteraemia in PP group
  - 3.28 per 1000 days vs. 4.93 per 1000 days
- 1% bathed with CHG withdrew due to skin irritation

Milstone et al (2013); Lancet 381:1099-1106
Misadventures in Neonatal Skin Care

• Hexachlorophene (Phisohex)
  – Used to control outbreaks of *s. aureus* infection in nurseries
  – Initial bath after birth, then every 2 days
  – Irreversible brain damage (vacuolar encephalopathy) found in premature infants washed 4 or more times
What is Chlorhexidine?

- Topical antiseptic used since 1954
- Hand washing, skin prep, vaginal antisepsis, gingivitis, body washing
- Concentrations: 0.5%-4%, with or without isopropyl alcohol or methanol
- Low concentrations affect membrane integrity, high concentrations cytoplasmic (cell death)
- Some pseudomonas species, other non-fermenting gram negative organisms have high level resistance

Milstone AM et al, Healthcare Epidemiology (2008), 46:274
Chlorhexidine Baths for Newborns

**Da Cunha (2008):** RCT of 94 full term newborns, cleanser vs. 0.25% CHG; staph aureus colonization reduced at 24 hours (36.7% vs 13.6% with CHG)

**Sankar (2009):** RCT of 60 premature infants 28-36 weeks; 0.25% CHG, saline, no cleansing; CHG reduced colonization by half in the axilla at 24 hours but not at 72 hours; no difference in the groin at 24 or 72 hours; skin scores not changed
Chlorhexidine Gluconate Bathing

- Safety in neonates?
- Influence on normal colonization, barrier function?
Hexachlorophene and CHG are phenol derivatives, but differ chemically; hexachlorophene is bacteriostatic, CHG is bacteriocidal

CHG more strongly binds to protein in the SC, withstands removal by alcohol

Recent survey indicates that 61% of NICUs use CHG
  - some restrict by weight, GA
  - report adverse skin reactions, no systemic toxicity

Skin irritation seen in preterm infants, even with aqueous CHG

CHG absorption also a concern, seems to increase with repeated exposures
Skin Disinfectants

• Chlorhexidine gluconate (CHG)
  – 2% CHG aqueous
  – 2%, 3.15% CHG in 70% isopropyl alcohol
  – 0.5% CHG in 70% isopropyl alcohol

• Povidone Iodine (PI)

• Isopropyl Alcohol (IA)
New FDA Labeling (2013) for CHG/isopropyl alcohol agents

“Use with care in premature infants less than 2 months of age. These products may cause irritation or chemical burns.”
Disinfectant Issues: Toxicity

• PI shown to cause thyroid abnormalities in premature infants
  – Smerdley (1989); Parravicini (1996); Mitchell (1991); Linder (1997)

• CHG toxicity: rare reports
  – Ocular and corneal damage
  – Reports of anaphylaxis in adults with impregnated catheters
  – Frequent surgical exposure
Disinfectant Issues: Efficacy

- **Adults**: CHG reduced risk for catheter-related blood stream infection by 49%; Chaiyakunapruk (2002)
  - CDC strongly recommends 2% CHG/70% isopropyl alcohol used for insertion of CVC, dressing changes
  - CVC in adults average 7-10 days duration

- **Neonates**: CHG reduces skin colonization, reduces contaminated blood cultures, no evidence for reducing blood stream infection Garland (2009)
  - CVCs in neonates have longer dwell times
  - Care of IV tubing, accessing IVs may be more important to prevent infection Mermel (2011)

- Isopropyl alcohol least effective at reducing bacterial colonization, very irritating Maki (1991)
Chemical Burns:
Povidone-iodine + isopropyl alcohol
Chemical Burns:  
2% CHG with 70% Isopropyl Alcohol
Case Reports:
CHG chemical burns, erosive contact dermatitis

- Reynolds (2005)
  - 0.5% CHG/methanol
- Mannan (2007)
  - 0.5% CHG/isopropyl alcohol
- Espuny (2010):
  - 0.5% /methanol
- Anderson (2005):
  - 2% aqueous CHG caused erythema, breakdown in 4/36 infants <1000g, <48 hours of age
- Kutsch & Ottinger (2014)
  - 2 cases using “a chlorhexidine solution”; “CHG liberally applied”
- Weitz (2013):
  - Erosive contact dermatitis from CHG-impregnated gel dressings
Disinfectants

Remove with water or saline, although CHG may still have lingering effect

Avoid using isopropyl alcohol-containing disinfectants
Most vulnerable to chemical burns are the extremely low birth weight infants (<1000 grams) in the first weeks of life

There is insufficient evidence to recommend a single disinfectant for use in all NICU patients, all invasive procedures
Medical Adhesives in the NICU

- Acrylates (Transpore™, cloth)
- Zinc oxide (pink tape)
- Hydrocolloids (Duoderm™)
- Hydrogel (electrodes)
- Polyurethane (transparent dressings)
- Silicone
Disruption of Barrier Function Associated With Adhesive Removal


- 30 infants, 26-40 weeks, <7 days of age
- Significant alteration in skin barrier (TEWL, color, visual assessment) after removal of acrylate-based tape and hydrocolloid
- Hydrogel fell off in 7 infants before 24 hours
- Changes seen in big as well as small babies
The MARSI Project

- Consensus statements published in JWOCN in July 2013 about the risk of skin injury from medical adhesives

- In 2001, an evidence-based practice project evaluating the first Neonatal Skin Care Clinical Practice Guideline found:
  
  **Adhesive removal was primary cause of skin breakdown**

Medical Adhesive-related Skin Injury: MARSI

- Skin Stripping
Medical Adhesive-related Skin Injury: MARSI

- Skin Tears
Medical Adhesive-related Skin Injury: MARSI

- Tension Blisters
- Contact Dermatitis
Silicone Adhesives

- Adhere well to skin, hair
  Gentle when removed, can be replaced
- Won’t stick to plastic!
Silicone Tape in High Humidity
Bonding Agents

- Tincture of Benzoin, Mastisol
- Used to enhance adhesion of wound closure tapes
- Not recommended in newborns, can increase epidermal stripping
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 do not need FDA label, covered under the original patented product
Adhesive Removers

Alcohol/organic-based solvents
  Contain hydrocarbon derivatives or petroleum distillates
  Toxicity
  Case report of skin injury and hemorrhage in premature infant after exposure to Detachol

Oil-based solvents
  Paraffin based (mineral oil), some citrus-based
  Leave oily residue, cannot replace adhesive

Silicone-based removers
  Safest medical adhesive remover

Black 2007
Conclusions

• Newborn skin is uniquely different compared to older children or adults.
• Control of TEWL is necessary for premature infants less than 30 weeks gestation.
• Evidence-based practices for bathing are available.
• There is not a single disinfectant to recommend for all newborns, all procedures.
• Medical adhesives can be a source of skin damage; prevention possible using some of the newer products.