

Neonatal Skin Science 2012

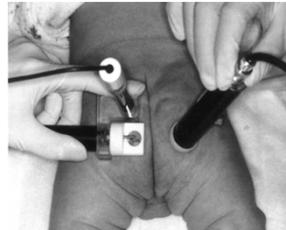
Anatomic and Physiologic Differences

New Adhesives, Diaper Dermatitis and IV Infiltrates

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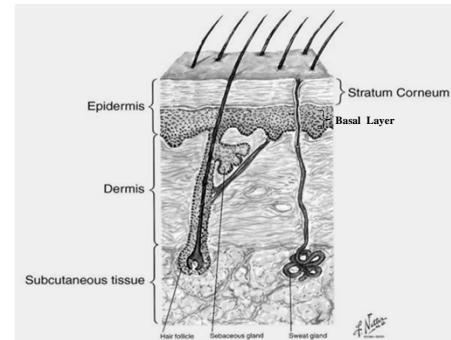
Disclosures

- Team leader for revision of the Neonatal Skin Care Guideline (AWHONN); due to be released in 2013
- Investigator-initiated grant to study the first bath in full term newborns, 2011 (Johnson & Johnson Consumer Products)
- Member, professional advisory panel for 3M Skin and Wound Care Division
- Will be discussing off-label use of some products

What's Different about Neonatal Skin?

- Review of the anatomy of skin
- Differences in neonatal skin
- Differences between full term neonates and premature neonate's skin

Skin Layers



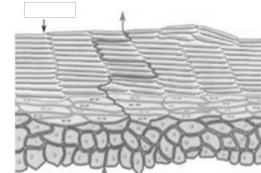
Measuring Skin Parameters

- TEWL
 - Transepidermal Water Loss
- pH
 - acid-base balance
- SCH
 - Surface hydration
- Colorimeter
 - erythema
- Visual Inspection Scales
- Skin cultures, PCR analysis

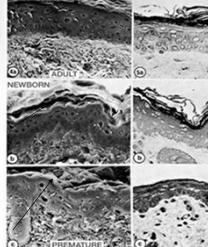


What is Skin Barrier Function?

- 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



Stratum Corneum and TEWL

	Adult SC 10-20 layers	Newborn SC 10-20 layers	Premature Infant 2-3 layers
	10-20 layers	10-20 layers	2-3 layers

- 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

Premature Infants and TEWL



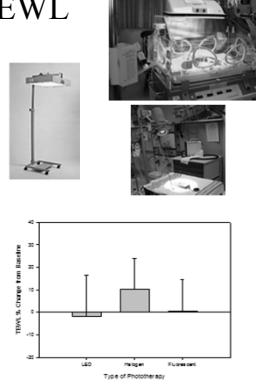
- 23 weeks – 75 gmH²O/m²/hr
- 26 weeks – 45 gmH²O/m²/hr
- 29 weeks – 17 gmH²O/m²/hr
- 32-40 weeks: – 5-10 gmH²O/m²/hr
- Stratum corneum becomes mature at 30-32 weeks PCA

Development of Skin Barrier Function in Premature Infants

Kalia, Nonato, Lund et al (1998) J Invest Derm 111:320

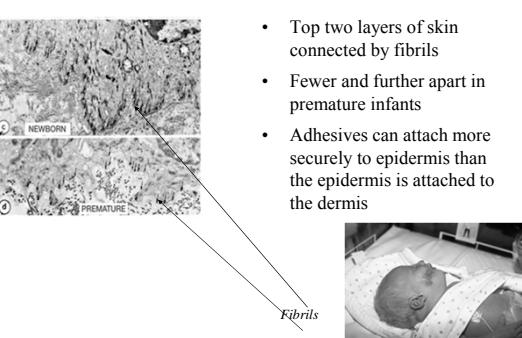
- 10 infants, 23-32 weeks gestational age, <7 days of age
- Measured barrier function using two methods: TEWL (evaporimeter) and impedance spectroscopy
- Barrier matures at 200-230 days (30-32 weeks)

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)

Cohesion Between Epidermis and Dermis



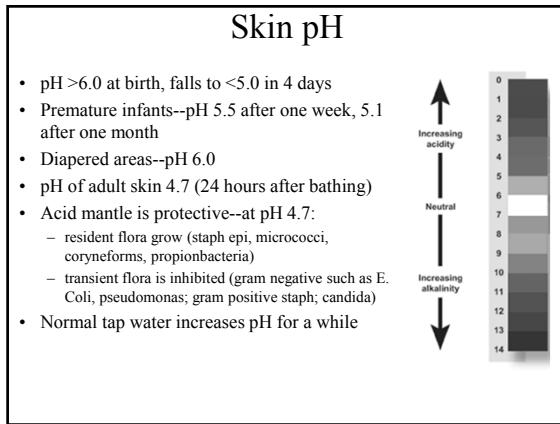
- Top two layers of skin connected by fibrils
- Fewer and further apart in premature infants
- Adhesives can attach more securely to epidermis than the epidermis is attached to the dermis

Disruption of Barrier Function Associated With Adhesive Removal

Lund et al (1997) Peds 1997;131:367-372



- 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



Recent publications in Pediatric Dermatology and Journal of Investigative Dermatology (2008, 2010)

- Baby stratum corneum is 30% thinner than adult, epidermis is 20-30% smaller
- Keratinocyte cells smaller with higher cell turnover rate; explains better wound healing in babies
- Dermis is also different; short collagen fibers, absent reticular layer, makes skin feel softer
- Baby skin absorbs more water, and loses it faster than adult
- Baby skin contains less total lipids and less sebaceous lipids, confirming the decreased activity of glands

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

Misadventure in Neonatal Skin Care #1: Aniline Dye and Methemoglobinemia

- 1886, Dr. Rayner notes link between outbreak of cyanosis in normal newborns and aniline dye used to print the hospital's name on diapers
- Found to have methemoglobinemia
- Nine further outbreaks attributed to aniline dye
- Factors include larger surface area to body weight, skin pH higher due to urine, ↑ permeability when skin is covered, occluded
- Implications for diaper dermatitis remedies in neonates

Skin Assessment: Which Scale?

- Braden Q, Starkid Skin Scale
 - Assess risk for pressure sores, skin breakdown in pediatric patients
 - Number of neonates in each study not indicated, no premature infants included
- Neonatal Skin Condition Score (NSCS)
 - Used in original Neonatal Skin Project
 - Sample 2,820 neonates
 - Validity, reliability demonstrated using data set from project (Lund & Osborne 2004)

Braden Q

Patient's Name:	Evaluator's Name:	Score of Assessment:
SENSORY PERCEPTION Dulls perception of pain, pressure, temperature, moisture, etc.	1. Completely intact Sensory intact, able to perceive all sensations normally. 2. Slightly intact Sensory intact, but may have difficulty perceiving some sensations or may require more time to respond. 3. Impaired Has a sensory impairment, but still able to perceive most sensations. 4. No impairment Sensory intact, able to perceive all sensations normally.	
MOISTURE Skin dryness or moisture retention	1. Completely intact Skin is moist but not soggy, retains moisture well. 2. Slightly intact Skin is affected but not soggy, retains moisture well. 3. Impaired Skin is affected and soggy, retains moisture poorly. 4. No impairment Skin is usually dry, retains moisture well.	
ACTIVITY Ability to move and control body	1. Sedentary Cannot move. 2. Limited Ability to walk, sit, turn, etc. limited by physical condition, equipment, or environment. 3. Able to move Ability to walk, sit, turn, etc. without limitation. 4. Able to ambulate Move without limitation, can walk, sit, turn, etc. without limitation.	
MOBILITY Ability to move and control body	1. Completely Does not make even slight changes in position or movement. 2. Slightly Does not make even slight changes in position or movement. 3. Impaired Does not make even slight changes in position or movement. 4. No impairment Does not make frequent changes in position or movement.	
NUTRITION Diet, food intake	1. Poor Does not eat or drink enough. 2. Adequate Eats 1/2 of recommended amount. 3. Good Eats most of recommended amount. 4. Excellent Eats most of recommended amount and has a varied diet.	
FRICTION AND SHEAR	1. Poor Requires assistance to turn or reposition. 2. Adequate Turns or repositions self against chair, bed, or wheelchair. 3. Good Turns or repositions self against chair, bed, or wheelchair. 4. Excellent Turns or repositions self against chair, bed, or wheelchair.	

Starkid Skin Scale

		www.medscape.com	
		Starkid Skin Scale	
		4	
Mobility/ Activity	Confining to bed, remains quiet spontaneous changes in position	Cannot weight bear but uses chair, occasional spontaneous changes in position	ODG with assistance, occasional spontaneous changes in position. OR able to move independently but needs more than brief assistance
Sensory- Perception: Ability to feel and respond to touch and pressure related pain	Unresponsive to pain due to injury or conduction abnormalities (e.g., muscular blockade)	Decreased LOC but responds to painful stim- uli, may cry, may have mild confusion or restlessness in response to pain > half of body	Age appropriate responses to commands, can identify pain source & location, able to feel and communicate pain (crying baby)
Moisture	Dripping must be age appropriate	Linen changed every 8 hours or diaper changes q2 for diarrhea	Routine diaper changes. Linen change once a day
Frication-Shear From skin against bed, blanket, ortho device	Constant thrashing and kicking, limbs Agitated	Unable to lift but skin slides easily against sheets (unresistable ability or size) Slides down frequently	Easy to lift but skin slides easily against sheets (unresistable ability). OR occasional sliding down independent of position most of time
Nutrition	NPO for ≥ 5 days OR rarely eats half of food offered No supplements	TPN or Tube Feedings with inadequate calories and/or supplemental OR capsule half of food offered	TPN, Tube feeds of adequate calories OR eats over half of food offered
Tissue Perfusion (use pulse oximeter if pulse oximeter available)	Hypotensive Hypotension seen in new- borns does not physio- logically tolerate position changes	Nonrespiratory but O ₂ sat <92% or <10 seconds above normal CfT > 2 seconds HR > 150	Nonrespiratory, O ₂ Sat > 94% or within expected range CfT > 2 seconds HR > 150

Pressure Sores in Neonates



Neonatal Skin Condition Scale

- Dryness:
 - 1 = Normal, no signs dryness
 - 2 = Dry skin, visible scaling
 - 3 = Very dry skin, cracking/fissures
- Erythema:
 - 1 = No evidence erythema
 - 2 = Visible erythema, <50% body surface
 - 3 = Visible erythema, >50% body surface
- Breakdown:
 - 1 = None evident
 - 2 = Small, localized areas
 - 3 = Extensive



Skin Assessment

- Neonatal Skin Condition Score (NSCS) recommended in 2007 guideline:
 - Objective scale quantifies overall skin condition
 - Does not replace head-to-toe assessment
 - May be linked to actions: consult with skin team/CNS, emollient use, skin culture, etc
 - Need to identify infants at high risk for pressure sores: HFV, hypotension/hypoperfusion, ECMO, NCPAP

Skin Colonization: What We Thought

- After vaginal birth, skin is colonized after descent through the birth canal
- After C/S, skin thought to be sterile if intact membranes
- In utero, fetal skin colonization
 - after premature rupture of the membranes
 - penetration through amniotic membranes (candida, group B strep)
- “Under hygienic conditions, resident flora resembles that of adults after the first few weeks of life”

(Neonatal Skin: Structure and Function, 2003)

Do We Have the Full Story on Colonization of the Skin?

- The past decade has seen a shift in how we see the microbes and viruses in and on our bodies
- 9 in 10 of the cells in our body are microbial; especially in the gut and on the skin
- A few microbes make us sick, most are commensal (“good bacteria”)
- Inbalance of commensal bacteria may lead to disease states
- Newer studies that determine the “microbiome” of our skin and GI tract involve PCR techniques

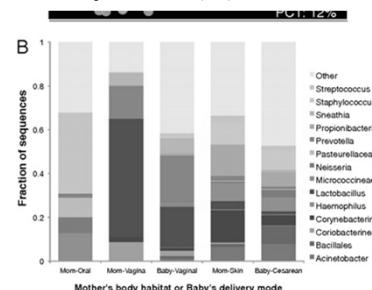
Microbiome Aspects of Perinatal and Neonatal Health

Gregory KE (2011) *J Perinat Neonat Nursing*, 25:158-162

- 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 birth (*Dominguez-Bello 2010*): 64-82% of MRSA infection found in C/S births (*Malloy, Peds 2008; 122:285*)
- Intestinal microbiome altered in premature infants – antibiotics, often C/S
- Lack of protective bacteria may be involved in pathogenesis of NEC

Delivery Mode Shapes Initial Microbiota in Newborns

Dominguez-Bello MG et al (2010) *PNAS* 107:11971-11975



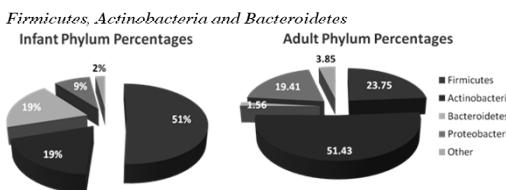
Diversity of the Human Skin Microbiome Early in Life

Capone K., et al (2011) *J Invest Derm*; doi:10.1038/jid.2011.168

- PCR microbiome: skin swabs from 31 infants (1-3, 4-6, 7-12 months); arm, forehead, buttocks
- 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 inflammatory responses.

Infant Skin Has Same Phyla of Bacteria, Represented in Different Proportions, Compared With Adult Skin

- Bacterial phyla in infant skin showed a predominance of Firmicutes, Actinobacteria and Bacteroidetes**



- Bacilli were found to be one of the most abundant classes within the baby skin samples, along with Actinobacteria and Clostridia.

Our “First Bath” Study

- 100 babies randomized, first bath with water alone or water with baby wash
- Babies will be immersed and swaddled in the bath
- Pre and Post-Bath Measurements include: Transepidermal water loss, pH, stratum corneum hydration, and microbiome of baby and Mom.

Skin Surface pH and Microflora

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

Skin and the Immunologic System

- Interplay of immune responses arise from skin
- Includes cellular and humoral components in the epidermis and dermis
- Cellular components
 - Keratinocytes
 - Monocytes and macrophages
 - Mast cells
 - Lymphocytes, primarily T cells
 - Endothelial cells
- Humoral components
 - Antimicrobial peptides
 - Complement proteins
 - Immunoglobulins
 - Cytokines
 - Prostaglandins

Antimicrobial Peptides and Skin



- Marchini (2002): biopsy of 4 babies with erythema toxicum(ET), 4 without
- Human antibacterial peptide LL-37 present in skin of babies with ET, not found if no ET
- Vernix contained LL-37 and lysozymes which have antibacterial effects against pathogens (E. coli)
- Antimicrobial defense system in the skin is more than just a mechanical barrier

Should We Reconsider Antimicrobial Bathing?

- Concerns about community-acquired MRSA
- Newborns seen in emergency departments with cellulitis, skin infections due to MRSA
- Would initial bath with antimicrobial cleansers decrease infection?



What's Wrong with this Picture?



Misadventure in Neonatal Skin Care#2: Hexachlorophene

- Hexachlorophene was used in 1950-60 to control outbreaks of *s. aureus* infection in nurseries
- Initial bath after birth, then every 2 days
- Irreversible brain damage (vacuolar encephalopathy) in premature infants washed 4 or more times
- Extreme prematurity, low birth weight, rashes, acidosis, hyperbilirubinemia are risk factors for toxicity

Recent Studies with Chlorhexidine Baths

- 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?



- Daily baths to adults in ICU reduced VRE, BSIs
- Clinical trial in pediatric patients
- Safety in neonates?
- Influence on normal colonization, barrier function?

Blood Concentration of CHG in Hospitalized Children Undergoing Daily CHG Bathing

Lee et al (2011) Inf control and Hosp Epidemiol 32:395-397

- 12 subjects, 3 months – 17 years
- Mean daily baths 9 (range 1-30)
- 8 subjects had samples after at least 7 days CHG exposure
- Low concentrations CHG
- No evidence CHG accumulation

International Skin Science:

Topical Applications of Chlorhexidine for Prevention of Omphalitis and Neonatal Mortality in Southern Nepal

Mullaney LC, Darmstadt GL et al (2006) Lancet 367:910

- Community-based, cluster-randomised trial
 - 4934 infants- 4% CHG
 - 5107 infants- soap and water
 - 5082 infants- dry cord care
- Severe omphalitis reduced by 75%, neonatal mortality 24% lower with CHG
- If enrolled at <24 hours of age, mortality reduced by 34%
- Questions about current WHO recommendation for dry cord care

Adhesives: New Technologies

Diaper Dermatitis

IV Infiltrates: Prevention and Immediate Treatment



Adhesives in the NICU

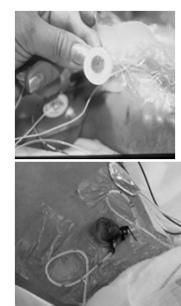


- Widely used in premature and full term infants
- Attach life support devices such as ETTs, intravenous and arterial catheters, chest tubes, and monitoring sensors, electrodes
- Adhesive removal was primary cause of skin breakdown in AWHONN neonatal skin care project

Other Adhesive Products



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



Types of Adhesive Skin Damage

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



• Seminars in Neonatology
2000;5:112-119

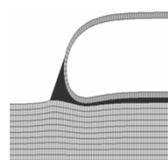
Concerns with Adhesive Removers



- 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

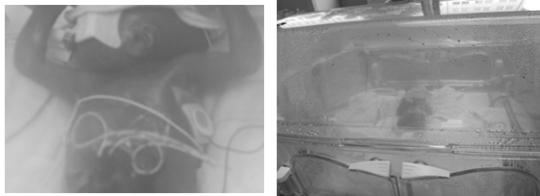


- Plastic polymers sprayed or wiped on skin to protect from trauma
- Alcohol-free products less irritating to skin
- Cavilon is FDA approved in infants >30 days as diaper dermatitis treatment
- Other manufacturers haven't approached FDA

New Technology: Silicone Adhesives



Silicone Tape in High Humidity



Silicone Tape



Silicone Dressing



Redesigning Adhesive Products

Adhesive circles have removable top layer

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



Diaper Dermatitis

- Irritant contact diaper dermatitis (IDD)
- Candida (fungal) diaper dermatitis
- Combination



Pathogenesis IDD

- Wetness
 - Maceration of stratum corneum, impaired skin barrier function
- Friction
 - Mechanical trauma from skin-to-diaper contact
- Urine and feces
 - Ureases in stool release ammonia
 - Increase in skin pH
 - ↑ pH activates proteases and lipases, disrupts epidermal barrier

Risk Factors for IDD

- Malabsorption
 - Short bowel syndrome
 - Infectious diarrhea
 - Opiate withdrawal
- Fecal incontinence
 - Hirschsprung's disease
 - Ano-genital malformations
- Atopic dermatitis (altered barrier function)
- Wearing diapers!

Diapers

- Frequent changes
 - Every 3-4 hours, more frequently in neonates
- Super-absorbent diapers bind fluid with a gel matrix
- Breathable covering
 - permeable to air and vapor, impenetrable to leaks
- ? Petrolatum liners
- Diaper wipes: +/-
 - Wide range of brands, chemicals in formulations
 - Fragrance, preservative free are best
 - Some reported to cause allergic contact hand dermatitis in mothers



Skin Care in the NICU Patient: Effect of wipes vs. Cloth and Water on Stratum Corneum Integrity

Visscher et al. (2009) Neonatology 96:226-234

- 130 NICU infants, 23-41 weeks, 30-51 weeks when studied
- RCT: wipe A, wipe B or cloth/water
- Measured TEWL, erythema, pH, SCH, skin condition every day
- TEWL, erythema ↓ with wipes
- pH lower with wipe B (acidity as preservative)

Premie Diapers?



Contact Irritant Diaper Dermatitis: Create a Barrier “frosting-on-a-cake”



Ingredients in Diaper Dermatitis Treatments

- Zinc oxide
- Petrolatum
- Pectin
- Dimethicone (silicone)
- Plastic polymers
- Lanolin
- Glycerin
- Cholestyramine

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, peri-ostomy skin protection
- Other manufacturers haven't approached FDA

Candida Diaper Rash

- Fiery red, satellite lesions
- Distributed on thigh, perineum
- Treat with antifungal ointment (not powder)



Fungal Diaper Dermatitis Products



Combination Diaper Rash

- Dust with antifungal powder
- Seal powder on with skin protectant
- Apply thick layer of barrier



Treat the Underlying Cause!

- Diarrhea from malabsorption, opiate withdrawal, infection
- May need change in formula to reduce frequency of stooling



Diaper Dermatitis



- Contact irritant or candida?
- Primary irritant is fecal enzymes
- Use protective coating: zinc oxide, pectin paste, plastic polymer to protect skin from re-injury
- Candida diaper dermatitis: antifungal ointment
- Avoid products with multiple chemicals

Preventing IV Infiltrates

- Insertion site clearly visible
- Check every hour
- Keep IV site out of swaddling blankets
- Tape at joint: knee for foot, elbow for hand
- OR no arm- or foot-board at all!
- Avoid tape or wraps that constrict venous return



Preventing IV Infiltrates: Other Issues

- Avoid calcium-containing infusions whenever possible
- If calcium in IV fluids, consider placing two IVs and "rotating" sites for infusion
- Are intermittent boluses of calcium less irritating to veins compared to continuous infusion?
- Consider PICC line if: vasopressors, calcium infusions, irritating meds (Vancomycin, Amphotericin, Nafcillin/Methicillin/Penicillin, Acyclovir)

IV Infiltrate Requiring Intervention

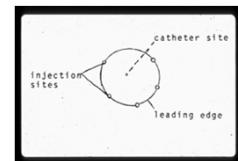


Characteristics of Infiltrates Requiring Intervention

- Swelling
- Pain at site
- Blanching or coolness of skin
- Leakage at site
- Erythema
- Severe cases: blisters, ischemia

Hyaluronidase and Phentolamine

- Vitrase: www.istavision.com
- Amphadase: www.amphastar.com
- Doses 15-20 units, 1 cc volume injected at 5 sites around periphery
- Do not use for vasopressors; phentolamine (Regitine) is antidote



IV Infiltrates: Multiple Puncture Technique

- Disinfect skin
- Analgesia
- Puncture at 5-10 sites with 22-24 gauge needle
- Apply saline soaked gauze
- Compress to release more fluid

Multiple puncture technique



Hyaluronidase + Puncture + Gel/Bag

- Vitrase (hyaluronidase) 20 units
- Deliver 0.2 ml in 5 sites around periphery of infiltrate
- No need to change needles



Hyaluronidase + Punctures + Gel/Bag

- Puncture to release extravasated fluid
- Use 23 gauge or greater
- Don't be timid
- May repeat hyaluronidase, punctures
- Apply hydrogel, bag



Approach to IV Infiltrates (CHO)

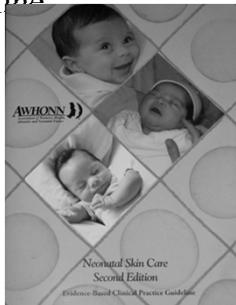
- Use combination of hyaluronidase and multiple puncture technique
- No time frame, although earlier is best
- Be aggressive to allow extravasated fluids to leak out; several "rounds" may be needed
- Use bag/boot method with hydrogel immediately after punctures, hyaluronidase

History of the Neonatal Skin Care Guideline

- Collaboration between two national nursing organizations in the US (AWHONN and NANN)
 - Included Canadian representation
 - Reviewed over 200 research articles about neonatal skin and skin care
- First evidence-based, clinical practice guideline (2001) evaluated in 51 US nurseries
- Revision of guideline December 2007.
- Revision planned for 2012

2007 Neonatal Skin Care Guideline

- Newborn skin assessment
- Bathing
- **Vernix**
- Umbilical cord care
- Circumcision care
- Disinfectants
- Diaper dermatitis
- Adhesives
- Emollients
- Transepidermal water loss in ELBW infants
- Skin breakdown
- Intravenous infiltration



2012 Neonatal Skin Care Guideline

- Will include New Information on:
 - Product Selection
 - Microbiome of the Skin
 - Atopic Dermatitis
 - Parent Education