Pediatric Burns From A to Z

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University of Colorado
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Improving Care.

Disclosures

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This topic will not reference anything related to the above disclosures

Overview

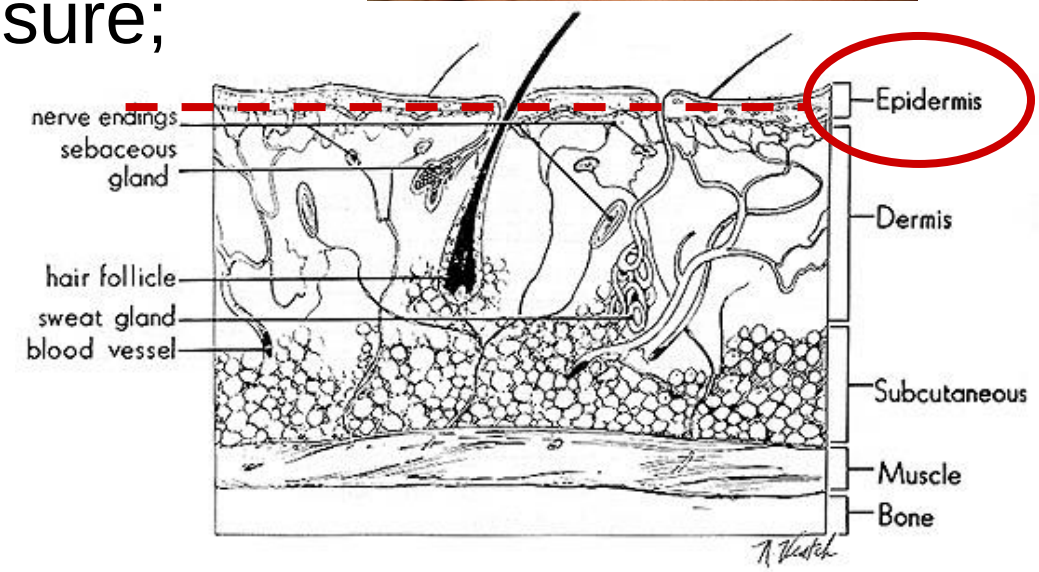
- How to calculate depth and extent
- Initial management
- Fluid resuscitation
  - Fluids and formulas
- Monitoring
  - Traditional vital signs, urine output
  - Computerized decision support system (CDSS)
- Burn wound management
  - Dressing changes, excision and grafting
- Accidental vs. non-accidental burn injuries

How to Calculate Depth and Extent

Depth

1st DEGREE - SUPERFICIAL

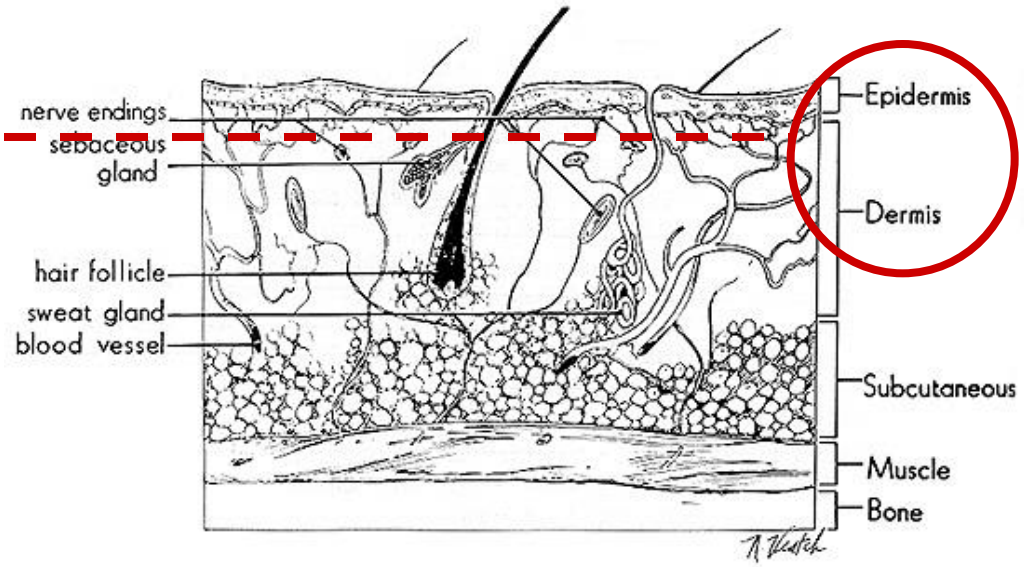
- Limited to the epidermis
- Red, dry and painful
- Blanche when pressed, often slough the next day
- After intense sun exposure; periphery of 2nd degree burns
- Heal spontaneously without intervention



Depth

2nd DEGREE-SUPERFICIAL

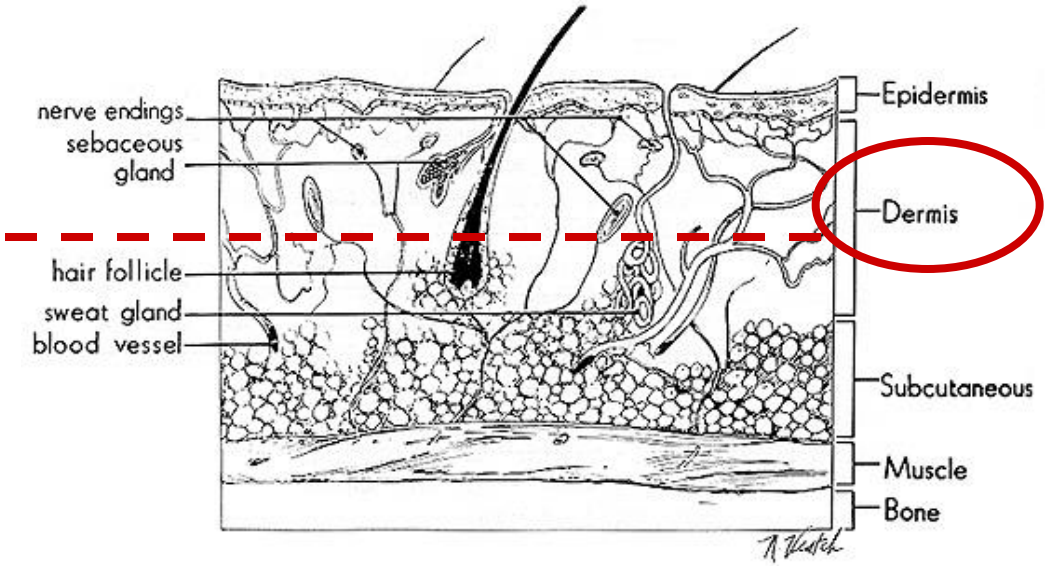
- Involves epidermis and superficial dermis
- Hallmark is blister, often still intact
- Painful, moist
- Commonly caused by hot liquids or contact
- Heal spontaneously in ≤ 21 days with simple wound care



Depth

2nd DEGREE PARTIAL AND DEEP PARTIAL THICKNESS

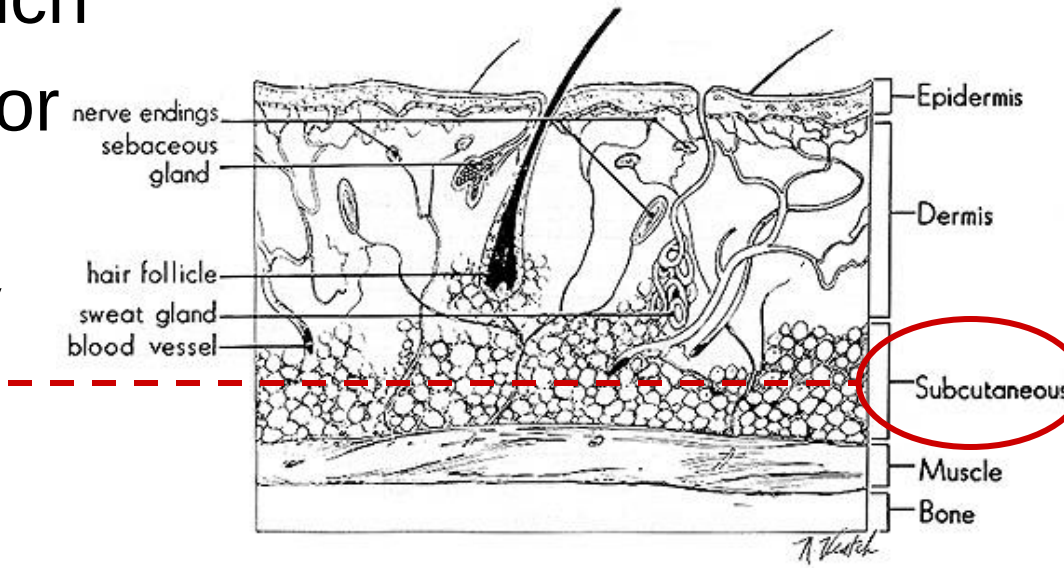
- Involves epidermis and deeper dermis
- Blisters usually ruptured on presentation
- Moist, painful
- Grease, heat contact, flame
- Hair follicles common epithelial source
- May need grafting, i.e. may not heal by 21 days



Depth

3rd DEGREE-FULL THICKNESS

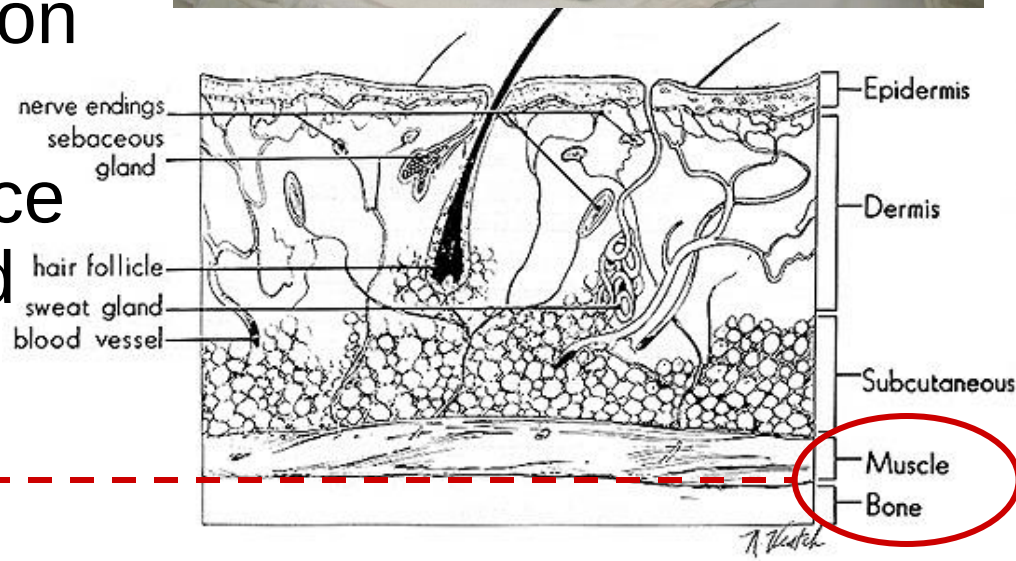
- Burn extends into subcutaneous tissue
- Dry, leathery, insensate and waxy; do not blanch
- Usually white, yellow or brown color
- Commonly caused by flame or heat contact
- Will need grafting



Depth

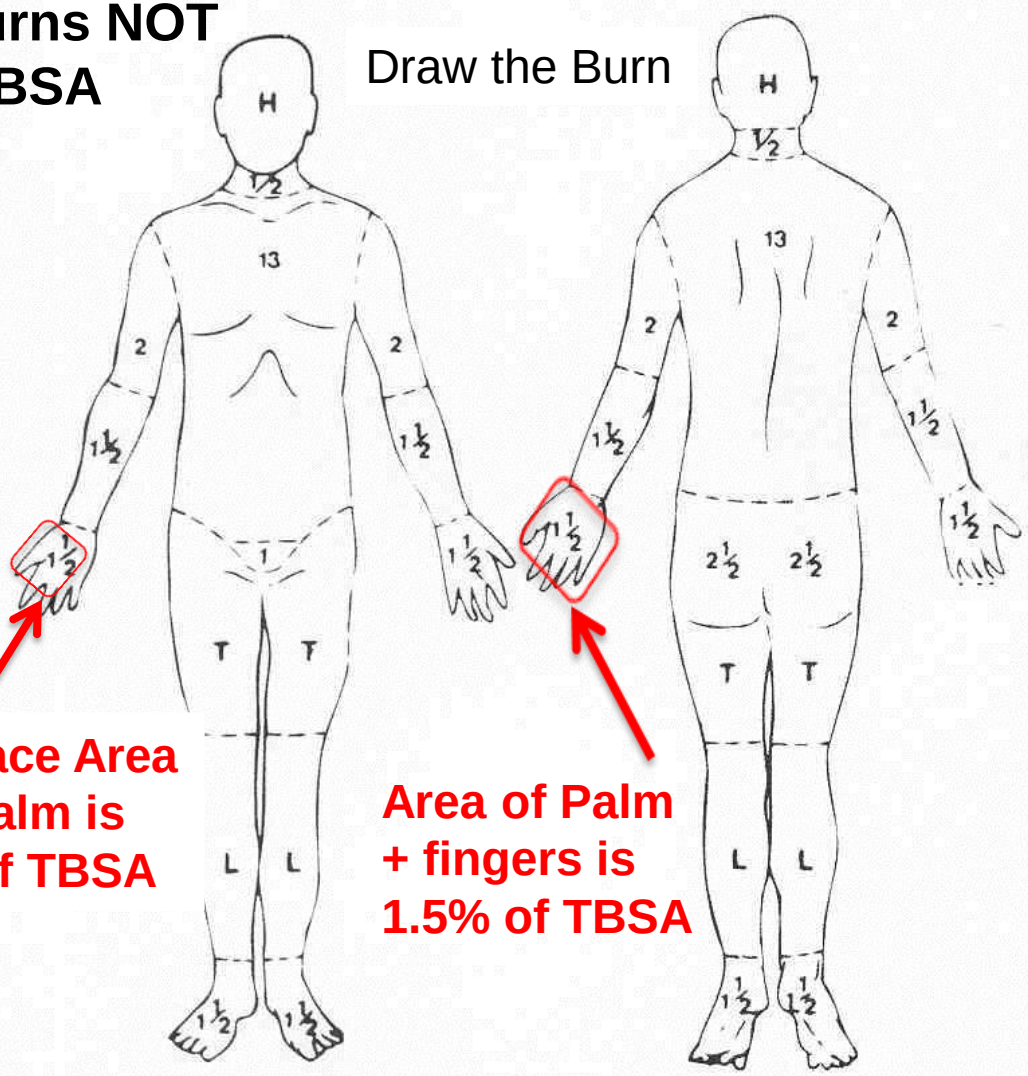
4th DEGREE-DEEP FULL THICKNESS

- Burn extends into muscle, tendons, ligaments and bone
- Hard, black eschar
- Minimal pain, destruction nerve endings
- Caused by closed space flame burns; prolonged heat contact
- Will need grafting



1st degree burns NOT included in TBSA calculation

Draw the Burn



Surface Area of Palm is 1% of TBSA

Area of Palm + fingers is 1.5% of TBSA

Lund Browder Burn Diagram AM

Circle Age:	Percent of Areas Affected by Growth 0	6m	ly	3	5	8	10	13	15	adult
H=½ if the Head	9½	9	8½	7½	6½	6	5½	5	4½	3½
T=½ of a Thigh	2¾	3	3¼	3¾	4	4¼	4¼	4½	4½	4¾
L=½ of a Leg	2½	2½	2½	2½	2¾	3	3	3¼	3½	3½

ESTIMATION OF SIZE OF BURN BY PERCENT

Calculate extent of burn

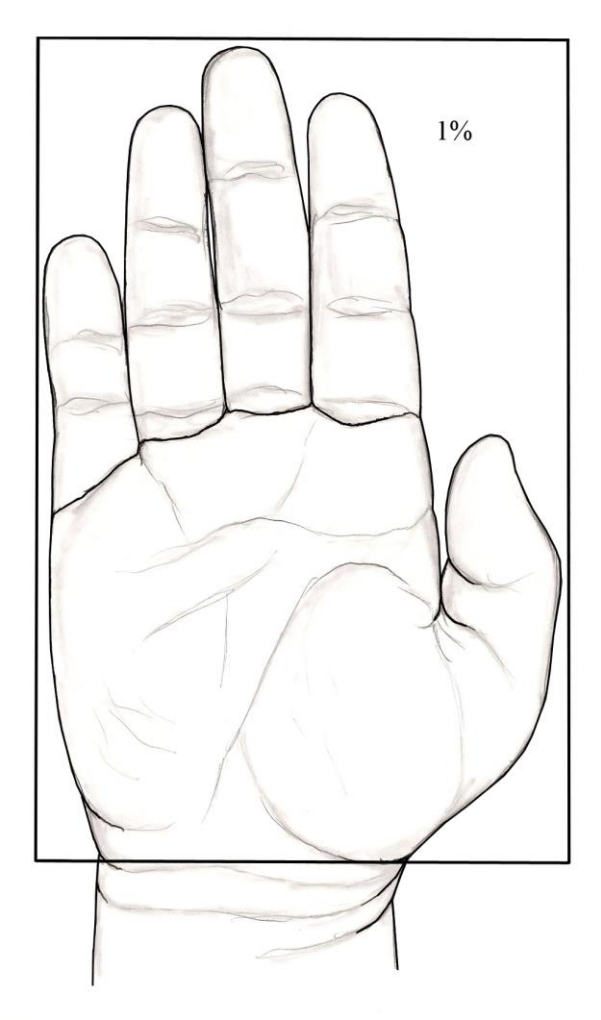
	Anterior	Posterior
Head		
Neck		
R. Arm		
R. Forearm		
R. Hand		
L. Arm		
L. Forearm		
L. Hand		
Trunk		
Buttock		
Perineum		
R. Thigh		
R. Leg		
R. Foot		
L. Thigh		
L. Leg		
L. Foot		
Subtotal		

% Total Area Burned

Signature Person Completing Form:

Date:

Extent of Burns



Patient's palmar surface (hand + fingers) is1% TBSA

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Initial Management

ABA Pre-Hospital Resuscitation

Immediate Treatment on scene

- Cool the burn wound (“stop the burning process”)
- Apply clean moist towel
- Seek medical help if needed

IV Fluid

- Age < 5 yrs D5LR or LR at 125 ml/hr
- Ages 6-14 yrs LR at 250 ml/hr
- Age > 14 yrs LR at 500 ml/hr

Initial Care in the ED

In ED

- OK to peek, but o/w keep burn covered
  - Prevent desiccation (drying)
- Medicate for pain; get supplies for dressing
- When ready
  - Uncover
  - Assess and diagram
  - Redress, then calculate TBSA
- Local care versus referral to burn center

ABA Burn Referral Criteria

University Hospital: ages ≥ 15

CHCO Burn Center: ages 0 – 14 (≤ 60% TBSA)

- (Partial thickness, age < 2, > 5% TBSA)
- Partial thickness, age ≥ 2, > 10% TBSA
- Burns of: face, hands, feet, genitalia, perineum, major joints
- Full thickness burns
- Electrical (incl. lightening)/chemical burns
- Special: infant, trauma/NAT, etc.

Pediatric Burn Care

Indications for IV Fluid

- Infants (< 2 years old)
  - ≥ 5%TBSA
  - Maintenance IVF (D5LR); pain control; urine output > 1 cc/kg/hr
- Young children (ages 2 – 10 years)
  - TBSA burn > 10%
  - Maintenance IVF (LR); pain control; urine output ~ 1 cc/kg/hr
- Older children and adults (ages > 10 years)
  - TBSA burn > 15%
  - Maintenance IVF (LR); pain control; urine output = 0.5 – 1 cc/kg/hr
- Burns > 20% TBSA
  - 3 cc's/ kg / % TBSA = 24 hr IVF requirement; give ½ in first 8 hrs
  - urine output = 0.5 – 1 cc/kg/hr; start tube feeds ASAP

Fluid Resuscitation

Choice of Fluid

- Ideal fluid: effectively restores plasma vol.
- Isotonic crystalloids: available, inexpensive
  - Lactated Ringer's
    - Slt hypotonic (Na 130 mEq/L, K 4 mEq/L, Ca 3 mm/L)
    - Lactate converted to HCO_3 counteracts acidosis
    - Increases neutrophil activation
    - D-lactate isomers increase reactive oxygen species
  - Hartmann
    - Similar to LR
  - Normal saline
    - Hyperchloremic acidosis

Choice of Fluid

- Hypertonic solutions
  - Hypertonic saline
    - Na^+ increases plasma osmolality, limits cell edema
    - Lower total volume c/w isotonic IVFs
    - Increased incidence renal failure and death
  - Colloids
    - Increase plasma osmolality
    - Limited clinical benefit < 24 hrs (Bocanegra, Goodwin)
    - Decreased IVF req's and lower abdominal pressures using FFP w/in 48 hrs for large burns > 50% (O'Mara)
    - Decreased hourly and total IVF req's (Lawrence)

Table 1 Effect of Different Solutions on Plasma Volume Expansion

Volume infused (mL)	Type of Fluid Infused	Plasma Volume Expansion (mL)
1,000	D_5W	100
1,000	lactated Ringer's	250
250	7.5% hypertonic saline	1,000
500	5% albumin	375
100	25% albumin	450
500	Pentastarch	500

Rizoli SB. Crystalloids and colloids in trauma resuscitation. J Trauma 2003 54(5):S82-S88

Formulas

For burns ≥ 20% TBSA

- Parkland
  a) Initial 24 hours: Lactated Ringer's
     - Children: 3 ml/kg/ % TBSA (= 24 hr IVF req.) + maintenance IVF
     - Adults: 4 ml/kg/% TBSA = 24 hr IVF requirement
     - No colloid in first 24 hours
  b) Next 24 hours: Colloids 20-60% calculated plasma vol.
- Modified Parkland
  a) Initial 24 hours: LR at 3-4 ml/kg/% TBSA
  b) Next 24 hours: colloid (5% albumin) 0.3-1 ml/kg/%TBSA
- Modified Brooke
  a) Initial 24 hours: LR at 2 ml/kg/% TBSA

Other Formulas

For burns ≥ 20% TBSA

- Shriner's Cincinnati (Initial 24 hours)
  a) Older Children:
     - LR 4 ml/kg/% TBSA + 1500 ml/m^2 total (half total in 8 hrs)
  b) Younger children:
     - First 8 hours: LR + 50 mEq $NaHCO_3$
     - Second 8 hours: LR
     - Third 8 hours: 5% albumin in LR
- Galveston
  a) LR 5000 ml/m^2 burn + 2000 ml/m^2 total (half total in 8 hrs, rest of total in 16 hours)

Excessive Fluid Resuscitation

Fluid creep….

- Patients with inhalational burn injuries (Baxter)
- Patients with electrical burns (Pruitt)
- Patients whose resuscitation is delayed (Pruitt)

Large resuscitation volumes are associated with:

- Increased risk of infectious complications
- Acute respiratory distress syndrome (ARDS)
- Abdominal compartment syndrome
- Death

What We Use

For burns ≥ 20% TBSA

- ABA (Initial 24 hours)
  a) Initial 24 hours:
    - Children < 2: D5LR 3 ml/kg/ % TBSA (= 24 hr IVF req.) + maint IVF
    - Children > 2: LR 3 ml/kg/ % TBSA (= 24 hr IVF req.) + maint IVF
    - Adults: 3 ml/kg/% TBSA = 24 hr IVF requirement
    - 5% albumin starting at 16 - 24 hours post burn to treat any decrease in urine output
  b) Next 24 hours
    - Titrate IVF/albumin to keep urine output 0.5 – 1 ml/kg/hour

Limited physiological reserve in children mandates increased vigilance and precision during fluid resuscitation from burn injuries

Monitoring

Physiologic Monitoring

- Traditional vital signs
  - EKG, BP, pulse oximetry
- Urine output is the primary index
- Other parameters (caution):
  - Arterial lactate
  - Base deficit
  - Central venous pressure
    - Preload strategy is inadvisable

Computerized decision support system improves fluid resuscitation following severe burns: An original study*

José Salinas, PhD; Kevin K. Chung, MD; Elizabeth A. Mann, MS; Leopoldo C. Cancio, MD; George C. Kramer, MD; Maria L. Serio-Melvin, RN; Evan M. Renz, MD; Charles E. Wade, PhD; Steven E. Wolf, MD

Crit Care Med 2011;39:2031-2038

Table 2. Demographics and injury comparison between control and computer decision support system cohorts

Parameter	Control (n = 38)	Computer Decision Support System (n = 32)	*p*
Age (years)	50 ± 21	44 ± 16	.18
Weight (kg)	88 ± 24	87 ± 23	.83
Gender	Male: n = 28, 74%	Male: n = 25, 78%	.67
% Total Body Surface Area[a]	40 ± 19	39 ± 16	.94
% Full Thickness[a]	11.5 (QI: 0, 11.50, 40.75)	9 (QI: 0, 9, 16.75)	.07
Inhalation Injury (%)[b]	Positive: n = 11, 29%	Positive: n = 10, 31%	.83

QI, quartiles (25%, 50%, 75%).

[a]Variables are not normal. Log transform used for Student's *t* test comparison. [b]measured via a fiber optic bronchoscopy test.

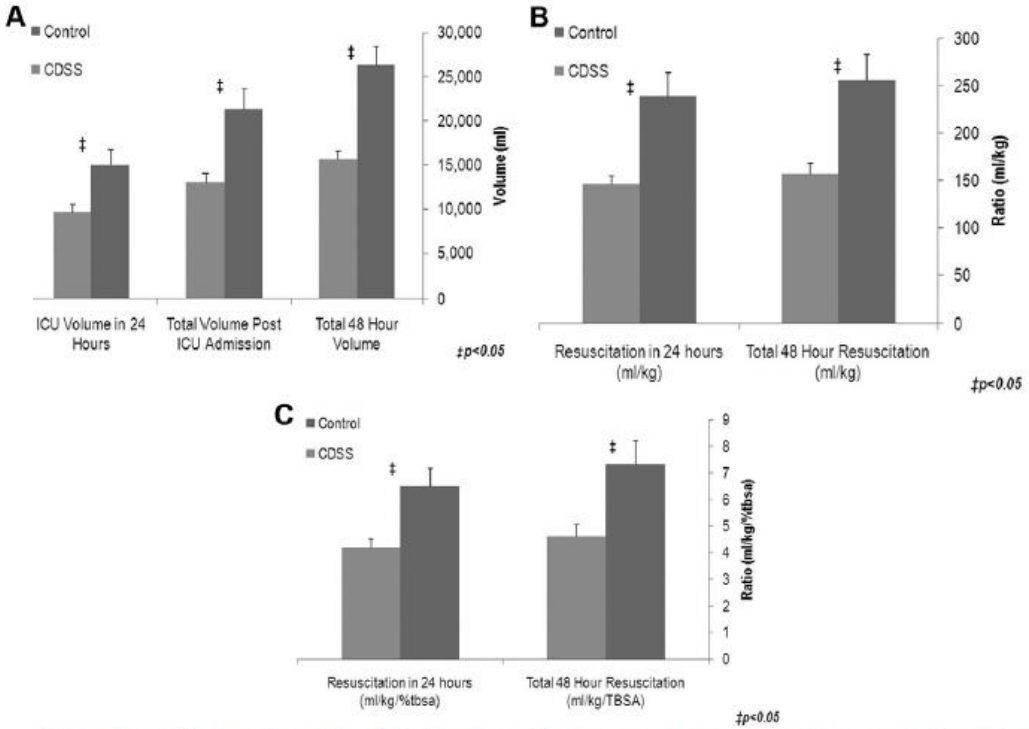


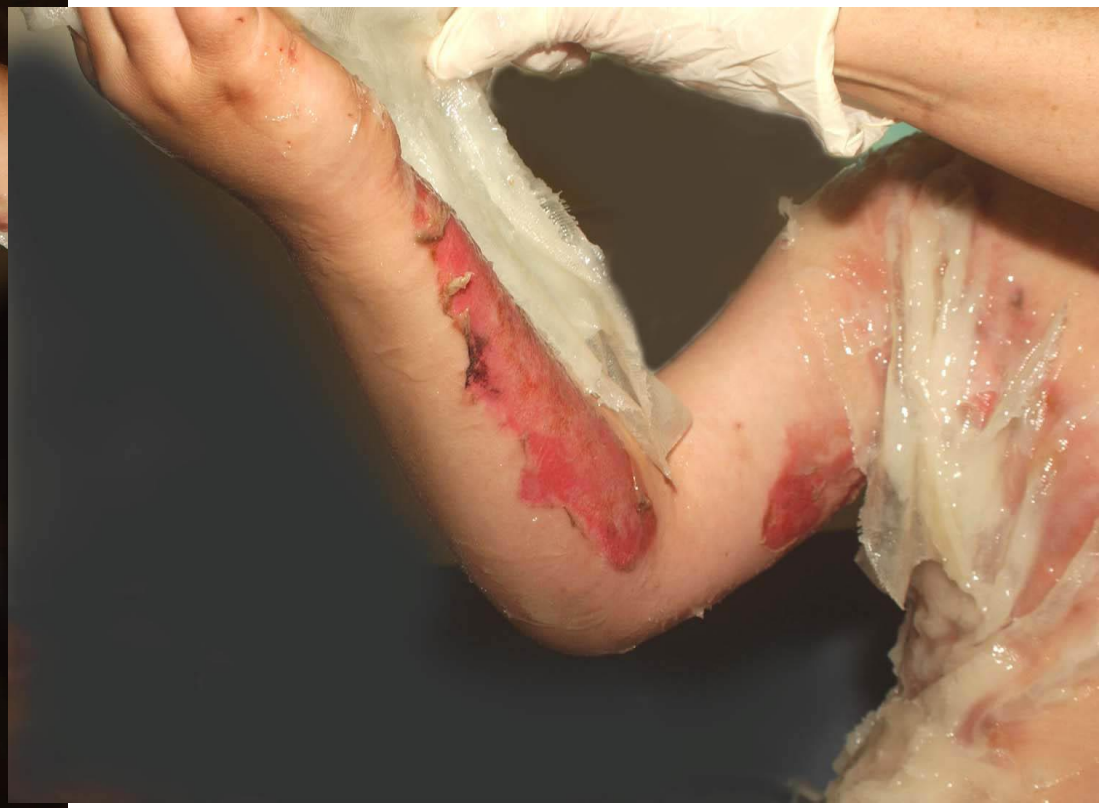
Figure 4. *A*, Volume comparison between the control and the computerized decision support system (*CDSS*) groups. *B*, Total resuscitation (mL/kg) comparison between control and the CDSS. *C*, Total resuscitation (mL/kg/% total body surface area [*TBSA*]) comparison between control and CDSS. *ICU*, intensive care unit.

Burn Wound Management

Pediatric Burn Care

- Blisters--if FLAT leave them INTACT
- Cleanse burn wound: Saline or Shur-Clens
- Topical agents
  - Triple antibiotic ointment or Neosporin or Bacitracin in non-adherent gauze
    - Inexpensive, easy to apply/remove; soothing
    - Change once or twice per week for small area burns
    - Change daily/QOD for larger burns
  - Sulfamylon for burn wound or donor infections
- Follow 21-day rule
    - Early excision and grafting for full thickness burns

Apply antibiotic ointment in Adaptec to all open areas.



Wrap with Kling or Kerlix f/b Coban or Co-Flex

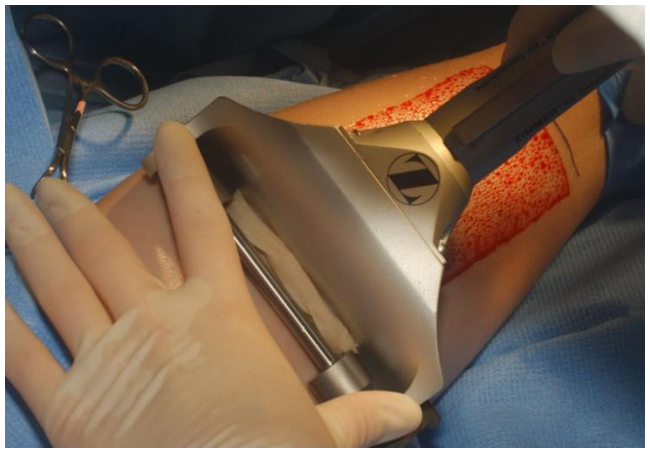
1. Leave blistered skin on burn
2. Cover all open areas of the hand with TAO impregnated Adaptec, f/b Kling or Kerlix

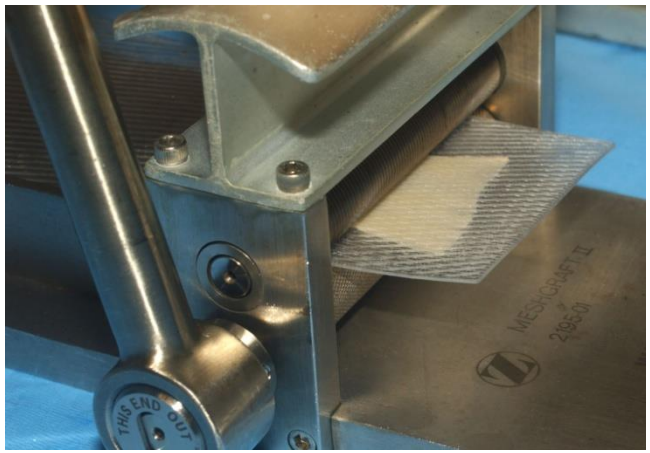
3. Wrap with Co-flex or Coban. Include wrist joint to anchor dressing
4. Soft cast as needed

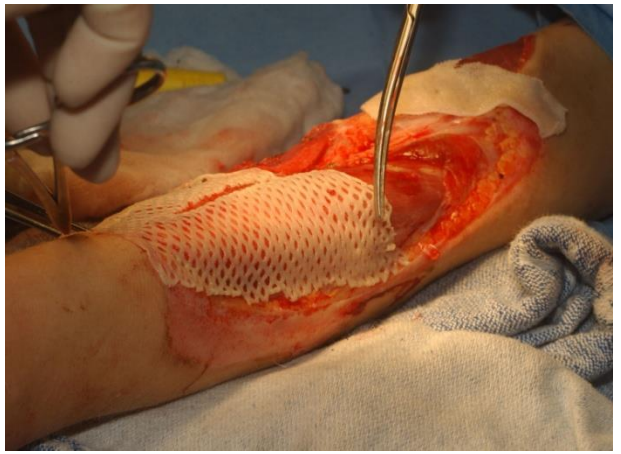
Skin Grafting

DEEP SECOND AND THIRD DEGREE BURNS

- Enormous variability in:
  - Size, depth and ability to heal spontaneously
  - Propensity to hypertrophic scar formation
- Require close observation
  - Failure to heal in 14-21 days
  - **Primary indication for surgical intervention**







Accidental versus Non-accidental Burn Injuries

Non-Accidental Burn Injuries

- Burns represent about 10% of NAT cases
  - 10-20% of pediatric burn admissions

- Children are intentionally burned for different reasons
- Intentional burns often leave characteristic patterns
- Scald type burns are most common inflicted burn
  - Often overlooked at accidental

- History, psychosocial risk factor assessment and pattern of injury are critically important

Non-Accidental Burn Injuries

- Explanation consistent with injury?
  - Contradictory or varying accounts among witnesses?
  - Burn attributed to a sibling?
- Delay in seeking care?
- Other injuries present?
  - Look for bruising!!
  - Consider bone survey
  - Consider ophthalmologic exam if < 2
- Anger or resent toward child?
  - Inappropriate affect?

Non-Accidental Burn Injuries

- Physical findings associated with NAT
  - History incompatible with physical exam
    - Anatomic location of burn injury; sparing of flexion creases
    - Presence or absence of clothing at time of injury
    - Scald: spill/splatter vs. flow vs. immersion pattern
    - Heat contact burns are usually branding type; mirror object
  - Burn incompatible with developmental age
    - Location of child at time of burn
  - Sharply delineated burn margins
  - Localized burns of perineum, genitalia, buttocks
  - Burns older than history given
  - Other injuries
    - Cigarette burns, bruises, fractures

Suspicious for Non-accidental Trauma

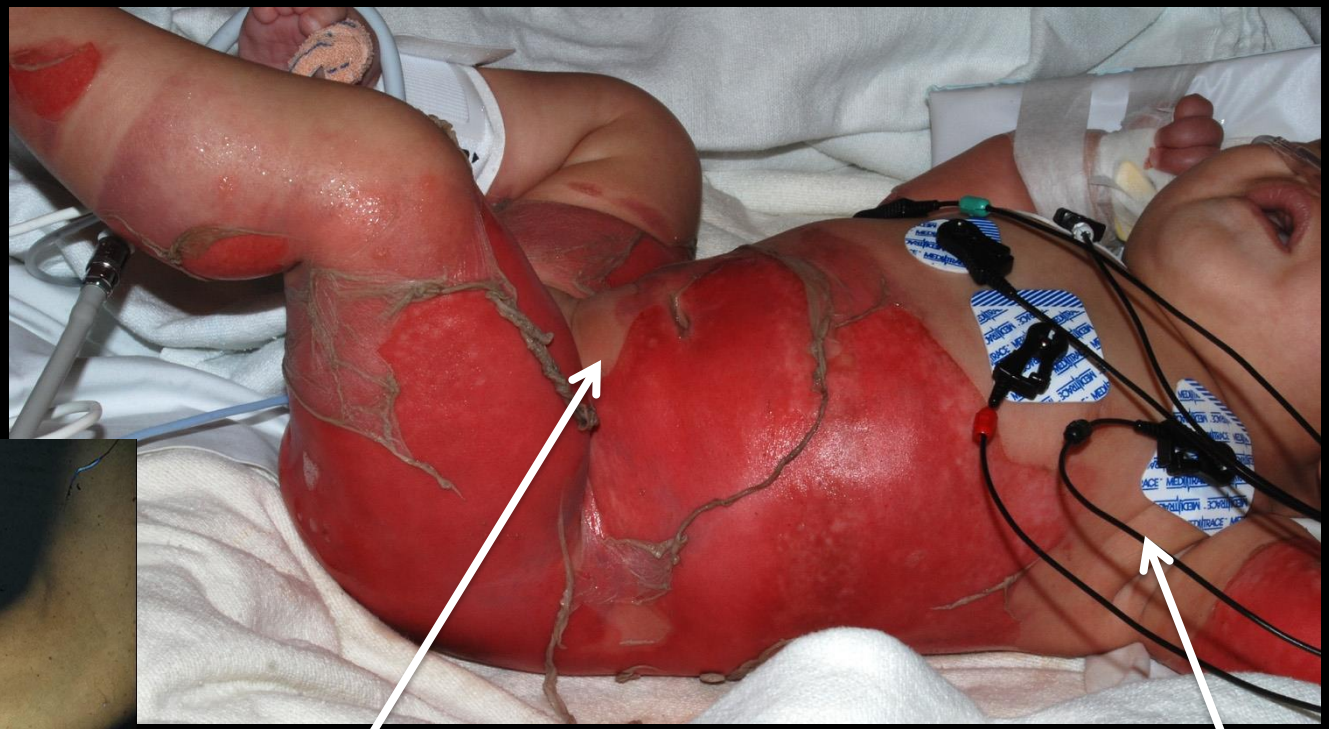
Inflicted Iron Burn

Non-accidental Trauma

Immersion Type Burns

Lines of demarcation

- History not consistent
- Deep burns
- No splash marks



Flow pattern with areas of sparing
Neglect?

Spill pattern scald type burns:
Accidental trauma

4 year old male
Step MOC soaking his hands in warm water
She left room to care for other child
Pt reportedly turned on hot water burning hand
Seen in ED, unexplained facial and other bruises
Child very quiet in room w/ FOC and Step MOC

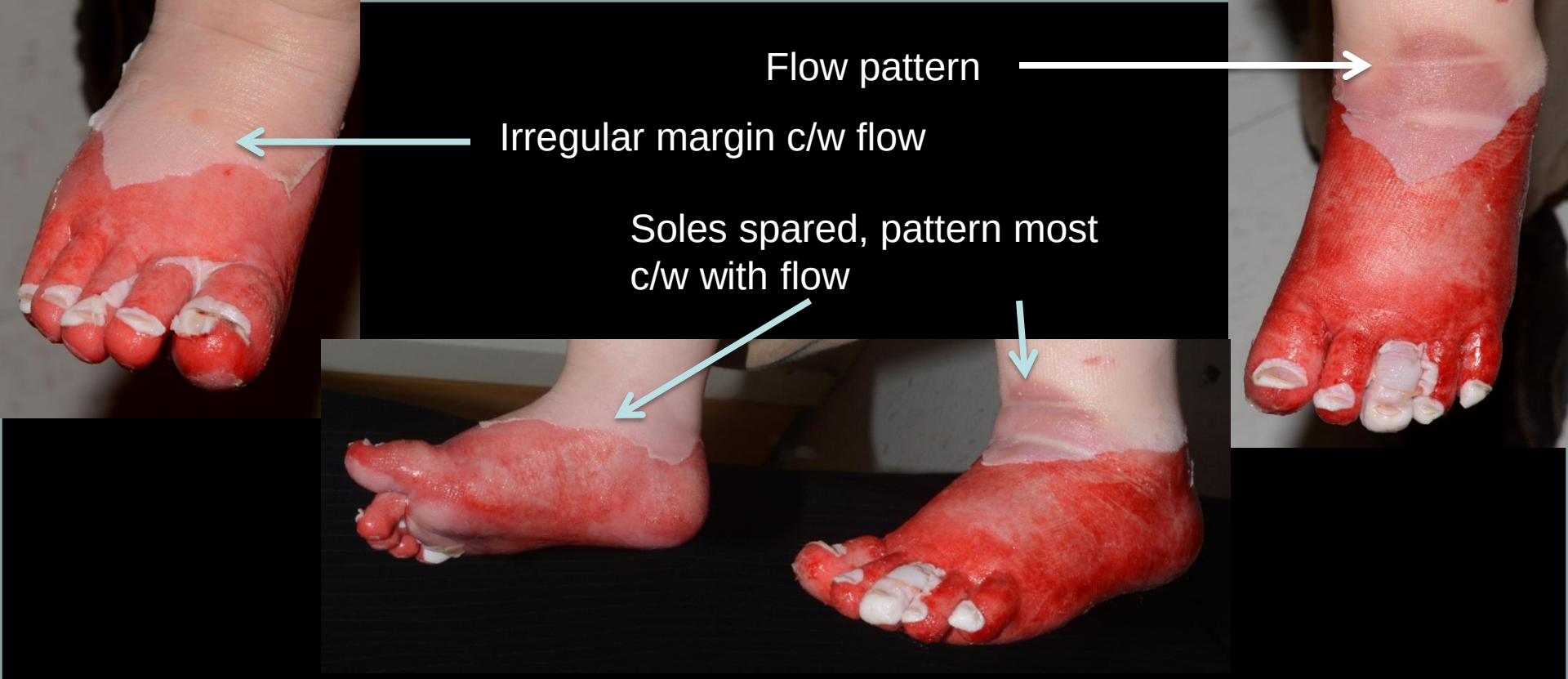
Type of burn?
History consistent with injury?

4 year old male
Step MOC soaking his hands in warm water
She left room to care for other child
Pt reportedly turned on hot water burning hand
Seen in ED, unexplained facial and other bruises
Child very quiet in room w/ FOC and Step MOC

Type of burn? Scald, flow pattern.
History consistent with injury? No
Discharged to foster care; pending trial.

21 month old male playing in bathroom sink during Broncos game
FOC hears patient crying at top of stairs, notes skin sloughing from feet
Calls 911
Brings patient to ED, refuses to repeat hx after speaking with police

Type of burn?
History consistent with injury?



21 month old male playing in bathroom sink during Broncos game
FOC hears patient crying at top of stairs, notes skin sloughing from feet
Calls 911
Brings patient to ED, refuses to repeat hx after speaking with police

Type of burn? Scald, immersion pattern with flow.
History consistent with injury? No, but other adults in home corroborated hx.
Discharged with parents; ruled neglect.

3 year old female in kitchen with mom making dinner
Mom steps away to answer phone, MGMOC remains in kitchen
Child pulls chair up to stove to check boiling water in pot on stove?
Mom hears crying, notes child with burns

Type of burns?
History consistent with injury?

Fingertips spared

Flow pattern, palmar surface deeper than dorsal

3 year old female in kitchen with mom making dinner
Mom steps away to answer phone, MGMOC remains in kitchen
Child pulls chair up to stove to check boiling water in pot on stove
Mom hears crying, notes child with burns

Type of burns? Scald, flow pattern (finger tips are spared, palmar deeper).
History consistent with injury? No
Child in custody of mom; MGMOC removed from home, DHS monitoring.

11 month old male with nasal congestion
Parents instructed by MD to place child in humidified environment
Father fills tub with hot water while intoxicated
Holds child over hot water in tub, child's extremities immersed

Type of burn?
History consistent with injury?

11 month old male with nasal congestion
Parents instructed by MD to place child in humidified environment
Father fills tub with hot water while intoxicated
Holds child over hot water in tub, child's extremities immersed

Type of burn? Scald, immersion pattern.
History consistent with injury? Yes, one hand, forefeet.
Dad jailed; substance abuse rehab (alcohol and meth). Home with mom.
DHS monitoring.

4 year old female
Father claims she touched hot pot
Father later claims she touched hot stovetop

Type of burn?
History consistent?

4 year old female
Father claims she touched hot pot
Father later claims she touched hot stovetop

Type of burn? Heat contact.
History consistent? No, palm/dorsum.
Mom later confessed, jailed.

Dorsal and palmar burns

23 month old female, potty training
Poops in her pants
Mom places child in shower
Notes skin sloughing
Next day father brings child to ED

Type of burn?
History consistent?

23 month old female, potty training
Poops in her pants
Mom places child in shower
Notes skin sloughing
Next day father brings child to ED

Type of burn? Scald, immersion.
History consistent? No, delay in care.
Discharged to foster care.
Slowly reintegrated with POC.
Criminal charges pending against mom.

6 month old male reportedly napping indoors next to window w/o blinds
“sunburn” noted, treated at home with topical antibiotic for 5 days
No improvement; seek medical care

Type of burn?
History consistent?

6 month old male reportedly napping indoors next to window w/o blinds
“sunburn” noted, treated at home with topical antibiotic for 5 days
No improvement; seek medical care

Type of burn? Scald, spill pattern with sparing.
History consistent? No, delay in seeking care.
Discharged in care of MGFOC.

2 year old male in c/o father's GF
Potty training; later playing in toilet
GF washed his hands, skin peeling
GF believes chemicals in toilet water
O/E in ED, blood in both ears, bruises and abrasions

Type of burn?
History consistent?

2 year old male in c/o father's GF
Potty training; later playing in toilet
GF washed his hands, skin peeling
GF believes chemicals in toilet water
O/E in ED, blood in both ears, bruises and abrasions

Type of burn? Scald, flow pattern
History consistent? No
Placed in foster care

Sparing of palms and fingertips

4 MO male had “poopy diaper”

FOC placed pt in sink, ran water

Returned, skin peeling, calls mom

FOC takes pt to local ED

25% TBSA burn, bite mark

Type of burn?

History consistent?

4 MO male had “poopy diaper”

FOC placed pt in sink, ran water

Returned, skin peeling, calls mom

FOC takes pt to local ED

25% TBSA burn, bite mark

Type of burn? Scald, flow

History consistent? No

3 week old infant
Mom warming frozen BM in pot of hot water
Carries infant and pot with hot water/BM
Stumbles, spills hot water on infant
Mom distraught in ED

Type of burn?
History consistent?

Sparing

3 week old infant
Mom warming frozen BM in pot of hot water
Carries infant and pot with hot water/BM
Stumbles, spills hot water on infant
Mom distraught in ED

Type of burn? Scald, spill/splatter
History consistent? Yes, accidental



6 month old female
Father bathed infant yesterday while mom was at work. Noted sloughing facial skin. He thinks there were chemicals on the washcloth. Father put infant to bed. Today her face looked like this: thick weeping eschar, legs mottled. Crying, but no tears.

Type of burn?
History consistent?

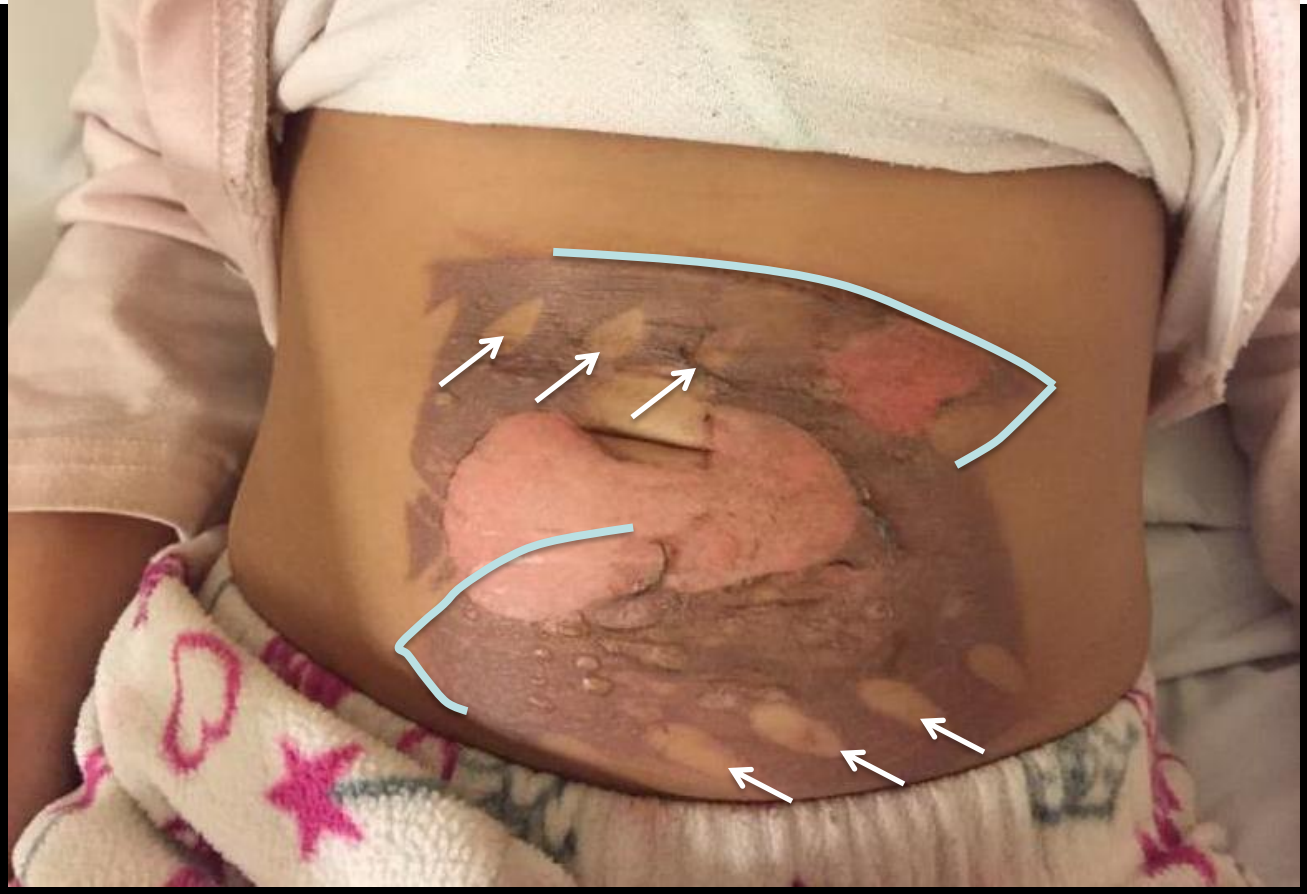


6 month old female
Father bathed infant yesterday while mom was at work. Noted sloughing facial skin. He thinks there were chemicals on the washcloth. Father put infant to bed. Today her face looked like this: thick weeping eschar, legs mottled. Crying, but no tears.

Type of burn? Scald, spill pattern.
History consistent? No, delay in seeking care. Severe dehydration. Eyes goupy and "less swollen" than yesterday. Portions of eschar are lifting off revealing healed burn.

4 year old female plugs in iron. Later playing in house with 12 and 3 year old sisters, while father in garage and stepmother at store. 12 year old sister hears commotion and finds patient on her back, on floor, with hot iron stuck to her skin, trying to remove iron; 12 year old sister pulls off iron off patient.

Type of burn?
History consistent?



4 year old female plugs in iron. Later playing in house with 12 and 3 year old sisters, while father in garage and stepmother at store. 12 year old sister hears commotion and finds patient on her back, on floor, with hot iron stuck to her skin, trying to remove iron; 12 year old sister pulls off iron off patient.

Type of burn? Heat contact
History consistent? Pt described iron "fell“ on her; also stated she fell on iron. Given her age and development, possible fear about getting in trouble, inconsistencies in her story seem developmentally appropriate.

J Burn Care Res. 2014 Nov-Dec;35(6):525-7

Falling clothes irons rarely cause burns.

Allasio D, Shanti C.

Children's Hospital of Michigan, Detroit

Abstract

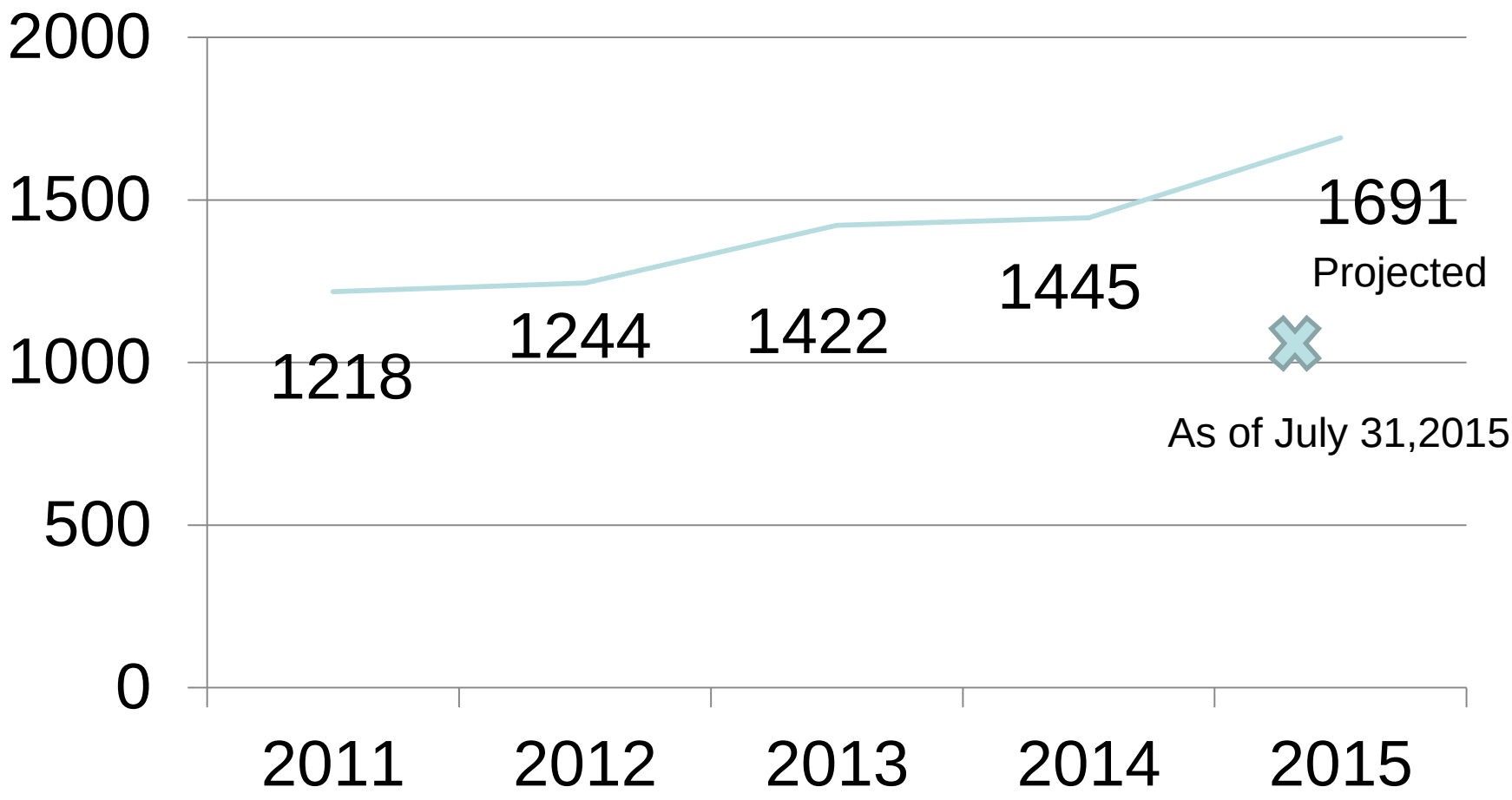
- Iron burns leave well-demarcated burn patterns, including the steam holes
- Average age 15 months
- History by the parent is child pulled cord of iron on an ironing board or high shelf
- Seemed unlikely to investigators that a falling iron would produce demarcated burns.

- A free-standing shelf unit was built; shelf heights of 36, 60, and 72 inches.
- Three irons of different weights put in 3 different positions on each shelf, cord dangling. A doll the size of a 15-month old was positioned in front of the shelf.
- Dangling cord was pulled, and the falling iron was videotaped.
- Video was edited in freeze frame to the point at which the iron hit the doll.
- 270 falls were recorded.
- Flat heat plate of the iron never hit the doll; linear edge of heat plate hit doll on 7 falls.

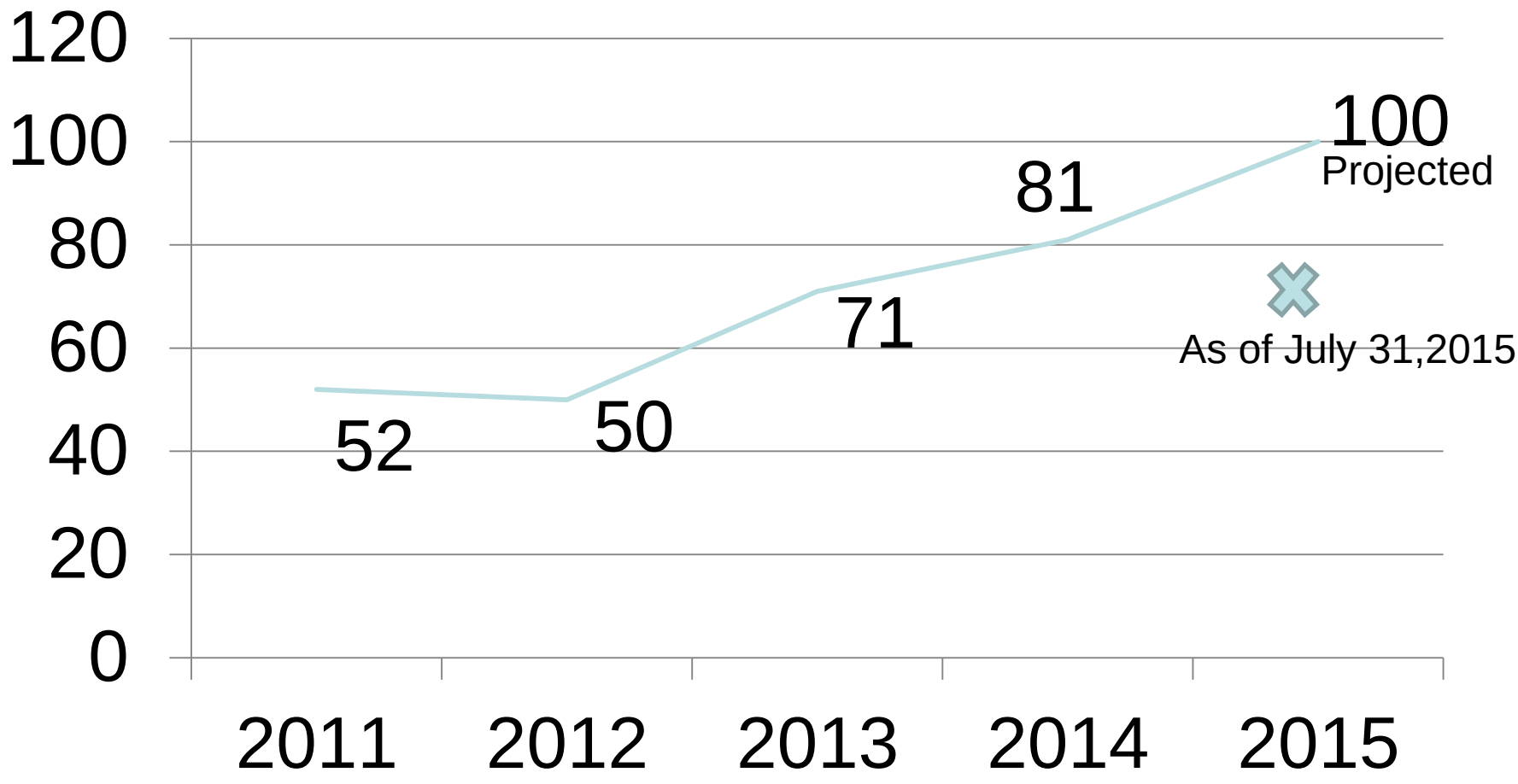
- It is very unlikely for the flat heat plate of a falling iron to contact a toddler-sized doll.
- Children who allegedly sustain demarcated iron burns should be investigated for NAT

Anschutz Medical Campus
Aurora, Colorado

Burn Outpatient Clinic Visits



Burn Inpatients



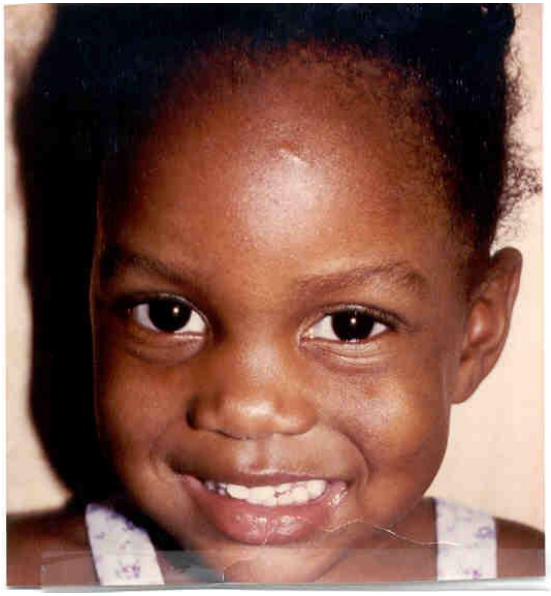
Key Points

- Optimal fluid resuscitation aims to support organ perfusion with the least amount of fluid necessary, at the least physiological cost
- Under and over resuscitation are associated with adverse outcomes
- Early recognition of when to refer vs. keep
- Be skeptical, critically evaluate the circumstances and pattern of every burn

Pham TN, et al. J Burn Care Res 2008 (1): 257-266

PBD #1

PBD #10



14 months post burn.

It will take several months for pigment to return

Burns heal,
but the scars
may last a lifetime!

Caring For Children With Burn Injuries is a Team Sport

COLORADO FIREFIGHTER CALENDAR

Firefighters Hot Times Kool Cars

Children's Hospital Colorado
No ordinary camps!
Burn Camps Program

Improving the Lives of Burn-Injured Children