

# Advancing Child Abuse Recognition & Evaluation

Nancy S. Harper, MD FAAP  
Child Abuse Pediatrics  
Associate Professor of Pediatrics, University of Minnesota  
Medical Director:  
University of Minnesota Masonic Children's Hospital  
Hennepin County Medical Center

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## Objectives

- Discuss the range of symptoms and presentations of child abuse in infants and children using case scenarios and the literature
- Identify the mechanisms of injury causation in serious physical abuse
- Identify scenarios in which serious injury from abuse may be “missed”
- Discuss the recommended medical and forensic evaluation for physical abuse cases

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## Child Maltreatment: Facts

- In 2015, Child Protective Services received 4 million referrals
  - 683,000 children were victims of child maltreatment
  - 75% Neglect, 17% Physical Abuse, 8% Sexual Abuse
- 1,670 deaths in children were the result of child abuse
  - More children die yearly from child abuse than from childhood cancers (1,250 yearly)
  - 75% of child abuse fatalities occur in children under 3 years of age
- Our youngest children are disproportionately affected
  - Infants are 2.5 times more likely to be maltreated, 3 times more likely to die than children older than 1 year
- Caregivers play an intimate role

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## Missed Abuse – More than Anecdotes

- Jenny 1999
  - 31% of Abusive Head Trauma initially missed at a physician visit
- Ravichandran 2010
  - 20% of abusive fractures initially missed
- Thorpe 2014
  - 33% of abusive fractures had previous medical visits where the diagnosis was not recognized

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# Bias in Screening

## ARTICLE Skeletal Surveys in Infants With Isolated Skull Fractures

Joanne N. Wood, MD<sup>1,2,3</sup>, Cindy W. Christian, MD<sup>1,2</sup>, Cynthia M. Adams, MD<sup>1,2</sup>, David M. Rubin, MD, MSc<sup>1,2,4</sup>

<sup>1</sup>Department of General Pediatrics and Safe Place, The Center for Child Protection and Health, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania; <sup>2</sup>Robert Wood Johnson Clinical Scholars Program, Leonard Davis Institute, and Department of Pediatrics, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania; <sup>3</sup>Children's Hospital Boston, Boston, Massachusetts

The authors have indicated they have no financial relationships relevant to this article or disclosure.

### What's Known on This Subject

Skeletal surveys are performed frequently for infants with skull fractures and are not significantly associated with rates for skull fractures resulting from inflicted trauma. However, the risk of skull fractures in this population is not known.

### What This Study Adds

For infants with simple or complex skull fractures but no significant intracranial injuries or suspicious clinical findings, skeletal surveys are not associated with increased rates of skull fractures and may not be warranted.

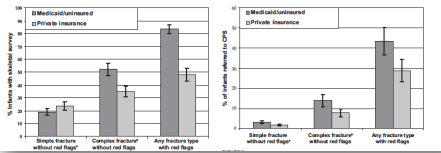
### ABSTRACT

**OBJECTIVE:** The goal was to describe the utility of skeletal surveys and factors associated with both skeletal survey use and referral to child protective services for infants with skull fractures in the absence of significant intracranial injury.

**METHODS:** A retrospective chart review was performed for infants who were evaluated at a tertiary children's hospital because of an isolated, non-motor vehicle-related, skull fracture between 1997 and 2006. Logistic regression analyses were used to test for associations of demographic factors, clinical findings that raised suspicion for abuse (absence of trauma history, changing history, delay in care, previous child protective services involvement, and other cutaneous injuries), and fracture type (simple versus complex) with the primary outcomes of skeletal survey use and reports to child protective services.

**RESULTS:** Among the 341 infants in the study, 31% had clinical findings that raised suspicion for abuse and 42% had complex skull fractures. Skeletal surveys were obtained for 141 infants (41%) and detected additional fractures for only 2 (1.4%) of those 141 infants. Child protective services reports were made for 52 (15%) of the 341 children. Both infants with positive skeletal survey findings had other clinical findings that raised suspicion for abuse, and they were among those reported. With controlling for race and age, Medicaid-eligible/uninsured infants were more likely than privately insured infants to receive skeletal surveys and child protective services reports in the presence of a complex skull fracture or clinical findings that raised suspicion for abuse.

**CONCLUSION:** Skeletal surveys were ordered frequently for infants with isolated skull fractures, but they rarely added



## Disparities in the Evaluation and Diagnosis of Abuse Among Infants With Traumatic Brain Injury

**WHAT'S KNOWN ON THIS SUBJECT:** Results of small regional studies have suggested that racial and SES biases exist in the evaluation and diagnosis of ABI, a leading cause of morbidity and mortality in young children.

**WHAT THIS STUDY ADDS:** Data from 39 pediatric hospitals suggest continued racial and SES biases in the evaluation for and diagnosis of ABI among infants with TB.

**ABSTRACT:** Joanne N. Wood, MD, MSc<sup>1,2,3</sup>, Matthew Hall, PhD,<sup>4</sup> Samantha Schilling, MD,<sup>5</sup> Ron Keren, MD, MPH,<sup>1,2,3</sup>, Nicholas Mitra, PhD,<sup>1,2,3</sup> and David M. Rubin, MD, MSc<sup>1,2,3,4</sup>

<sup>1</sup>General Pediatrics, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania; <sup>2</sup>Samuel Gross Institute, and Department of Biostatistics and Epidemiology and <sup>3</sup>Pediatrics, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania; and <sup>4</sup>Child Health Corporation of America, Research Station, Kansas

**KEY WORDS:** child abuse, nonaccidental trauma, traumatic brain injury, biomathematics, medical survey, disparity

**ABBREVIATIONS:** CPE—child protective services; ABI—abusive head trauma; SES—socioeconomic status; TB—traumatic brain injury; PHIS—Pediatric Health Information System; CHCA—Child Health Corporation of America; SES-DEM—demographic Classification of Economic, Health, and Education; Clinical Modification; ICD—International Classification of Diseases, Ninth Revision, Clinical Modification; SES—socioeconomic status; AIS—abusive injury score

www.pediatrics.org/cgi/doi/10.1542/peds.2010.0001

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Address correspondence to Joanne N. Wood, MD, MSc<sup>1,2,3</sup>, General Pediatrics, Children's Hospital of Philadelphia, 34th Market Street, Room 5017, Philadelphia, PA 19104. E-mail: woodjn@upenn.edu

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CONFLICT OF INTEREST: The authors have indicated they have no financial relationships relevant to this article or disclosure.

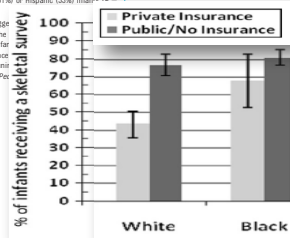
### abstract

**OBJECTIVE:** To evaluate in a national database the association of race and socioeconomic status with radiographic evaluation and subsequent diagnosis of child abuse after traumatic brain injury (TBI) in infants.

**METHODS:** We conducted a retrospective study of infants with non-motor vehicle-associated TBI who were admitted to 39 pediatric hospitals from January 2004 to June 2008. Logistic regression controlling for age, type, and severity of TBI and the presence of other injuries was performed to examine the association of race and socioeconomic status with the principal outcomes of radiographic evaluation for suspected abuse and diagnosis of abuse. Regression coefficients were transformed to probabilities.

**RESULTS:** After adjustment for type and severity of TBI, age, and other injuries, publicly insured/uninsured infants were more likely to have had skeletal surveys performed than were privately insured infants (31% vs 18%). The difference in skeletal survey performance for infants with public or no insurance versus private insurance was greater among white (82% vs 53%) infants than among black (88% vs 79%) or Hispanic (72% vs 55%) infants ( $P = .022$ ). Although skeletal surveys were performed in a smaller proportion of white than black or Hispanic infants, the adjusted probability for diagnosis of abuse among infants evaluated with a skeletal survey was higher among white infants (61%) than among black (51%) or Hispanic (53%) infants ( $P = .009$ ).

**CONCLUSIONS:** National data suggest that for abusive head trauma, the skeletal surveys among white infants evaluated with a skeletal survey was higher among white infants (black or publicly insured/uninsured) than among black or Hispanic infants (white or privately insured/uninsured).  $P < .05$ .

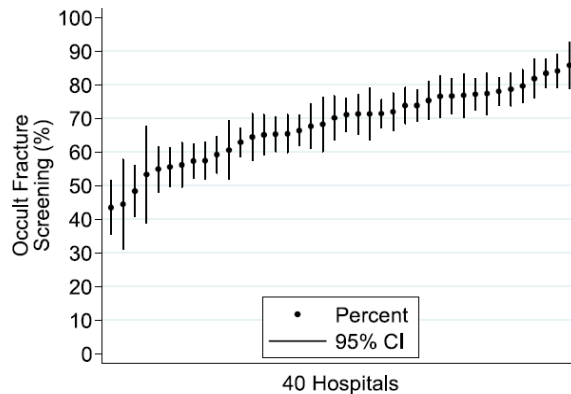


## Variation in Occult Injury Screening for Children With Suspected Abuse in Selected US Children's Hospitals

Joanne N. Wood, Chris Feudtner, Sheyla P. Medina, Xianqun Luan, Russell Localio and David M. Rubin

*Pediatrics* 2012;130:853; originally published online October 15, 2012; DOI: 10.1542/peds.2012-0244

## Skeletal Survey Screening in Children Under 24 Months



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## HOW CAN WE ADVANCE CARE?

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## Why Guidelines on Physical Abuse

### REASONS TO SUPPORT

- Increased recognition
  - Reduce missed abuse
- Fairness
  - Reduce bias & disparity
- Cognitive handicaps
  - Reduce cognitive dissonance
  - Reduce reliance on subjective factors
  - Focus on injury identification

### IS IT EVIDENCE-BASED?

- Welsh Child Protection Systematic Review Group
  - Established 2002
  - Systematic reviews of literature
- Multisite Investigators
  - ULTRA, ExSTRA, PediBIRN
- Expert Consensus Guidelines
  - RAND/UCLA method on Skeletal Survey use in Bruises, Fractures

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## Example 1: Unexplained Injury?



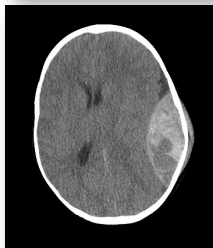
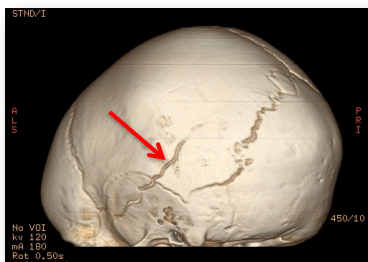
- Age: 1 month
- History: “The baby rolled off the bed to the floor”
- Injury:
  - Spiral fracture left femur
- Mechanism for Spiral Fractures:
  - Torsion or twisting of long bone
- Key Development?
  - Babies begin to roll at 4-6 months
- Common Injury Falls in Infancy:
  - Scalp injury, skull fracture
  - Head is large in proportion to body and usually leads the way in falls in infants.

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## Example 2: Unexplained Injury?



- Age: 13 months
- History:
  - Fell from dad's shoulders to floor
- Injury:
  - Epidural hemorrhage, life-threatening
  - Skull fracture
- Mechanism for Head Injury:
  - *Contact head injury* – usually arterial bleed in association with skull fracture
- Key Development:
  - Ability to sit independently
  - Well documented fall

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### Assessment for Physical Abuse: Injury Patterns, "Red Flags" & Child Abuse Programs

<p><b>When the following injuries are present, ADDITIONAL MEDICAL EVALUATION IS ALWAYS INDICATED:</b></p> <ul style="list-style-type: none"> <li>Rib Fractures</li> <li>Metaphyseal Fractures</li> <li>Longbone Fracture (non-ambulatory)</li> <li>Bruising (infants less than 6 months of age)</li> <li>Oral or Pharyngeal Injury (non-ambulatory)</li> <li>Abdominal Injury (non-MVC under 5 yrs)</li> <li>Head Injury (unwitnessed, unexplained)</li> </ul>	<p><b>Patterned Skin Injuries &amp; Unusual Locations of Injury</b></p> <p style="text-align: center;"><b>TEN-4 FACES</b></p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;"><b>TEN</b></td> <td style="width: 50%; border: none;"><b>FACES</b></td> </tr> <tr> <td style="border: none;">Torso (trunk)</td> <td style="border: none;">Frenulum (mouth)</td> </tr> <tr> <td style="border: none;">Ear</td> <td style="border: none;">Auricular area (ear)</td> </tr> <tr> <td style="border: none;">Neck</td> <td style="border: none;">Cheek</td> </tr> <tr> <td style="border: none;"></td> <td style="border: none;">Eyelids (bruising)</td> </tr> <tr> <td style="border: none;"></td> <td style="border: none;">Scleral Hemorrhage (eye)</td> </tr> </table> <p><b>4:</b> Bruises in the TEN distribution in a child under 4 years of age, or ANY bruise in an infant less than 4-6 months of age</p>	<b>TEN</b>	<b>FACES</b>	Torso (trunk)	Frenulum (mouth)	Ear	Auricular area (ear)	Neck	Cheek		Eyelids (bruising)		Scleral Hemorrhage (eye)	<p><b>Contact a Child Abuse Physician:</b></p> <p>CARE Team Driscoll Children's Hospital Corpus Christi, TX (361) 694-CARE (2273)</p> <p>Center for Miracles The Children's Hospital of San Antonio San Antonio, TX (210) 704-3800 <a href="mailto:Lukefahr@uthscsa.edu">Lukefahr@uthscsa.edu</a></p> <p>Child Abuse Pediatrics Section of Public Health Pediatrics Texas Children's Hospital Houston, TX (832) 824-0200 <a href="mailto:publichealthped@texaschildrens.org">publichealthped@texaschildrens.org</a></p> <p>FACN (Forensic Assessment Center Network) <a href="http://www.factx.org">www.factx.org</a> 1-888-TX4-FACN</p> <p><b>For Further Assistance on Guidelines:</b> Univ. of Minnesota Masonic Children's Hospital Minneapolis MN Director: Nancy Harper MD <i>Otto Bremer Trust</i> Center for Safe &amp; Healthy Children (612) 273-SAFE (7233) or (612) 365-1000 <a href="mailto:safechild@fairview.org">safechild@fairview.org</a></p> <p>Children's Hospitals and Clinics of Minnesota Minneapolis and St. Paul MN Director: Mark Hudson MD Midwest Children's Resource Center (MCRC) (651) 220-6750</p>
<b>TEN</b>	<b>FACES</b>													
Torso (trunk)	Frenulum (mouth)													
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Neck	Cheek													
	Eyelids (bruising)													
	Scleral Hemorrhage (eye)													
<p><b>MOST CHILD FATALITIES:</b></p> <ul style="list-style-type: none"> <li>i. Occur in children under 4 years of age (80%)</li> <li>ii. Occur at the instigation of a caregiver (80%)</li> <li>iv. Involve head (leading cause) and/or abdominal (second cause) Injury</li> </ul>	<p><b>What Is An Unexplained Injury:</b></p> <ul style="list-style-type: none"> <li>i. Injury that is not consistent w/ child's age, developmental abilities, or injury type</li> <li>ii. History that is vague or changes w/ time, repetition, or caregiver</li> <li>iii. Delay in seeking medical care</li> </ul>													
<p><b>Signs of Head Injury*:</b></p> <ul style="list-style-type: none"> <li>i. Bulging fontanelle (soft spot) in an infant</li> <li>ii. Rapidly increasing head circumference</li> <li>iii. Bruising/Swelling to Face/Head</li> <li>iv. Vomiting or fussiness</li> <li>v. Unresponsive, "altered mental status"</li> <li>vi. Apnea or change in breathing</li> </ul>	<p><b>Signs of Abdominal Injury*:</b></p> <ul style="list-style-type: none"> <li>i. Abdominal pain or distention</li> <li>ii. Abdominal bruising</li> <li>iii. Vomiting</li> <li>iv. Lethargic, "altered mental status"</li> <li>v. Rectal bleeding</li> <li>vi. Presents in shock, low blood pressure</li> </ul>													
<p><small>*Simple household falls rarely result in serious injury.</small></p>	<p><small>*Simple household falls rarely result in serious injury.</small></p>													

These recommendations are not a substitute for expert medical evaluation. It should also not take the place of human decision-making. Injuries that are suspicious for abuse require careful assessment by a physician or medical provider with expertise in child abuse.

### Minnesota Child Abuse Network ASSESSMENT FOR PHYSICAL ABUSE

• Head CT (recommended in all)

• Skeletal Survey

• Labs (CBC, Metabolic Panel with Liver Enzymes,\* Lipase)

• Urine Drug Screen

• Social Work Consult \*

• Ophthalmology Consult \*

• Trauma Service Consult \*

• Skeletal Survey

• Labs (CBC, Metabolic Panel with Liver Enzymes,\* Lipase)

• Urine Drug Screen

• Neuro-Imaging \*

• Social Work Consult \*

• Ophthalmology Consult \*

• Trauma Service Consult \*

**2 - 5 years**

• Labs (CBC, Metabolic Panel with Liver Enzymes,\* Lipase)

• Urine Drug Screen

• Skeletal Survey (Extensive Trauma, Developmental Delays, Burns) \*

• Neuro-imaging \*

• Social Work Consult \*

• Trauma Service Consult \*

**1-2 years**

• Skeletal Survey

• Labs (CBC, Metabolic Panel with Liver Enzymes,\* Lipase)

• Urine Drug Screen

• Neuro-Imaging \*

• Social Work Consult \*

• Trauma Service Consult \*

**5 years and older**

- Labs (CBC, Metabolic Panel with Liver Enzymes,\* Lipase, Urine Drug Screen) \*
- Neuro-Imaging \*
- Social Work Consult \*
- Mental Health Assessment

**\* Clinical Indicators**

- Labs – Non-Patterned Bruising or ICH: add PT/PTT; Extensive Trauma: add CPK
- Abdominal Imaging – AST or ALT > 80 and/or abdominal bruising/tenderness
- Neuro-Imaging - Altered Mental Status, Skull Fracture(s), Bruising Face/Head
- Ophthalmology – Positive Neuro-Imaging and/or Altered Mental Status
- Social Work Consult – Suspected Abuse/Neglect, Ingestions, CPS involvement
- Trauma Service Consult – Head, Abdomen and Multi-system Trauma
- Contact a Child Abuse Physician for guidance on evaluation and management

Updated 10/05/2016  
Otto Bremer Trust Center for Safe & Healthy Children  
[safechild@fairview.org](mailto:safechild@fairview.org)

## BRUISING & ORAL INJURY

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### Bruising is a Sentinel Injury

*defined as a previous injury suspicious for abuse as the infant is unable to cruise, or an improbable explanation is offered for the injury*

- A BRUISE or history of a BRUISE is seen in:
  - 1 in 4 infants referred to child abuse providers<sup>H</sup>
  - 1 in 4 infants with abusive head trauma<sup>S</sup>
- BRUISING is seen in child abuse fatalities<sup>A,I</sup>; and may be initially *missed* as an abusive injury in infants later presenting as child fatalities<sup>P</sup>

**NOTE:** An ORAL injury is *also* a sentinel injury<sup>S</sup> seen in infants with abusive injuries.

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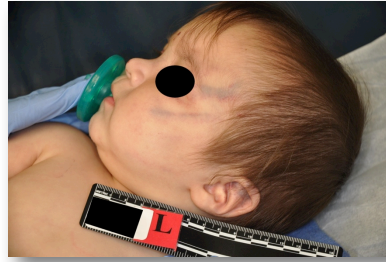
Harper 2014, Sheets 2013,  
Atwal 1998, Ingham 2011,  
Pierce 2009



## “Those Who Don’t Cruise Rarely Bruise”

- Bruising and other soft tissue injury is extremely uncommon in children younger than 6 months of age
- Any bruising on an infant less than 6 months old should be considered suspicious for abuse

Sugar et al. Archives Pediatrics and Adolescent Medicine 1999



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## Prevalence of Bruising in Infants *Ambulatory Settings*

- Clinic-based study: 0.6% of infants 0-5 months<sup>S</sup>
  - *Bruising significantly associated with age*
  - *“Those who don’t cruise rarely bruise”*
- ED & Clinic study: 1.2% of infants 0-8 months<sup>L</sup>
- 3 Pediatric EDs: 1.3% of infants 0-5 months<sup>P</sup>
- Infants between 6-12 months are more likely to have bruises with increasing mobility, with rates of bruising 11-13%.<sup>S,C</sup>

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Sugar 1999, Labbe 2001,  
Pierce 2016, Carpenter 1999





## PIERCE - Bruise Characteristics Discriminating Physical Child Abuse From Accidental Trauma - 2010

- NUMBER:
  - Accidental: Up to 4 bruises, 1.5 bruises (median)
  - Abuse Patients: Up to 25 bruises, 6 bruises (median)
- LOCATION:
  - All bruising to the ear, neck, hands, right arm, chest and buttocks was perfectly predictive of abuse.

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## TEN-4 Torso, Ear, Neck



- DECISION RULES/MODEL:
  - \* Is there bruising in the TEN region of a child under 4 years of age?
  - \* Is there bruising in any region in an infant under 4 months of age?
  - \* Is there a confirmed accident in a public setting in the TEN region on an infant?
- MODEL: Correctly classified 32/33 abuse patients with sensitivity 97%, specificity 84%

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## Abusive injury is more likely if bruises occur...

- In infants
- On multiple planes
- Are patterned:
  - Slap Mark
  - Grab Mark
  - Looped Mark
- “TEN distribution”
  - TORSO
  - EAR
  - NECK
- “FACES distribution”
  - Frenulum
  - Auricular (ear)
  - Cheek
  - Eyelid
  - Sclera



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## Can you age bruises accurately in children? A systematic review

S Maguire, M K Mann, J Sibert, A Kemp

*Arch Dis Child* 2005;90:187-189. doi: 10.1136/adc.2003.044073



Supplementary material is available on the Archives of Disease in Childhood website ([www.archdischild.com/supplemental](http://www.archdischild.com/supplemental))

See end of article for authors' affiliations

Correspondence to: Dr A Kemp, Department of Child Health, Cardiff University, Wales College of Medicine, Llandough Hospital, Penarth, Wales CF64 2XX, UK; [kempam@cf.ac.uk](mailto:kempam@cf.ac.uk)

Accepted 3 May 2004

**Aims:** To investigate whether it is possible to determine the age of a bruise in a child in clinical practice by means of a systematic review.

**Methods:** An all language literature search up to 2004. Included studies assessed the age of bruises in live children less than 18 years old. Excluded: review articles, expert opinion, and single case reports. Standardised data extraction and critical appraisal forms were used. Two reviewers independently reviewed studies.

**Results:** Of 167 studies reviewed, three were included: two studies described colour assessment in vivo and one from photographs. Although the Barciak *et al* study showed a significant association between red/blue/purple colour and recent bruising and yellow/brown and green with older bruising, both this study and Stephenson and Bialas reported that any colour could be present in fresh, intermediate, and old bruises. Results on yellow colouration were conflicting. Stephenson and Bialas showed yellow colour in 10 bruises only after 24 hours, Carpenter after 48 hours, and Barciak *et al* noted yellow/green/brown within 48 hours. Stephenson and Bialas reported that red was only seen in those of one week or less. The accuracy with which clinicians correctly aged a bruise to within 24 hours of its occurrence was less than 40%. The accuracy with which they could identify fresh, intermediate, or old bruises was 55-63%. Intra- and inter-observer reliability was poor.

**Conclusion:** A bruise cannot accurately be aged from clinical assessment in vivo or on a photograph. At this point in time the practice of estimating the age of a bruise from its colour has no scientific basis and should be avoided in child protection proceedings.

**Conclusion:** A bruise cannot accurately be aged from clinical assessment in vivo or on a photograph. At this point in time the practice of estimating the age of a bruise from its colour has no scientific basis and should be avoided in child protection proceedings.

## Occult Injuries in Infants

- Head CT (recommended in all)
- Skeletal Survey
- Labs (CBC, Metabolic Panel with Liver Enzymes,\* Lipase)
- Urine Drug Screen
- Social Work Consult \*
- Ophthalmology Consult \*
- Trauma Service Consult \*

0 - 6 months

- Neuroimaging:
  - Occult injury in approximately 25-30% of neurologically asymptomatic infants (Laskey 2004, Rubin 2003)
- Skeletal Survey:
  - Occult injury in as many as 25% of infants and 12% children
- Abdominal Injury Screening:
  - Occult abdominal injury prevalence ranges from 3-6% depending on population studied
  - Highest risk group (12-23 months): 1 in 20 toddlers

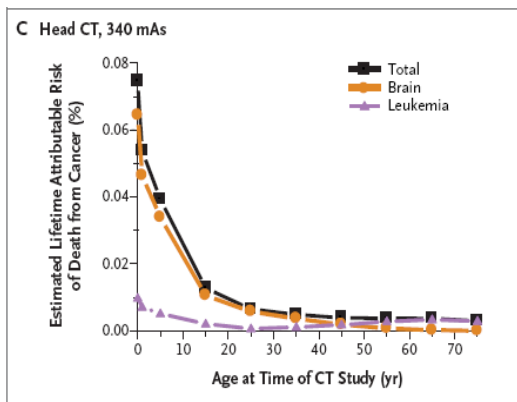
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## A.L.A.R.A.

*As Low As Reasonably Achievable*



- Background radiation 3 mSv
- Skeletal Survey
  - 15 view 0.2 mSv
  - 24 days background
  - REID 2-5/100,000
  - PA death 30/100,000 (Berger et al *J Peds* 2016)

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## Scripting to Caregivers

- *“Whenever I see a baby with this injury, I am worried that there other injuries we cannot see.”*
- *“I recommend that all babies with this injury (or this history of injury) get blood work to screen for internal injury and x-rays called a skeletal survey of your baby’s body so we don’t miss any injuries.”*

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### Sentinel Injuries in Infants Evaluated for Child Physical Abuse

Lynn K. Sheets, Matthew E. Leach, Ian J. Koszewski, Ashley M. Lessmeier, Melodee Nugent and Pippa Simpson  
*Pediatrics*; originally published online March 11, 2013;  
DOI: 10.1542/peds.2012-2780

- SENTINEL INJURY: previous injury reported in the medical history that was suspicious for abuse because the infant could not cruise, or the explanation was implausible
- Compared the following infants under 12 months:
  - 200 definite abuse
  - 100 intermediate concern for abuse
  - 101 non-abused infants

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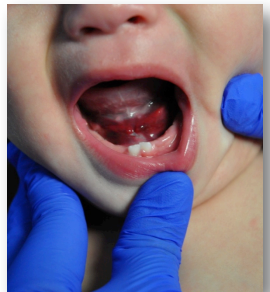


**Sentinel Injuries in Infants Evaluated for Child Physical Abuse**  
 Lynn K. Sheets, Matthew E. Leach, Ian J. Koszewski, Ashley M. Lessmeier, Melodee  
 Nugent and Pippa Simpson  
*Pediatrics*; originally published online March 11, 2013;  
 DOI: 10.1542/peds.2012-2780

- **SENTINEL INJURY:**
  - 27.5% (55) of definite abuse infants
    - 80% BRUISING, 11% INTRAORAL INJURY
    - 41 Face, Forehead, Ear
    - 14 Extremity, 11 Trunk
  - 8% of the intermediate abuse infants
  - 0% of the non-abuse infants

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## Trauma to the Oropharynx

- Types of Injury
  - Lip
  - Frena
  - Palate
  - Tongue
  - Posterior Pharynx
- Mechanisms of Injury
  - Blunt trauma
    - Direct Impact or Blow
  - Insertion of an Object
    - Physical or Sexual Abuse
  - Burns
    - Hot/Caustic Liquids
  - Biting the tongue

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## FRACTURES

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### Long bone fractures: Humerus

- Child abuse accounts for 12% of fractures in children under 3 years of age (Leventhal 2008)
- 48% probability of abuse with fractures of the humerus in children under 3 years (Kemp 2008)
- Predictors of child abuse with humerus fx:
  - AGE – less than 15 months
  - LOCATION
    - oblique, spiral (abusive) vs. supracondylar (accidental)

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## Skeletal Survey

American College Radiology, AAP

- AP,LAT skull (2)
- AP and LAT C-spine (2)
- AP,LAT, OBL chest/ribs (4)
- AP pelvis with mid lumbar spine (1)
- AP,LAT axial skeleton/spine (2)
- AP,LAT long bones (4-8)
- PA hands (2)
- PA or AP feet (2)
- LAT sternum (1)

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**TABLE 2** Indications for Obtaining a Skeletal Survey

All children <2 y with obvious abusive injuries
All children <2 y with any suspicious injury, including
Bruises or other skin injuries in nonambulatory infants;
Oral injuries in nonambulatory infants; and
Injuries not consistent with the history provided
Infants with unexplained, unexpected sudden death (consult with medical examiner/coroner first)
Infants and young toddlers with unexplained intracranial injuries, including hemorrhage and hypoxic-ischemic injury
Infants and siblings <2 y and household contacts of an abused child
Twins of abused infants and toddlers

## Skeletal Survey

- All children under 2 years of age:
  - Yield 10-25% (Day 2006, Duffy 2011, Lindberg 2014)
  - As high as 30% in children < 12 months
  - Yield in burns 14-18%
- Select children 2-5 years of age
  - Developmental Delay, Extensive Trauma
  - Yield in children 2-3 years 10% (Lindberg 2014)
- What is a Follow-up Skeletal Survey
  - Repeat SS performed in 2 weeks to detect occult fractures
  - Minimum: Infants under 1 year of age
  - Yield is approximately 1 in 5 (Harper 2012)

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## Rib Fractures

- Most common type of abusive fracture
  - 80% occur in children under 3 years
  - Rib fractures have an estimated 95% PPV for abuse
- Rarely occur:
  - Accidentally in healthy infants/children
  - As a result of birth trauma
  - As a result of CPR in children
- Posterior rib fx do not occur as a result of CPR
- Accidental causes are rare, especially if there are multiple fractures in differing stages of healing

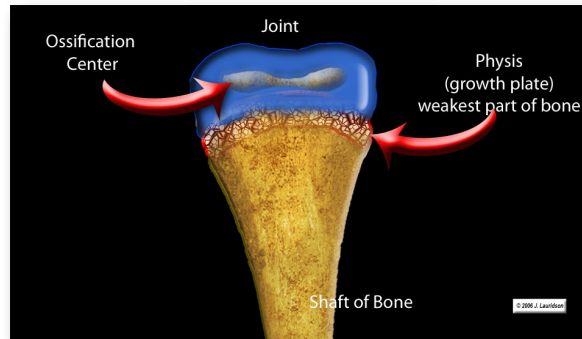
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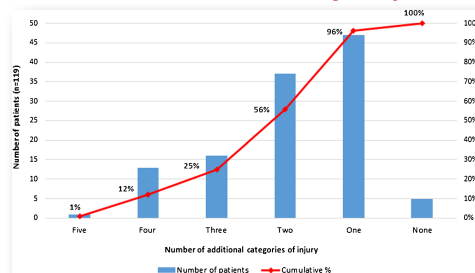


## Metaphyseal Fractures



- Fractures occur at the growth plate of the long bones in the legs or arms
- Considered to be highly specific for inflicted injury

## Classic Metaphyseal Lesion (CML) & Traumatic Injury



- 2,890 subjects → 1500 were infants 12 months and younger with 8% of these having a CML identified
- 95% had at least one additional injury
  - 84% had additional fractures
  - 44% had cutaneous injury
  - 28% had traumatic brain injury

Thackeray et al.  
*Pediatr Radiol.* 2016

## Prevalence of the Classic Metaphyseal Lesion in Infants at Low Versus High Risk for Abuse

Paul K. Kleinman<sup>1</sup>  
 Jeannette M. Perez-Rossello<sup>1</sup>  
 Alice W. Newton<sup>2</sup>  
 Henry A. Feldman<sup>3</sup>  
 Patricia L. Kleinman<sup>1</sup>

**OBJECTIVE.** The purpose of this article is to determine the relative likelihood of encountering a classic metaphyseal lesion in infants at low and high risk for abuse.

**MATERIALS AND METHODS.** This 10-year retrospective study compared the prevalence of the classic metaphyseal lesion on high-detail American College of Radiology–standardized skeletal surveys in infants at low and high risk for abuse. Low-risk infants met all of the following criteria: skull fracture without significant intracranial injury on CT, history of a fall, and no other social risk factors for abuse. High-risk infants met all of the following criteria: significant intracranial injury, retinal hemorrhages, and skeletal injuries (excluding classic metaphyseal lesions and skull fractures). Differences between the two groups were calculated using the Fisher exact test.

**RESULTS.** There were 42 low-risk infants (age range, 0.4–12 months; mean age, 4.4 months) and 18 high-risk infants (age range, 0.8–10.3 months; mean age, 4.6 months). At least one classic metaphyseal lesion was identified in nine infants (50%) in the high-risk category. No classic metaphyseal lesions were identified in the low-risk group. The relative prevalence of classic metaphyseal lesions in the low-risk group (0/42) versus that in the high-risk group (9/18) was statistically significant ( $p < 0.0001$ ; 95% CI, 0–8% to 29–76%).

**CONCLUSION.** Classic metaphyseal lesions are commonly encountered in infants at high risk for abuse and are rare in infants with skull fractures associated with falls, but no other risk factors. The findings support the view that the classic metaphyseal lesion is a high-specificity indicator of infant abuse.

AJR:197, October 2011

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## Radiologic Findings

- Rib Fractures
- Classic Metaphyseal Fractures
  - AKA “Corner” or “Bucket Handle” fractures
- Long bone fractures in non-ambulatory infants

Other *unusual* radiologic findings:

- Complex skull fractures
- Scapula & acromium (shoulder) fractures
- Sternum, vertebral, pelvic fractures
- Unsuspected fractures in children with normal mineralization of bone.
- Lack of repeated fractures in a protective environment

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## Fractures Without Bruising

- Only 9% of fractures had bruising at presentation near site of fracture (Matthew; Peters)
- 72% of fractures were without bruising within one week of the injury (Matthew)
- It is normal for children to have fractures without bruises
  - “The presence or absence of bruising does not make the fracture more or less likely from abuse” (Matthew)

Matthew et al BMJ 1998; Peters et al Arch Ped Adolesc Med 2008

## ABDOMINAL INJURY

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## Laboratory Testing

- Bruising/Bleeds: CBC, PT/PTT
- Abdominal Injury:
  - **Comprehensive Metabolic Panel with Liver Enzymes & Lipase (abdomen)**
- Fractures (bones):
  - Add: Calcium, Phosphorous, Alk Phos (bones)
- Consider CPK (extensive cutaneous & muscular injury)
- Troponin (cardiothoracic injury)
- Urinalysis
- Urine Drug Screening

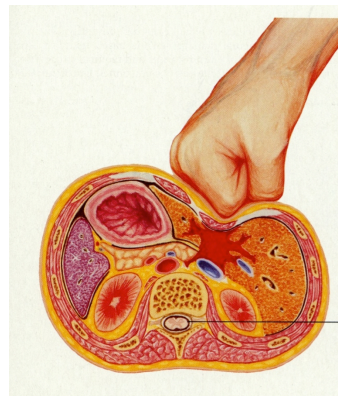
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- Injuries are related to blunt force trauma
  - Duodenal hematoma
  - Splenic and liver lacerations/contusions
  - Bowel rupture
  - Pancreas laceration
- These injuries account for a significant percentage of fatal abuse injuries
- 2<sup>nd</sup> Leading Cause of Physical Abuse Deaths

## Abdominal trauma



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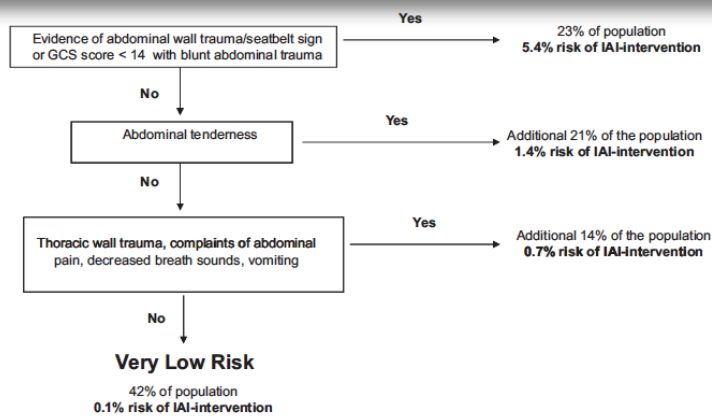
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## Clinically v Forensically Significant Injuries

CLINICAL DECISION RULES/ORIGINAL RESEARCH

### Identifying Children at Very Low Risk of Clinically Important Blunt Abdominal Injuries



Holmes 2013

Figure 5. Clinical risk stratification of children with blunt torso trauma.

### Markers for Occult Liver Injury in Cases of Physical Abuse in Children Pierre N. Coant, Allan E. Kornberg, Alan S. Brody and Karen Edwards-Holmes *Pediatrics* 1992;89;274-278

TABLE. Laboratory Values of Patients A Through E\*

Patient	Time	AST	ALT	LDH	Alk Phos	CT scan result
A	Initial	239	106	685	576	Liver laceration
	48 h	101	70	536	534	
	72 h	30	34	237	589	
B	Initial	81	27	504	108	Liver laceration
	120 h	82	16	560	91	
C	Initial	460	574	660	178	Liver laceration
	24 h	159	372	355	163	
	72 h	43	191	262	286	
D	Initial	340	510	577	161	Normal
	24 h	59	242	288	133	
E	Initial	4793	2979	2624	220	Liver laceration
	24 h	1386	2090	616	206	
	96 h	66	526	198	161	
Normal values†		50	45	645‡ 195§	290	

\* Abbreviations: AST, aspartate aminotransferase; ALT, alanine aminotransferase; LDH, lactate dehydrogenase; Alk Phos, alkaline phosphatase; CT, computed tomographic. Values for AST, ALT, LDH, and ALK Phos are in international units per liter.

† Values up to those listed are normal. From Meites.<sup>13</sup>

‡ In infants younger than 1 year of age.

§ In children older than 1 year of age.

† Holmes Children's Hospital

# PEDIATRICS®


OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

**Utility of Hepatic Transaminases to Recognize Abuse in Children**  
 Daniel Lindberg, Kathi Makoroff, Nancy Harper, Antoinette Laskey, Kirsten Bechtel,  
 Katherine Deye, Robert Shapiro and for the ULTRA Investigators  
*Pediatrics* 2009;124:509-516; originally published online Jul 20, 2009;  
 DOI: 10.1542/peds.2008-2348


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## ULTRA 2009


- 1676 consultations, 1272 transaminases
- 54 (3.2%) with abdominal injuries
  - Liver, bowel/mesentery, spleen, pancreas, adrenal, kidney, other
  - 14 (26%) clinically occult
    - No bruising, tenderness, distention
- AST or ALT cutoff of 80
  - Sensitivity 77%, Specificity 82%

For every 100 children with liver enzymes:  
18 CT Scans will be ordered, 3 new injuries will be detected


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## Mechanisms of Injury



- Fall
  - Not associated small intestinal injury in young children (Barnes 2005, Gaines 2004)
  - No small intestinal perforations from stairway falls in young children (Huntimer 2000)
- Motor vehicle crash
- Bicycle (e.g. handlebar injury)
  - Older children 5-10 years (Canty 1999)
- Direct blows or impacts

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## So uncommon, why so deadly?

- 40-50% mortality from inflicted abdominal injury
- 2nd leading cause of fatal child physical abuse
  - Delay in seeking care
  - Lack of obvious external injury
  - Low suspicion
  - Misleading or inaccurate history

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## CONTACTS & SIBLINGS

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### Prevalence of Abusive Injuries in Siblings and Contacts of Physically Abused Children

Lindberg et al. *Pediatrics*. 2012

- 627 abused index children & 479 contacts
  - *Contacts: Children who share a home with an injured abused child*
- Exam positive in 6%, Skeletal Survey in 12%
- Interview? **Positive in 30%**

Conclusion: Skeletal Survey should be obtained in all children under 24 months regardless of physical examination findings.

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## VALUE OF THE MEDICAL HISTORY

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### Medical History from the Child (separate from caregiver)

- Correlate history with medical findings
- Determines additional medical evaluation
- May direct medical treatment
- Chance to provide therapeutic messages

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## Medical History (separate from caregiver)

- Build rapport, use child’s language (developmentally appropriate questions)
- Minimal facts
- Wh’ questions – who, what, where, when, how, sometimes why...
- Open ended: “What happened here (point)?”  
“How did you get that bruise?”
- Focused: “What were you hit with?”
- Facilitators: listening, “what else happened?”

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## Federal Rules of Evidence Article VIII. Hearsay

### Rule 803. Exceptions to the Rule Against Hearsay – Regardless of Whether the Declarant is Available as a Witness

- (2) Excited Utterance. A statement relating to a startling event or condition made while the declarant was under the stress or excite that it caused.
- (4) Statement Made For Medical Diagnosis or Treatment. A statement that:
  - (A) is made for – and is reasonable pertinent to – medical diagnosis or treatment; and
  - (B) describes medical history; past or present symptoms or sensations; their inception; or their general cause.

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## Applications in the Field

- DOCUMENT CAREGIVERS: Persons Present
- DOCUMENT HISTORY:
  - What is the initial history? History changing?
  - FRE Rule 803: “Excited Utterance”
  - FRE Rule 803: Statement for the purpose of medical diagnosis and treatment
- DOCUMENT GCS with vital signs
- DOCUMENT Injuries – especially injuries present to Torso-Ear-Neck & Oropharynx prior to CPR and/or intubation
- STABILIZE cervical spine in suspected abusive head trauma even in infants

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## Recommendations to *Prevent Missed Injuries*

- Fully undress children especially infants
  - ***Look for bruises and oral injuries in all infants***
- Unwrap splints and log roll to see all skin
- No injuries are “pathognomic” for abuse, but any injury can be child abuse
- Consider transfer for specialty care including *child abuse physician consultation* and *skeletal survey*
- Follow ACR standards and include oblique views of the chest on all skeletal surveys
- Add 3D Reconstruction to trauma head CTs in children under 4 years of age
- Take a systematic approach to identify additional injuries and minimize bias in screening

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## What Will Be Your Barriers?

- A strong desire to believe caregivers
- Failure to add child abuse to the differential
- Challenge of working in a a busy clinic or ED setting
- Frustrations of the mandated reporting process
- Lack of follow-up from child protective services
- Fear of court testimony

### Facilitators: Advocacy, Education, Case Consultation

(Tiyagura et al. Barriers and Facilitators to Detecting Child Abuse and Neglect in General Emergency Departments. *Annals of Emer Med* 2015)

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#### Contact a Child Abuse Physician:

Univ. of Minnesota Masonic Children's Hospital  
Minneapolis MN  
Center for Safe & Healthy Children  
(612) 273-SAFE (7233) or (612) 365-1000

Hennepin County Medical Center  
Minneapolis MN  
Center for Safe & Healthy Children  
(800) 424-4262 Hennepin Connect

Children's Hospitals and Clinics of Minnesota  
Minneapolis and St. Paul MN  
Midwest Children's Resource Center (MCRC)  
(651) 220-6750

Mayo Clinic  
Rochester MN  
Mayo Child and Family Advocacy Program  
(507) 266-0443 daytime or (507) 284-2511

Essentia Health  
Duluth MN (218) 786-8364

Gundersen Health System  
La Crosse WI 1-800-362-9567

Sanford Health  
Sioux Falls SD  
Child's Voice Child Advocacy Center  
(605) 333-2226

Sanford Health  
Fargo ND  
Child & Adolescent Maltreatment Service  
(CAMS) (701) 234-2000 or (877) 647-1225

## MN Child Abuse Network Child Abuse Physicians

- Consultants on call 24 hours/day
- Consider calling a consultant:
  - Bruising or oral injury in infants
  - Unexplained head injury
  - Unexplained fractures or fractures in non-ambulatory infants
  - Unexplained (non-MVC) abdominal injury
  - Unexplained burns including immersion, patterned, and questionable burns
- May need to refer/transfer for skeletal surveys, consultation or other studies



## Otto Bremer Trust Center for Safe & Healthy Children



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University of Minnesota Masonic Children's Hospital:

Center for Safe & Healthy Children

- (612) 273-SAFE (7233) – Referrals
- (612) 625-6678 Office
- Email: [safechild@fairview.org](mailto:safechild@fairview.org)

Hennepin County Medical Center:

Center for Safe & Healthy Children

- (612) 365-1000 Operator
- (800) 424-4262 Hennepin Connect
- (612) 873-2671 Office
- Email: [safechild@hcmcd.org](mailto:safechild@hcmcd.org)



University of Minnesota  
Masonic Children's Hospital