WHEN SHOULD EMS CALL A CHILD A SMALL ADULT: DISPARITIES IN PROTOCOL DEFINITIONS

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ABSTRACT

Understanding age-related patient differences is important to those providing care in the prehospital environment, yet there is currently no research evaluating how emergency medical services (EMS) systems across the US categorize patients as pediatric. The US Health Resources and Services Administration’s Maternal Child Health Bureau (HRSA MCHB) through their Emergency Medical Services for Children (EMSC) program has coordinated a focus on pediatric EMS care. However, there is a wide variety of age and other categorizations used to define the pediatric EMS population. In order to start discussion on this variation, this paper reviews the current state of pediatric EMS categorization from several sources, including national-level agencies and organizations, EMS Protocols, and other sources, and provides an overview of the anatomic, physiologic, and behavioral parameters that are generally expected within the range of pediatric ages. We found that, of 32 states publishing statewide EMS protocols online, there was great variability in the definition of a pediatric patient. The age at which states identified the transition from pediatric to adult patient ranged from 12-18 years old, and several states used non-aged-based definitions. Consistent definitions of pediatric patients across regional or national boundaries may provide a base for future research on pediatric outcomes and interventions and may allow for better development of evidence-based pediatric EMS protocols.

INTRODUCTION

19.1% of US emergency department visits and 13% of EMS patient transports involve patients generally defined as pediatric (Moore et al., 2017; Shah et al., 2008). The US EMSC effort began in its current form in 2016 ("About EIIC", n.d.), after the realization that US ambulances, EMS personnel, and emergency departments often lacked at least some of the equipment, training, and other resources necessary to provide optimal pediatric care. Despite this extensive effort, one missing feature is a universally accepted and implemented definition of the age when a child becomes a small adult. Indeed, this debate continues far beyond
the world of EMS. While the American Academy of Pediatrics now discourages formal age limits, it defines adolescence as the period from 12-21 years old (Hardin et al., 2017). While not an official definition of "pediatric", the American College of Surgeons 2021 revised trauma triage criteria includes vital sign categories for patients aged 0-9, 10-64, and 65+ (Newgard et al., 2017). This is an especially salient data point, as traumatic injury remains the leading cause of death for those aged 0-14 years in the United States (Centers for Disease Control and Prevention, 2023). The National Association of State EMS Officials (NASEMSO) model EMS guidelines define pediatric patients as "those patients who weigh up to 40 kg or up to 14 years of age, whichever comes first” (National Association of State EMS Officials). Disparities between individual state protocols’ definitions of pediatric span a 6-year time range and include variations on the methodology used to determine which patients are considered pediatric.

This paper reviews the current state of this situation to begin discussions regarding the varied definitions of pediatric patients and reviews some of the anatomical, physiological, and behavioral aspects of EMS patients at various ages to serve as a streamlined reference point. This paper is divided into 2 sections: Section 1 is a descriptive study of the currently available pediatric EMS definitions from national organizations and from an available sample of EMS protocols; Section 2 reviews developmental anatomy, physiology, and behavior as a reference for EMS clinicians to inform future discussions regarding the definition of a pediatric patient in EMS.

SECTION 1

METHODS

Our research project was exempt from IRB review. To assess the EMS protocol landscape nationally, we used an internet search to locate all available EMS protocols that apply to an entire US state and are available for detailed review online, as there is no centralized database for state or local EMS protocols. We read these protocols, searching for criteria that identify patients as pediatric or adult, including a narrative definition of pediatric, age-based criteria, anatomic or physiologic criteria, or a combination of the above.

FINDINGS

We located 32 states with available statewide EMS protocols. After review and analysis, we identified large variations in the definition of a pediatric patient between states, and sometimes within a single state’s protocols. The distribution of ages (for states that identify a transition age) or other criteria that define pediatric patients in each state protocol is shown in Figures 1 and 2 below. A full list of specific protocols and where to find them can be found in Supplemental Spreadsheet 1.

Additionally, six states explicitly enable EMS clinician judgment in their statewide protocols, shown in Figure 3, allowing paramedics to select the most appropriate pediatric or adult protocols for the specific patient encounter.

SECTION 2

There are many important physiologic and psychological differences between pediatric and adult patients. In this paper, we will highlight the important differences in pediatric shock, airways, vital signs, injury patterns, and psychosocial development to provide
Figure 1. Distribution of pediatric definition criteria.

Figure 2. Pediatric definitions by state.
points of reference for future discussions regarding a more standardized definition of pediatric patients.

**SHOCK**

The ability to identify a patient in shock, especially during the early compensated phase, is a vital skill for prehospital clinicians. Pediatric patients in shock have a similar course to adult patients in shock; they will progress from compensated to decompensated shock, then to coma and/or death without recognition or intervention. However, the physical exam findings for children in shock can be more subtle and potentially ignored by practitioners unfamiliar with them. Early recognition of shock is key to improved survival (Evans et al., 2018). Thus, EMS protocols must pay attention to the differences between pediatric and adult presentations of shock, providing clear guidance for EMS clinicians. Here we outline signs of shock in a pediatric patient progressing from early to late signs,

<table>
<thead>
<tr>
<th>State</th>
<th>Pediatric Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts</td>
<td>Determination is different for different protocols. 20 kg for “Diabetic Emergencies” (Protocol 2.3P) 25 kg for “Bronchospasm/Respiratory Distress” (Protocol 2.6P) 25 kg for “Pain &amp; Nausea Management” (Protocol 2.13)</td>
</tr>
<tr>
<td>Nebraska</td>
<td>Newborn to 1 year is determined as an infant for resuscitation. 1 year to onset of puberty is defined as a child for resuscitation.</td>
</tr>
<tr>
<td>North Dakota</td>
<td>Length/Weight-based dosing for most protocols, with age-based differentiation for anaphylaxis, 12-lead EKG obtainment, and LUCAS application.</td>
</tr>
</tbody>
</table>

*Table 1. Elaboration of statewide protocol definitions of “pediatric” for selected states.*
with the information summarized in Appendix 1. Children rely on heart rate to boost cardiac output more than adults (Peitzman, 2008), with tachycardia being an early sign (Mendelson, 2018). They may also show subtle signs like delayed capillary refill (>2 sec) or mild irritability (Kleinman et al., 2010). As shock worsens, orthostatic vital sign changes can occur (Peitzman, 2008). EMS personnel trained in Pediatric Advanced Life Support (PALS) are better at recognizing pediatric shock (Baker et al., 2009). Note that 2020 PALS guidelines define infants as patients up to approximately 1 year old and children as patients between 1 year old and the onset of puberty, defined as "breast development in females and the presence of axillary hair in males" (Topjian et al, 2020).

If compensated shock is not noticed or corrected, it progresses. Tachypnea worsens as a respiratory response to metabolic acidosis. Capillary refill further delays (>4 sec), and extremities become pale, cool, or mottled due to peripheral vasoconstriction. Hypotension is an ominous sign (Kleinman et al., 2010). Children can maintain normotension until significant blood loss (Wolfson et al, 2009). Their smaller baseline circulating volume exacerbates this (Howie et al 2011).

Decreased perfusion leads to altered mental status, coma, abdominal distention, decreased bowel sounds, constipation, and reduced urine output. Dyspnea, tachypnea, and cyanosis may result from an inflammatory response (Wolfson et al, 2009). Bradycardia in decompensated shock indicates ischemic cardiac muscle. Neurogenic shock may present with bradycardia (Peitzman, 2008). Pediatric patients are more prone to hypothermia due to their body size and thermoregulation (Kleinman et al, 2010).

**Vital Signs**

A review of the normal vital signs in patients of different ages is included in Tables 2 and 3. This is especially important to note, as previous research indicates that most pediatric categories had reduced odds of complete vitals documentation, pain score documentation was lower in children after trauma (Ramgopal et al, 2018), and oxygen saturation documentation was lower in children with respiratory complaints (Ramgopal et al, 2018). Table 2 summarizes the anatomical changes of pediatric patients’ airways as they age, which may be of use in reaching a more unified definition of pediatric patients for EMS clinicians.

**Airway**

Pediatric airways are notoriously different from those of adults. One 2015 retrospective study found a rate of 1 pediatric intubation per 2,198 EMS responses; 44% of which were for patients in cardiac arrest and 66% of which were intubated on the first attempt. The most common challenge identified by this study was bodily fluids obstructing the laryngeal view (Prekker et al, 2016). Table 2 summarizes the anatomical changes of pediatric patients' airways as they age, which may be of use in reaching a more unified definition of pediatric patients for EMS clinicians.
It is important for prehospital clinicians to be familiar with milestones and their timeline to properly assess mental status, tone, and social needs. These milestones may help differentiate certain categories of patients (e.g., "toddler") within the broader category of pediatric patients. Here, we discuss some of the more important and easily remembered milestones. More can be found in Appendix 2 (Zubler et al, 2022). Knowing developmental milestones aids in assessing mental status, tone, and social needs. By the age of 2 months, infants should be soothed easily and track movement (Zubler et al, 2022). At 4 months, they become more interactive and coo. By 6 months, they recognize familiar people and may put objects in their mouth. At 9 months, stranger anxiety develops. At 1 year, children become more interactive and start basic language. At 15 months, they follow instructions with gestures. By age 2, they respond to others’ emotions. At 3, they ask questions and state their name. At 4, vocabulary and fine motor skills improve. Around 5, vocabulary expands, including time-related words (Zubler et al, 2022). These milestones have variability as to when children reach them; however, clinicians should have general expectations for how a healthy patient of that age should present in order to recognize a sick child.

**Injury Patterns**

Pediatric injury patterns differ from adults due to musculoskeletal differences. The distribution of these injury patterns may also be important for defining pediatric patients for EMS categories or defining specific categories therein. Children are more prone to bony injuries than ligamentous or tendinous injuries (Marzi et al, 2023). There's also a risk of cervical spine displacement in young children. Hip dislocation is rare and suspicious. Scapular fractures are rare but concerning. Pelvic injuries are worrisome, with or without fractures. Lung contusion can occur without rib fractures. "Nursemaid’s elbow" is common in young children, usually due to sudden arm pulling. Head size changes affect the estimation of burn injury severity (Table 5).
Finally, as children's relative head size decreases as age increases, the % Body Surface Area (BSA) in each part of the body changes with age, impacting the estimation of severity of burn injuries. This is summarized in Table 5.

**DISCUSSION**

As children's development varies, so too does the definition of a pediatric patient across EMS systems in the United States. The variation in protocols does not seem to follow significant regional patterns. This is clearly a highly complex and multifactorial issue where more standardization appears to be needed. As a point of comparison, geriatric patients are widely understood to be those patients aged 65 and up, allowing for clinicians and researchers to have a common understanding when discussing these patients and develop evidence-based guidelines for the treatment of these patients. Some situations, such as medication dose, may benefit from a weight-based definition, while others, such as equipment choice, may make better use of a length-based definition. Age of legal adulthood for purposes of consent may require an age-based definition. Therefore, different definitions may make sense within a set of protocols, but wide definition variation between states likely does not serve patients or EMS professionals well. As discussion of these standards occurs in the appropriate forums, we highly encourage EMS systems to establish more consistent, logical, and applicable definitions.

**CONCLUSION & RECOMMENDATIONS**

The authors recommend further discussion at a national level to determine a consistent definition of pediatric patients. Consensus regarding the definition of pediatric patients will allow for enhanced monitoring of patient care trends at regional or national levels and will better inform future research regarding and care of pediatric patients. The authors acknowledge that there may not be a singular definition of pediatric that is suitable for all patients and presentations. We encourage future investigation as to whether different definitions for certain presentations (e.g., traumatic injury, airway emergencies, acute psychiatric emergencies, etc.) may be most appropriate, as some states have already elected to include in their statewide protocols. However, the authors recognize the difficulty that these differing definitions may impose on EMS clinicians and researchers. While no single definition of a pediatric patient seems eminently available, increased national concordance regarding the definition of pediatric patients is of paramount importance for future development of EMS protocols and pediatric EMS research.

**REFERENCES**

Baker, T. W., King, W., Soto, W., Asher, C., Stolfi, A., & Rowin, M. E. (2009). The efficacy of pediatric advanced life support training in emergency medical service providers. *Pediatric Emergency Care, 25*(8), 508–512. [https://doi.org/10.1097/PEC.0b013e3181b0a0da](https://doi.org/10.1097/PEC.0b013e3181b0a0da)

<table>
<thead>
<tr>
<th>Area</th>
<th>Birth to 1 year</th>
<th>1 to 4 years</th>
<th>5 to 9 years</th>
<th>10 to 14 years</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>9.5</td>
<td>8.5</td>
<td>6.5</td>
<td>5.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Neck</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Trunk</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Upper arm</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Hand</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>Thigh</td>
<td>2.75</td>
<td>3.25</td>
<td>4</td>
<td>4.25</td>
<td>4.5</td>
</tr>
<tr>
<td>Leg</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>3</td>
<td>3.25</td>
</tr>
<tr>
<td>Foot</td>
<td>1.75</td>
<td>1.75</td>
<td>1.75</td>
<td>1.75</td>
<td>1.75</td>
</tr>
<tr>
<td>Buttock</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Genitalia</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*Table 5. Percent BSA of Body Parts by Age (Strobel et al 2018, Murari and Singh, 2019).*

Emergency Medical Services for Children Innovation and Improvement Center (EIIC). About EIIC. (n.d.). https://emscimprovement.center/about/


### APPENDICES

<table>
<thead>
<tr>
<th>Early (compensated) Shock</th>
<th>Late (uncompensated) Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>signs/symptoms</strong></td>
<td><strong>physiology</strong></td>
</tr>
<tr>
<td>tachycardia</td>
<td>Increased cardiac output; compensation for decreased stroke volume</td>
</tr>
<tr>
<td>Mild tachypnea</td>
<td>To meet oxygen demand of under perfused organs</td>
</tr>
<tr>
<td>Slightly delayed capillary refill</td>
<td>Due to peripheral vasoconstriction to maintain core organ perfusion (may not be true in some cases of septic shock)</td>
</tr>
<tr>
<td>Orthostatic BP</td>
<td>Decreased circulating volume causes orthostatic changes</td>
</tr>
<tr>
<td>Orthostatic pulse changes</td>
<td>Decreased circulating volume causes orthostatic changes</td>
</tr>
<tr>
<td>Mild irritability</td>
<td></td>
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<td></td>
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</tbody>
</table>

*Appendix 1. Summary of pediatric presentation of shock.*
### Appendix 2. Summary of pediatric developmental milestones.

<table>
<thead>
<tr>
<th>Age</th>
<th>Social-emotional</th>
<th>Language</th>
<th>Cognitive</th>
<th>Motor</th>
</tr>
</thead>
</table>
| 2 months   | Calms down when spoken to or picked up up  
Looks at your face  
Seems happy to see you  
Smiles when you talk to or smile at them | Makes sounds other than crying  
React to loud sounds | Watches you as you move  
Looks at a toy for several seconds | Holds head up when in prone position  
Moves both arms and legs  
Opens hand briefly |
| 4 months   | Smiles to get your attention  
Chuckles (not yet a full laugh)  
Looks at you, moves, or makes sounds to get or keep your attention | Makes sounds like "ooooo" and "aahh" (cooking)  
Makes sounds back when you talk to them  
Turns head toward the sound of your voice | If hungry, opens mouth when the breast or bottle is seen  
Looks at own hands with interest | Holds head steady without support  
Holds a toy when put in hand  
Uses arm to swing at toys  
Brings hands to mouth  
Pushes up onto elbows/forearms from prone position |
| 6 months   | Knows familiar people  
Likes to look at themself in the mirror  
Laughs | Takes turns making sounds with you  
Blows "raspberries" (sticks tongue out and blows)  
Makes squealing noises | Puts things in mouth to explore  
Reaches to grab a toy  
Closes lips to show they do not want more food | Rolls front to back  
Pushes up with straight arms when in prone position  
Leans on hands to support self when sitting |
| 9 months   | Is shy, clingy, or fearful around strangers  
Shows several facial expressions, like happy, sad, angry, and surprised  
Looks when name is called  
Reacts when you leave (looks, reaches for you, or cries)  
Smiles or laughs when you play peek-a-boo | Makes different sounds like "mamamama" and "babababa"  
Lifts arms up to be picked up | Looks for objects when dropped out of sight  
Bangs 2 things together | Gets to a sitting position without assistance  
Sits without support  
Uses fingers to "rake" food toward self  
Moves things from one hand to the other |
| 12 months  | Plays games with you, like pat-a-cake | Waves "bye-bye"  
Calls a parent "mama" or "dada" or another special name  
Understands "no" (pauses briefly or stops when you say it) | Puts something in a container, like a block in a cup  
Looks for things he sees you hide, like a toy under a blanket | Pulls up to stand  
Walks, holding onto furniture  
Drinks from a cup without a lid, as you hold it  
Picks things up between thumb and pointer finger, like small bits of food |
| 15 months  | Copies other children while playing, like taking toys out of a container when another child does  
Shows you an object that they like  
Claps when excited  
Hugs stuffed doll or other toy  
Shows you affection (hugs, cuddles, or kisses you) | Tries to say 1 or 2 words besides mama or dada, like "ba" for ball or "da" for dog  
Looks at a familiar object when you name it  
Follows directions given with both a gesture and words. For example, gives you a toy when you hold it  
Say, "Give me the toy."  
Points to ask for something or to get help | Tries to use things the right way, like a phone, cup, or book  
Stacks at least 2 small objects, like blocks | Takes a few steps on their own  
Uses fingers to feed self |
| 18 months  | Moves away from you, but looks to make sure you are close by  
Points to show you something interesting  
Puts hands out for you to wash them  
Looks at a few pages in a book with you  
Helps you dress them by pushing arm through sleeve or lifting up foot | Tries to say ≥3 words besides mama or dada  
Follows 1-step directions without any gestures, like giving you the toy when you say, "Give it to me."  
Copies you doing chores, like sweeping with a broom  
Plays with toys in a simple way, like pushing a toy car | Holds something in 1 hand while using the other hand, for example, holding a container and taking the lid off  
Tries to use switches, knobs, or buttons on a toy  
Plays with ≥1 toy at the same time, like putting toy food on a toy plate | Walks without holding onto anyone or anything  
Scribbles  
Drinks from a cup without a lid and may spill sometimes  
Feeds self with their fingers  
Tries to use a spoon  
Climbs on and off a couch or chair without help |
| 24 months  | Notices when others are hurt or upset, like pausing or looking sad when someone is crying  
Looks at your face to see how to react in a new situation | Says at least 2 words together, like "More milk."  
Points to at least 2 body parts when you ask  
Uses more gestures than just waving and pointing, like blowing a kiss or nodding yes | Holds something in 1 hand while using the other hand, for example, holding a container and taking the lid off  
Tries to use switches, knobs, or buttons on a toy  
Plays with ≥1 toy at the same time, like putting toy food on a toy plate | Kicks a ball  
Runs  
Walks (not climbs) up a few stairs with or without help  
Eats with a spoon |
<table>
<thead>
<tr>
<th>Age</th>
<th>Social-emotional</th>
<th>Language</th>
<th>Cognitive</th>
<th>Motor</th>
</tr>
</thead>
</table>
| 30 months | Plays next to other children and sometimes plays with them  
Shows you what they can do by saying, “Look at me!”  
Follows simple routines when told, like helping to pick up toys when you say, “It’s clean-up time.” | Says ≥2 words, with 1 action word, like “Doggie run.”  
Says around 50 words  
Names things in a book when you point and ask, “What is this?”  
Says words like I, me, or we | Uses things to pretend, like feeding a block to a doll as if it were food  
Shows simple problem-solving skills, like standing on a small stool to reach something  
Follows 2-step instructions, for example, “Put the toy down and close the door.”  
Shows that they know at least 1 color, like pointing to a red crayon when you ask, “Which one is red?” | Uses hands to twist things, like turning doorknobs or unscrewing lids  
Takes some clothes off by themselves, like loose pants or an open jacket  
Jumps off the ground with both feet  
Turns book pages, one at a time, when you read to them |
| 3 years | Calms down within 10 minutes after you leave, like at child care drop off  
Notices other children and joins them to play | Talks with you in conversation using at least 2 back-and-forth exchanges  
Asks who, what, where, or why questions, like “Where is mommy/daddy?”  
Says what action is happening in a picture when asked, like running, eating, or playing  
Says first name when asked  
Talks well enough for others to understand, most of the time | Draws a circle when shown how  
Avoids touching hot objects, like a stove, when warned | Strings items together, like large beads or macaroni  
Puts on some clothes by themselves, like loose pants or a jacket  
Uses a fork |
| 4 years | Pretends to be something else during play (teacher, superhero, dog)  
Asks to go play with children if none are around, like “Can I play with Alex?”  
Comforts others who are hurt or sad, like hugging a crying friend  
Avoids danger, like not jumping from tall heights at the playground  
Likes to be a “helper”  
Changes behavior on the basis of location (place of worship, library, playground) | Says sentences with four or more words  
Says some words from a song, story, or nursery rhyme  
Talks about at least one thing that happened during the day, like “I played soccer.”  
Answers simple questions, like “What is a cat for?” or “What is a crayon for?” | Names a few colors of items  
Tells what comes next in a well-known story  
Draws a person with three or more body parts | Catches a large ball most of the time  
Serves food or pours water, with adult supervision  
Unbuttons some buttons  
Holds crayon or pencil between fingers and thumb (not in a fist) |
| 5 years | Follows rules or takes turns when playing games with other children  
Sings, dances, or acts for you  
Does simple chores at home, like matching socks or clearing the table after eating | Tells a story that was heard or made up with at least two events, like a cat stuck in a tree and a firefighter saving it  
Answers simple questions about a book or story after you read or tell it to them  
Keeps a conversation going with more than three back-and-forth exchanges  
Uses or recognizes simple rhymes (bat-cat, ball-tall) | Counts to 10  
Names some numbers between one and five when you point to them  
Uses words about time, like yesterday, tomorrow, morning, or night  
Pays attention for 5–10 minutes during activities, for example, during story time or making arts and crafts (screen time does not count)  
Writes some letters of their name  
Names some letters when you point to them | Buttons some buttons  
Hops on 1 foot |

Appendix 2 (continued). Summary of pediatric developmental milestones.
<table>
<thead>
<tr>
<th>Injury</th>
<th>Ages more common</th>
<th>Anatomical/ physiological reasoning</th>
<th>Bones most affected</th>
<th>Mechanism of Injury</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress fractures</td>
<td>2-4 years</td>
<td>Puberty</td>
<td>Tibia, fibula, tarsus, and femur when the proximal tibia or the metatarsals</td>
<td>Young children learning to walk or run</td>
<td>Excessive sports activity</td>
</tr>
<tr>
<td>Osseous, chondral, or periosteal ligament tears</td>
<td>10-12 years</td>
<td>Ligaments are more stable than their attachments</td>
<td>Tendons and ligaments are not directly connected to the growing skeleton in children but are attached to the cartilage or the growth region. The high elasticity and plastic deformability of the tendons and ligaments in children often lead to bony injuries and not to intra-ligamentous/intra-tendinous ruptures.</td>
<td>After the growth phase, laxity described above decreases and risk of ligament rupture is increased</td>
<td></td>
</tr>
<tr>
<td>Avalision or growth plate injuries</td>
<td>Children with open epiphyseal junctions (&lt;12 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ligament rupture</td>
<td>&gt; 12 years</td>
<td>After the growth phase, laxity described above decreases and risk of ligament rupture is increased</td>
<td>Humeral medial epicondyle, anterior iliac spines, lesser trochanter</td>
<td>Increased risk at adolescence due to hormonal changes and increased sports stress</td>
<td></td>
</tr>
<tr>
<td>Muscle tendons tear/ bone avulsion</td>
<td>Adolescents</td>
<td>Hormonal influence</td>
<td>Shaft of forearm long bones is most common</td>
<td>Fall on outstretched arm or other blunt trauma</td>
<td></td>
</tr>
<tr>
<td>Greenstick (Classic)</td>
<td>Adolescents</td>
<td></td>
<td></td>
<td></td>
<td>High refracture risk</td>
</tr>
<tr>
<td>Greenstick (Compressed)</td>
<td>&lt;5</td>
<td>Pediatric periosteum has a higher fat content, increased vascularization and is thicker than that of adults</td>
<td></td>
<td>Fall on outstretched arm or other blunt trauma</td>
<td>Not associated with healing problems</td>
</tr>
<tr>
<td>Greenstick (Bowing)</td>
<td>Late childhood/ adolescence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder Dislocation</td>
<td>&gt; 10-12 years</td>
<td></td>
<td></td>
<td></td>
<td>A result of high speed trauma</td>
</tr>
<tr>
<td>Posterior Hip Dislocation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High index of suspicion for other injuries</td>
</tr>
<tr>
<td>Physiological anterior displacement of C2 on C3 or C3 on C4 with the potential for pseudo-subluxation</td>
<td>Up to age 8</td>
<td>Greater elasticity of pediatric spine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle contusions/ sprain</td>
<td>Adolescents playing sports (rare in young children)</td>
<td></td>
<td></td>
<td></td>
<td>Sports related</td>
</tr>
<tr>
<td>Scapular fractures</td>
<td>Rare</td>
<td></td>
<td>High speed traffic accident or falls from height</td>
<td></td>
<td>Suspect concomitant rib and/ or vertebral fxfractures</td>
</tr>
<tr>
<td>Supracondylar humerus fracture</td>
<td>Peaks at age 5</td>
<td>Metaphysis of distal humerus</td>
<td>Fall on outstretched, hyperextended arm (breaking a fall)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transcondylar humerus fractures (Medial condyle)</td>
<td>Peaks at 12 years</td>
<td></td>
<td>Fall onto outstretched hand; sometimes direct trauma</td>
<td></td>
<td>Often seen with elbow dislocation</td>
</tr>
<tr>
<td>Transcondylar humerus fractures (Lateral condyle)</td>
<td>4-5 years</td>
<td></td>
<td></td>
<td></td>
<td>Missed lateral condyle fractures can lead to significant function deficit/ deformity and ulnar nerve irritation</td>
</tr>
<tr>
<td>Transcondylar humerus fractures (T-fractures)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow dislocation</td>
<td>&gt; 10 years</td>
<td>Fall on outstretched hand leads to posterior lateral dislocation; rarely, a direct fall on the posterior elbow will lead to anterior dislocation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subluxation of proximal radius “Nursemaids elbow”</td>
<td>&lt; 4 years more common in girls and left arm</td>
<td>Annular ligament’s distal attachment to proximal radius strengthens as child ages</td>
<td>Proximal radius slips out of the annular ligament when the muscles cannot counter-stabilize the joint</td>
<td>Abrupt force, often an adult pulling up or twisting an extended arm</td>
<td>Presents holding the injured elbow in moderate extension and pronation</td>
</tr>
<tr>
<td>Proximal Forearm</td>
<td></td>
<td>Supinator and biceps muscles pull the proximal fragment into supination and flexion. The pronator quadratus and teres muscles pronate the distal fragment</td>
<td>Radius and ulna</td>
<td>Immobilize in supination to approximate fracture</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injury</th>
<th>Ages more common</th>
<th>Anatomical/physiological reasoning</th>
<th>Bones most affected</th>
<th>Mechanism of Injury</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid shaft forearm</td>
<td>Ages 6-8; more common in boys</td>
<td>Pronator teres and the supinator neutralize each other, leaving only the biceps acting to flex the proximal fragment</td>
<td>Radius and ulna</td>
<td>Fall onto the outstretched hand</td>
<td>Immobilize in neutral or mild supination</td>
</tr>
<tr>
<td>Distal Forearm</td>
<td>Age 10</td>
<td>Supinates due to pull of the brachioradialis muscle</td>
<td>Usual distal third of radius and ulna</td>
<td>Immobilize in slight pronation</td>
<td></td>
</tr>
<tr>
<td>Carpal injuries</td>
<td>10-15 year</td>
<td>Carpal complex consists almost entirely of cartilage; as bones ossify injury patterns similar to adults is seen</td>
<td>Generally of scaphoid, lunate, and capititate bones</td>
<td>Fall from bike or while skating</td>
<td>Often in combination with distal radius fracture</td>
</tr>
<tr>
<td>Hip (Proximal femur)</td>
<td></td>
<td>Bone is more robust than adults</td>
<td></td>
<td>Massive trauma</td>
<td></td>
</tr>
<tr>
<td>Hip (Femur shaft)</td>
<td>Younger children/infants</td>
<td>Femoral shaft diameter increases with increasing cortical diameter during growth, while canal diameter proportionally decreases; bone less stable</td>
<td></td>
<td>Consider child abuse; falls from changing tables</td>
<td>Consider shock from blood loss, vascular, and nerve injury; evident from swelling, shortening, and rotation of affected leg</td>
</tr>
<tr>
<td>Hip (Distal femur)</td>
<td></td>
<td></td>
<td></td>
<td>Often sports related, can be from high-speed trauma or falls</td>
<td>Assess for vascular damage</td>
</tr>
<tr>
<td>Lower leg</td>
<td></td>
<td></td>
<td>Tibia only (70%)</td>
<td>High-risk for compartment syndrome</td>
<td></td>
</tr>
<tr>
<td>Talus</td>
<td></td>
<td></td>
<td>Tibia and fibula (30%)</td>
<td>High index for other injuries</td>
<td></td>
</tr>
<tr>
<td>Pelvis</td>
<td></td>
<td>Strong ligaments and multiple cartilaginous growth centers can absorb significant force without fracturing</td>
<td>Isolated ring fracture possible due to elasticity of hemipelvis</td>
<td>High energy trauma: traffic accident and fall from height; approx 25% of children with a fracture will have associated traumatic brain injury</td>
<td>High incidence of additional injuries; high risk of organ injuries without fracture; evaluate for perianal and scrotal hematomas; transport to center with pediatric surgery/ trauma highly encouraged</td>
</tr>
</tbody>
</table>

*Appendix 3 (continued).* Summary of pediatric musculoskeletal injury patterns.