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Pediatric procedural sedation and analgesia (PSA) is commonly used in emergency departments to decrease the pain and anxiety associated with procedures and to assure an environment conducive to the safe performance of necessary interventions. Over the twenty years since PSA initially was used outside the operating room, the indications, pharmacopeia, and literature regarding its practice have expanded considerably. A growing body of evidence demonstrates that properly trained specialists from a variety of backgrounds can safely and effectively use PSA. Emergency physicians have advanced airway, resuscitation, and critical care skills that make them particularly well suited to administer PSA and manage associated complications.

Providing PSA for children presents many unique challenges as they have important emotional, anatomic, and physiologic differences compared to adults. This article reviews the fundamentals of pediatric PSA, including current terminology and practice guidelines. Recent data concerning the rates, nature, and predictors of adverse outcomes are discussed. Recommendations for preprocedure assessment, necessary equipment and personnel, and post-procedure monitoring are included. In the second part of this issue, factors to consider when selecting an agent(s) for PSA and a review of the current pharmacopeia, including notable recent additions such as propofol and etomidate, will be discussed.

— The Editor

Part I. Pediatric Procedural Sedation: Personnel, Monitoring, and Patient Assessment

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Terminology

Though initially restricted to hospital based practice by anesthesiologists, pediatric procedural sedation (PSA) is now administered by a diverse group of non-anesthesiologist healthcare practitioners in a wide variety of settings. In 1985, the American

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Academy of Pediatrics (AAP) was the first major specialty organization to publish guidelines attempting to define terms, standardize practice, and improve safety[1] in response to the increasing use of PSA outside of the operating room and a growing number of case reports of serious adverse events, including death. Since that time, numerous specialty and regulatory organizations have published guidelines pertaining to PSA with similar goals of improving standardization, safety, and efficacy. The guidelines most pertinent to practicing emergency physicians are shown in Table 1. With respect to recommended terminology, there is no distinction made between adult and pediatric patients by any of the referenced guidelines.[1-8]

The depth of procedural sedation is inherently on a continuum which does not easily lend itself to classification schemes. The complex interaction between the agent(s) selected, route of administration, the patient, and stimulation provided by the procedure can make sedation depth difficult to predict and assess. The nature and severity of complications are correlated with increasing sedation depth.[9] The intended sedation depth is the principal factor underlying the recommended level of monitoring, setting, and skill-set of the practitioner.[1-8]

Many authors, including those that helped coin the term,[10] have recommended abandoning the term "conscious sedation" as it is inherently misleading and has been widely misconstrued.[10,11] Conscious sedation was originally defined by the AAP as "a medically controlled state of depressed consciousness that 1) allows protective reflexes to be maintained; 2) retains the patient's ability to maintain a patent airway independently and continuously; and 3) permits appropriate response by the patient to physical stimulation or verbal command, e.g. 'open your eyes.'" In practice, most pediatric patients being sedated in the emergency department do not meet this definition, either because they are developmentally unable or because deeper sedation is required to accomplish the procedure.[9] The inclusion of "conscious" in a term intended to mean "depressed consciousness" has been criticized as unclear and confusing.[10] Though not originally defined this way, "conscious sedation" is commonly used to refer to all levels of procedural sedation. "Moderate sedation"[2] most closely approximates the original definition of "conscious sedation" and is now the recommended terminology.

The current recommended terminology[12-14] for sedation and analgesia states is drawn from the Joint Commission guidelines,[2] though is very similar to terminology suggested by the AAP,[1,5,6] the American Society of Anesthesiologists (ASA),[3,4] and the American College of Emergency Physicians (ACEP).[8] Using the term "dissociative sedation" to describe the unique anesthetic state induced by ketamine is recommended by several prominent investigators.[15,16] The ACEP definition of "procedural sedation" *(see Table 2)* is an umbrella term that encompasses the practice of most emergency physicians, which includes light, moderate, deep, and dissociative sedation.

Pediatric Pain Management

Compared to adults, children are less able to communicate their pain, and may have significant anxiety that contributes to their perception of pain. Over the last five years, professional and regulatory bodies have placed renewed emphasis on adequate pain assessment, documentation, and management.[17,18] PSA is being used to manage an increasing variety of painful or anxiety-provoking procedures, with more than 20 different procedure types reported in a recent series.[19] *(See Table 3.)* Orthopedic procedures and laceration repair continue to constitute the majority of sedations.[19]

Despite increasing awareness and management options for pediatric pain, children still suffer from inadequate or absent analgesia when compared to adults suffering from similar, painful conditions.[20] Selbst and Clark published on the problem of pediatric "oligoanalgesia" in the early 1990s,[21] and surprisingly little progress has been made since that time.

A recent study examined analgesic use in 718 pediatric patients with long bone fractures who were seen between 1998 and 2000 in community and urban emergency departments (EDs), by both general and pediatric subspecialty boarded emergency physicians.[20] Children with long bone fractures received no analgesia of any kind in the ED 59% of the time, and were given an analgesic prescription only 7% of the time.[20] In children who did receive analgesics, non-narcotic medications were used in a majority of cases.[20] By comparison, adults receive analgesia

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Table 1. Guidelines and Standards Pertaining to Pediatric Sedation and Analgesia

The Joint Commission

— Joint Commission on Accreditation of Healthcare Organizations. Pain standards for 2001. 2001.
— Joint Commission on Accreditation of Healthcare Organizations. *Comprehensive Accreditation Manual for Hospitals: The Official Handbook.* 2005, Joint Commission Resources, Inc., Oakbrook Terrace, IL.
— *Revisions to Anesthesia Care Standards: Comprehensive Accreditation Manual for Hospitals.* 2001, Joint Commission on Accreditation of Healthcare Organizations Department of Publications, Oakbrook Terrace, IL.

American College of Emergency Physicians

— Godwin SA, et al. Clinical policy: procedural sedation and analgesia in the emergency department. *Ann Emerg Med* 2005;45(2):177-96.

American Academy of Pediatrics

— Committee on Drugs. American Academy of Pediatrics. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: addendum. *Pediatrics* 2002;110(4):836-8.
— American Academy of Pediatrics Committee on Drugs: Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures. *Pediatrics* 1992;89(6 Pt 1):1110-5.
— Guidelines for the elective use of conscious sedation, deep sedation, and general anesthesia in pediatric patients. Committee on Drugs. Section on anesthesiology. *Pediatrics* 1985;76(2):317-21.

American Society of Anesthesiologists

— Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002;96(4):1004-17.
— Practice guidelines for sedation and analgesia by non-anesthesiologists. A report by the American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists. *Anesthesiology* 1996;84(2):459-71.

in similar circumstances approximately 70% of the time.[20]

Other series have shown similar trends in analgesic use for children[18,22,23] and clearly demonstrate there is still room for improvement. PSA can play an important role in the management of painful injuries that require manipulation, improve satisfaction of both patients and parents, and decrease the anxiety children associate with healthcare providers in the future.

Alternatives to Procedural Sedation

Even in expert hands and under ideal circumstances, procedural sedation always carries risks to the patient. Alternative methods of pain management and anxiolysis can reduce the level of sedation necessary to accomplish a procedure or eliminate the need for PSA entirely. A few common-sense principles help increase the success rate of these alternative methods: using parents and staff to provide distraction and reassurance; applying topical anesthetics well in advance of the anticipated procedure; using local as well as systemic analgesia; and combining multiple strategies, including PSA, when appropriate.

Age appropriate distraction by parents or child life specialists is effective at providing anxiolysis, which may be the primary issue in certain pediatric procedures.[24] Forgoing sedation for some diagnostic imaging may be an option, as modern, multidetector CT scanners have dramatically reduced imaging times (less than 30 seconds for a CT scan of an infant's head). The use of an appropriately shielded parent to help with anxiolysis and restraint on a papoose board may be a safe, effective, and humane alternative to the risk of sedation in a young child with a potential head injury. Alternatively, deferring or modifying a procedure when an alternate management strategy is appropriate (observation versus head CT, wound glue versus suturing) may obviate the need for PSA.

Topical analgesics are widely available and should be considered as an adjunct even when PSA is anticipated. For non-intact skin, use LET (lidocaine, epinephrine, tetracaine) soaked pledgets applied directly to the wound at least 20 minutes before the procedure. LET has largely replaced TAC (tetracaine, Adrenaline [epinephrine], cocaine) because of its improved safety and efficacy.[14] There are several options for intact skin. For brief procedures 1-2 minutes in duration, topical sprays such as ethyl chloride (Cryogesic) and dichlorodifluoromethane and trichloromonofluoromethane (Fluori-methane) are moderately efficacious. For longer procedures or increased analgesia, 2.5 percent lidocaine and 2.5 percent prilocaine in a cream base (EMLA) provides 1-2 hours of analgesia but also requires 30-60 minutes for application to reach peak effect. Newer lidocaine based creams such as topical lidocaine (ELA-Max) and lidocaine 4 percent (L.M.X 4) topical anesthetic cream are designed to have more rapid onset with similar overall efficacy. For venipuncture, a commercially available preparation, lidocaine 70 mg and tetracaine 70 mg (SYNERA) is available in a self-activated, heated pouch that provides both enhanced absorption and venodilation. *(See Table 4.)*

Safety and Efficacy

PSA provided in the ED is safe and effective.[19,25-31] Failed PSA, typically defined as inability to provide sedation adequate to accomplish the procedure, occurs less than 2% of the time[9,32,33] Because of their increased anxiety, and decreased ability to cooperate and communicate pain, sedation is used for a wider variety of procedures in children as compared to adults. Procedures like foreign body removal that are typically performed without sedation in adults are more successful when PSA is used.[34] Using PSA to accomplish laceration repairs results in higher parental satisfaction and a decreased need for physical

Table 2. Recommended Terminology and Definitions of Sedation States*

STATE	DEFINITION	SOURCE
Procedural sedation	"A technique of administering sedatives or dissociative agents with or without analgesics to induce a state that allows the patient to tolerate unpleasant procedures while maintaining cardiorespiratory function. Procedural sedation and analgesia is intended to result in a depressed level of consciousness but one that allows the patient to maintain airway control independently and continuously. Specifically, the drugs, doses, and techniques used are not likely to produce a loss of protective airway reflexes."	American College of Emergency Physicians[8]
Minimal sedation (anxiolysis)	"A drug-induced state during which patients respond normally to verbal commands. Although cognitive function and coordination might be impaired, ventilatory and cardiovascular functions are unaffected."	Joint Commission Sedation and Anesthesia Care Standards[2]
Moderate sedation (formerly conscious sedation)	"A drug-induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation. Reflex withdrawal from a painful stimulus is not considered a purposeful response. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is usually maintained."	Joint Commission Sedation and Anesthesia Care Standards[2]
Dissociative sedation	"A trance-like cataleptic state induced by the dissociative drug ketamine characterized by profound analgesia and amnesia, with retention of protective airway reflexes, spontaneous respirations, and cardiopulmonary stability."	Green SM, Krauss B. "The semantics of ketamine"[16]
Deep sedation	"A drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully following repeated or painful stimulation. The ability to independently maintain ventilatory function could be impaired. Patients might require assistance in maintaining a patent airway and spontaneous ventilation might be inadequate. Cardiovascular function is usually maintained."	Joint Commission Sedation and Anesthesia Care Standards[2]
General anesthesia	"A drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation. The ability to independently maintain ventilatory function is often impaired. Patients often require assistance in maintaining a patent airway, and positive pressure ventilation might be required because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. Cardiovascular function can be impaired."	Joint Commission Sedation and Anesthesia Care Standards[2]

* Table adapted from Krauss B, SM Green. Procedural sedation and analgesia in children. *Lancet* 2006;367(9512):766-80.

restraint.[35] For highly painful maneuvers such as fracture reduction, PSA may be the only method available to humanely accomplish the procedure.

Children are at an increased risk compared to adults of suffering complications due to PSA because they have decreased pulmonary reserve, they require more frequent sedation dosing, their sedation level is more difficult to assess, and appropriate resuscitation equipment is less likely to be available.[5] Adverse drug events (ADEs) associated with PSA are categorized as serious (hypoxia, apnea, hypotension, stridor, laryngospasm, aspiration) and minor (nausea, emesis without aspiration, rash, agitation, emergence reactions, dizziness, fussiness). *(See Table 5.)* Clinically significant aspiration during procedural sedation, one of its most feared potential complications, has rarely been reported in the English language literature in the emergency department setting.[33,36]

Hospital-wide implementation of Joint Commission mandated record keeping has provided a wealth of data about the frequency and nature of adverse drug events (ADEs) associated with PSA. Investigators in a large, multicenter, prospective registry of such data recently published their first report of 30,037 pediatric sedation events. They report an overall complication rate of 5.3% with no deaths, one sedation requiring CPR, and one aspiration event in a PICU patient.[33] Depending on the definitions used and the setting, previous studies report serious adverse events in approximately 2-15% of sedations.[9,19,28-33,37] Hypoxia accounts for the large majority (75% or more) of serious ADEs and is generally easily treated with supplemental oxygen. Other respiratory complications (stridor, laryngospasm, apnea) are less common, occurring in less than 1-3% of cases.[9,19,29-33,37] Respiratory complications requiring bag-valve-

Table 3. Emergency Department Uses of Procedural Sedation

- Wound care
- Laceration repair
- Burn debridement
- Incision and drainage
- Reductions
  - — Dislocation
  - — Fracture
  - — Hernia
  - — Paraphimosis
- Diagnostic imaging
  - — CT scan
  - — MRI
- Chest tube placement
- Suprapubic catheter placement
- Cardioversion
- Lumbar puncture
- Arthrocentesis
- Foreign body removal
- Foley catheter placement
- Slit lamp examination
- Sexual assault exam

mask ventilation or endotracheal intubation as well as cardiovascular ADEs (hypotension, bradycardia) are all rare, occurring less than 1% of the time.[9,19,29-33,37] When they do occur, hypotension and bradycardia most often are self-limited and do not require active management beyond close monitoring.

Of the minor ADEs associated with PSA, emesis is the most common, occurring in 1-8% of cases[9,19,29-32,37] No clear link between fasting time and the incidence of emesis has been established.[19,31,36-38] Though aspiration is a potential risk of emesis, this complication has not been reported during PSA in the ED as noted above. In a series examining the timing of adverse events, there appeared to be a bimodal distribution of vomiting over time, with 25% of episodes occurring within 8 minutes of medication administration and the remainder occurring greater than 40 minutes later.[30] Other minor ADEs occur less than 1% of the time and include agitation, rash, dizziness, fussiness, abdominal pain, headache, and dystonia.[9,28-30,32] Up to 10% of children will have a minor ADE following discharge. Of these, vomiting remains the most common, representing 75% of all post-discharge ADEs.[9] Parents should be specifically advised of this complication.

The complication rates discussed above are averages derived from case series using various agents. Specific factors, however, may be predictive of adverse events. PSA using fentanyl and versed is associated with a higher rate of complications, in large part due to the higher incidence of the most common complication (hypoxia).[9,30] In contrast, there is no consistent association between adverse events and route of drug administration, premedication with analgesics, length of procedure, type of procedure, sex, or age of the patient.[9,28,30,39,40]

Though overall when properly administered and monitored PSA is very safe, tragic outcomes, including death, do still rarely occur, and primarily have been published in case reports.[41] Adverse events leading to catastrophic outcomes (death, permanent neurologic injury) are associated with dosing errors; use of three or more agents; drugs administered by non-medical professionals; inadequate observation time; the use of agents with long half lives like chloral hydrate and long acting barbiturates; inadequate resuscitation; delayed recognition of complications, particularly hypoxia; failure to use or properly interpret pulse oximetry; and lack of an independent observer dedicated to patient monitoring during the procedure.[39,40] *(See Table 6.)* Appropriate training of personnel and methodical attention to patient assessment and monitoring as detailed below should greatly reduce or eliminate the preventable deaths and disability related to PSA.

Administration of Pediatric Procedural Sedation

In response to a number of deaths associated with PSA, The Joint Commission has published increasingly specific regulations governing administration of PSA outside of the operating room.[42,43] All hospitals are required to develop institution specific policies governing the use of PSA that must apply uniformly regardless of where in the hospital PSA is used. Joint Commission requirements only apply in cases in which the medications administered "may reasonably be expected to result in a loss of protective [airway reflexes]." In other words, a patient administered morphine for analgesia and lorazepam for anxiolysis in doses not expected to produce sedation need not be monitored in the same fashion as a patient undergoing PSA. In addition to these mandatory requirements, numerous subspecialty organizations have made recommendations concerning the practice of PSA. Guidelines published by ACEP, ASA, and AAP are the most relevant to the practicing emergency physician.[1,3-8,44] These guidelines and Joint Commission regulations uniformly emphasize preprocedure patient assessment, adequately trained personnel, and appropriate monitoring and rescue equipment as the cornerstones of safe and effective PSA administration. Though there is a lack of strong evidence supporting many of the specific monitoring recommendations, implementation of standardized monitoring practices has been shown to increase the safety of PSA.[32]

Personnel

Providers should have training and experience in selecting, dosing, and reversal agents to provide as safe and reliable a level of sedation as possible. Equally important, personnel should be able to rapidly recognize and reverse cardiorespiratory complications associated with PSA, including hypoventilation, laryngospasm, partial and complete airway obstruction, aspiration, bradycardia, and hypotension. According to the Joint Commission, "practitioners intending to produce a given level of sedation

Table 4. Topical Anesthetics' Onset, Duration, and Comments

TOPICAL ANESTHETIC	ONSET OF ACTION	DURATION OF ACTION	COMMENTS
TAC/LET*			Not useful for intact skin.
Tetracaine 4% gel (amethocaine, Ametop)	30-45 min	4-6 hours	Not yet approved by the U.S. Food and Drug Administration.
Topical lidocaine (available in 2% or 5% concentration)			Max area of application should not exceed 100 cm^2 in children and 600 cm^2 in children weighing greater than 10 kg or adults.
Lidocaine 4% micro-emulsion (Tropicaine)	30 min		Max area of application should not exceed 100 cm^2 in children and 600 cm^2 in children weighing greater than 10 kg or adults.
Liposomal lidocaine 4% (L.M.X 4)	30 min		Max area of application should not exceed 100 cm^2 in children and 600 cm^2 in children weighing greater than 10 kg or adults.
2.5% lidocaine and 2.5% prilocaine (EMLA cream)	1-3 hours	2 hours	For infants 3 months or younger or less than 5 kg, a max dose of 1 g can be applied over a maximal surface of 10 cm^2. For children 3-12 months weighing more than 5 kg, a max dose of 2 g can be applied over a maximal surface area of 20 cm^2. For children 1-6 years and weighing more than 10 kg, a max dose of 10 g can be applied over a maximal surface area of 100 cm^2. For children 7-12 years, a max dose of 20 g can be applied over a maximal surface area of 200 cm^2.

* TAC = tetracaine, Adrenaline [epinephrine], cocaine; LET = lidocaine, epinephrine, tetracaine

should be able to rescue patients whose level of sedation becomes [one level] deeper than initially intended. Individuals administering moderate sedation/analgesia should be able to manage patients who enter a state of deep sedation/analgesia, while those administering deep sedation should be able to manage patients who enter a state of general anesthesia."[42,43] As most PSA used in the emergency department is intended to produce at least moderate sedation, the provider should possess the advanced airway skills (including excellent bag-valve-mask ventilation and definitive airway placement), and pediatric resuscitation experience needed to rescue a patient from inadvertent deep sedation, general anesthesia, and complications of sedation. Because of these requirements, most providers of PSA will be physicians. Though not strictly mandated by The Joint Commission or ACEP, most guidelines recommend an additional person, often a nurse or respiratory therapist, who is dedicated to patient monitoring during the procedure. As noted in the preceding section, providers with inadequate rescue skills and PSA utilizing only one provider have been associated with death and permanent neurologic injury as a consequence of PSA.[25,28,39,40]

Monitoring

Monitoring during PSA falls into three broad categories: respiratory, cardiovascular, and sedation depth. Commonly monitored parameters include general appearance, respiratory rate, oxygen saturation, heart rate, cardiac rhythm monitoring, and response to stimulation. All of these parameters should be regularly documented in a routine fashion in the written medical record. Other, less commonly utilized but potentially useful monitoring modalities, such as the bispectral index and capnography, may be useful when monitoring patients in deep sedation. A summary of suggested monitoring equipment as well recommended emergency airway supplies and resuscitative medications are shown in Table 7.

Meticulous attention to airway monitoring is of paramount importance as the great majority of PSA related complications are respiratory in nature; in turn, respiratory insufficiency is the precipitating factor in the majority of pediatric arrests.[25,39,40] Prompt recognition of airway complications is especially important because physiologic differences between adults and children lead children to decompensate more rapidly than adults. Compared to adults, children have a low functional residual capacity, and a basal oxygen consumption 2-3 times greater, leading to significantly more rapid development of hypoxia. With 5 minutes of preoxygenation, healthy infants reach a $SaO_2 < 90\%$ after less than 3 minutes of apnea. This happens much more quickly without preoxygenation. After the onset of hypoxia, an infant continues to desaturate much more rapidly than a healthy adult.

Table 5. Adverse Drug Events Associated with PSA

SERIOUS
Hypoxia
Stridor
Laryngospasm
Aspiration
Apnea
Hypotension
Permanent neurologic injury
Death

MINOR
Nausea
Emesis (without aspiration)
Rash
Agitation
Emergence reactions
Dizziness
Fussiness
Abdominal pain
Headache
Dystonia

Table 6. Factors Contributing to Devastating Outcomes with PSA

- Dosing errors
- Use of three or more agents
- Drugs administered by non-medical professionals
- Inadequate observation time
- The use of agents with a long half life (i.e., chloral hydrate)
- Inadequate resuscitation
- Delayed recognition of complications
- Failure to use or appropriately interpret pulse oximetry
- Lack of an independent observer dedicated to patient monitoring during the procedure

It occurs at approximately the same rate as an obese, 125 kg patient.[45]

The provider responsible for monitoring the patient should frequently assess airway patency and the adequacy of oxygenation and ventilation during PSA, though there is no consensus about what constitutes adequate assessment. For every patient, the chest wall should be observed for evidence of ventilation, with particular attention to the presence of sonorous respiration, stridor, or retractions, all of which indicate at least partial upper airway obstruction. Prompt recognition of these airway problems allows corrective measures, such as stimulating the patient, repositioning the airway, or providing positive airway pressure with a bag-valve-mask, to be taken before complete airway obstruction occurs. The general appearance of the patient, as well as continuous pulse oximetry with an audible indicator, are used to assess oxygenation. Unless it is impossible because of the procedure type, the person monitoring the patient must have an unobstructed view of the patient's chest, neck, and face in order to allow the continuous visual assessment described above. Compared to purely clinical assessment, capnography may be a more sensitive, reliable early indicator of hypoventilation and apnea.[46-52] Capnography may be particularly useful when the nature of the procedure precludes adequate clinical assessment (facial laceration repair, MRI), or deep sedation is anticipated.

Table 7. Suggested Equipment for Procedural Sedation

- Continuous pulse oximetry monitor (audible)
- End tidal CO_2 monitor (optional)
- Oxygen
- Non-rebreather mask
- Nasopharyngeal airway
- Oral airway
- Suction
- BVM (bag-valve-mask) attached to oxygen source
- Airway cart with intubation equipment (available)
- Blood pressure monitor with appropriate cuff
- Cardiac monitor
- Broslow tape
- IV supplies
- ACLS/PALS meds available
- Defibrillator if patient has a history of cardiovascular disease
- Reversal agents

Continuous suction and appropriately sized bag-valve-mask should be immediately available at the bedside. The use of supplemental oxygen during the procedure via nasal canula or non-rebreather mask is not universally recommended and should be used according to "physician preference" per ACEP guidelines.[8] Though doing so clearly reduces the incidence of hypoxia, it also may delay recognition of hypoventilation, airway obstruction, and apnea — a possible disadvantage when the cause is reversible upper airway obstruction. There is no evidence that mild hypoxia that is reversed is harmful to patients undergoing PSA. When opiates or benzodiazepines are used for sedation, reversal agents should be available in the room.

Cardiovascular parameters should be monitored, including the patient's general appearance, heart rate, and blood pressure. At a minimum, assessment of blood pressure is recommended before the procedure, after drug administration, upon completion of the procedure, and during the early recovery phase. Although there is no evidence clearly guiding practice, more frequent blood pressure assessment is probably indicated for patients with higher American Society of Anesthesiology (ASA) classes, during longer procedures, and for patients receiving agents with hemodynamic side affects. The use of cardiac monitors has not been shown to reduce the incidence or severity of complications

Table 8. Discharge Criteria*

- ❑ Mental status: alert, age-appropriate, at baseline
- ❑ Vital signs: normal and stable post-procedure
- ❑ Responsible adult available for monitoring of complications after discharge
- ❑ Pain: well-controlled, with clear plan for post-discharge pain management
- ❑ Written discharge instructions: including diet, activity, medications; and clear, procedure specific return precautions and follow-up plan

* Table adapted from: Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: addendum. *Pediatrics* 2002;110(4):836-8; and Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002;96(4):1004-17.

Table 9. Essentials of the Preprocedure Assessment

HISTORY

- ❑ Last oral intake
- ❑ Allergies
- ❑ Family and personal history of previous sedation/anesthesia
- ❑ History of previous airway procedures
- ❑ History of significant renal or hepatic disease
- ❑ History of cardiopulmonary disease (asthma, congenital heart disease)
- ❑ History of snoring/obstructive sleep apnea/stridor
- ❑ Current infectious symptoms (including URI)

PHYSICAL EXAM

- ❑ Airway (edentulous, obesity, abnormal facies, facial hair)
- ❑ Mallampati score
- ❑ Neck (short neck higher risk of difficult airway)
- ❑ Chin (small chin higher risk of difficult airway)
- ❑ Jaw and neck mobility (limited mobility higher risk of difficult airway)
- ❑ Cardiovascular exam
- ❑ Respiratory exam

during PSA, although as it is safe, non-invasive and has theoretical benefit, some guidelines recommend its use.[3] For patients sedated without parenteral agents, intravenous access is not necessary and no published study has shown an association between lack of intravenous access and adverse outcome.[9,25,29,30,39,40] When an IV is not used, supplies and skilled personnel for establishing IV access should be readily available as management of common complications may require administration of parenteral agents or fluids.

Depth of sedation has not been associated with adverse outcomes[9,39,40] but has been occasionally associated with the incidence of adverse events.[31] However, the depth of sedation may increase the skill required by the provider to manage complications. The Joint Commission, as well as the ACEP, ASA, and AAP guidelines, all recommend monitoring and recording sedation depth during all PSA. Several clinically based instruments have been validated as measures of sedation depth. However, patient response to verbal and tactile stimuli along with the cardiorespiratory monitoring described above are easily achievable, non-invasive, and are generally regarded as sufficient measures of sedation depth during minimal, moderate, and dissociative sedation according to the above guidelines. In contrast, response to stimulus may be inadequate or impractical to use to distinguish deep sedation from general anesthesia. This is of particular importance as newer sedative agents such as propofol frequently result in deep sedation. The bispectral index, derived from processed EEG signals, is a validated, objective measure of sedation depth in the operating room. Initial studies of its use during PSA support its validity in assessing sedation depth across the sedation continuum.[12,53,54] Equipment to measure the bispectral index may become increasingly available if the evidence supporting its use continues to grow.

The timing of adverse events is of critical importance to emergency physicians as adequate post-procedure monitoring is critical for patient safety, but also impacts the ED length of stay. As many more recent additions to the pharmacopeia such as ketamine that have shorter half-lives than older agents like chloral hydrate, the appropriate post-procedure monitoring time has decreased. A study from 2003 by Newman and coworkers examined the timing of adverse events in a series of 1367 sedations.[30] This study only examined PSA using combinations of the most commonly used agents: ketamine, midazolam, and fentanyl. The median time of ADEs was 2 minutes after the final dose of medication, and 92% of all ADEs occurred during the procedure itself. In patients who did not have an ADE during the procedure, no serious ADEs occurred greater than 25 minutes after the final medication administration. Minor ADEs, especially vomiting, continued to occur later in the ED stay and after discharge. For particularly painful procedures, this risk of adverse events may increase during the minutes following discontinuation of the painful stimulus. Though the appropriate monitoring time for these commonly used short-acting agents may be as little as 30-60 minutes after the final drug administration, current guidelines recommend 1-2 hours of post-procedure observation. This time should be increased to 2-4 hours when longer-acting or reversal agents are used, and for patients with developmental delay, age < 1-2 years, or other factors that may make assessing mental status more difficult. All patients should be assessed in a routine fashion prior to discharge including assessment of vital signs, mental status, and pain. Post-anesthesia scores such as the modified Aldrete score[55] (> 18) have been validated for predicting safe

Table 10. Physical Status Classification of American Society of Anesthesiologists*

CLASS	DESCRIPTION	EXAMPLES
1	A normal, healthy patient	Unremarkable past medical history
2	A patient with mild, systemic disease (no functional limitation)	Mild asthma, controlled seizure disorder, anemia, controlled diabetes mellitus
3	A patient with severe systemic disease (definite functional limitation)	Moderate-severe asthma, poorly controlled seizure disorder, pneumonia, poorly controlled diabetes, moderate obesity
4	A patient with severe systemic disease that is a constant threat to life	Severe bronchopulmonary dysplasia; sepsis; advanced pulmonary, cardiac, hepatic, renal, or endocrine disease
5	A moribund patient who is not expected to survive without the operation	Septic shock, severe trauma

* Table adapted from: Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002;96(4):1004-17.

discharge from the Post Anesthesia Care Unit (PACU) and may be adapted for use in the ED setting. Recommended discharge criteria are shown in Table 8.

Preprocedure Assessment

Documented preprocedure assessment prior to PSA is now required by The Joint Commission.[2] The history should focus on the last PO intake, allergies, personal and family history of previous sedation/anesthesia, history of snoring/obstructive sleep apnea/stridor, and the presence of significant renal or hepatic disease that may impact drug clearance, the presence of significant cardiopulmonary disease (i.e., asthma) or current upper respiratory infection (URI), both of which may increase the likelihood of adverse events.[56,57] *(See Table 9.)* The ASA class *(see Table 10)* should be determined. Though ED sedation of class 3 and 4 patients may be appropriate,[58] strong consideration should be given to alternatives such as performing the procedure in the operating room or accomplishing the procedure without sedation.

The physical examination should give special attention to the airway for factors associated with difficult bag-valve-mask ventilation (edentulous, obesity, abnormal facies, facial hair) or endotracheal intubation (high Mallampati score, short neck, small chin, obesity, limited neck or jaw mobility). A high ASA class or a potentially difficult airway should prompt consideration of alternatives to PSA. The cardiovascular and respiratory examinations are important to detect unknown and/or active disease that may affect the success of PSA.

The risks, benefits, and alternatives to procedural sedation should be discussed with the family; at a minimum, verbal consent should be documented. Written consent is not currently required by The Joint Commission, but institutional guidelines and/or protocols may require it and should be reviewed. Discussing common but minor complications such as emesis in advance decreases parental concern and anxiety if and when such complications occur.

The necessity of preprocedural fasting is an area of ongoing controversy. The ASA currently recommends fasting times of 2 and 4 hours for clear liquids and breast milk respectively and 6 hours for non-human milk, formula, or a light meal. In making these recommendations, the ASA acknowledges that the standards only apply to elective procedures (thus not applicable to most ED procedures) and that "the literature does not provide sufficient evidence to test the hypothesis that preprocedure fasting results in a decreased incidence of adverse outcomes in patients undergoing either moderate or deep sedation."[3]

Though preprocedural fasting theoretically decreased the risk of aspiration during sedation, there is little evidence to support this contention. ACEP guidelines state: "recent food intake is not a contraindication for administering procedural sedation and analgesia, but should be considered in choosing the timing and the target level of sedation."[8]

Two large studies have recently examined the relationship between preprocedural fasting and complication rates. In a series of 1014 patients by Agrawal and colleagues,[31] 56% of patients did not meet ASA fasting guidelines. There were no statistically significant differences in adverse events between patients who meet fasting guidelines and those who did not, and the overall rate of complications was low (6.7%). A large study by Roback and coworkers[19] in 2004 had similar findings, although this study had fasting data missing for 25% of the patients studied. A set of evidence-based, emergency medicine specific consensus guidelines was recently published with specific fasting recommendations based on patient risk and procedure duration.[38] These guidelines are the most specific to date, although their complexity precludes discussion within the scope of this article. In general, the provider should weigh the risks and benefits of immediate versus delayed PSA in patients who do not meet current fasting guidelines.

Conclusion

This issue deals with the commonly encountered clinical scenario of managing pediatric pain in the emergency department. The indications for PSA may include a laceration repair, fracture reduction, or other painful procedure. Children, because of their unique clinical and physiologic characteristics, may be more challenging to assess and require frequent and careful assessments during PSA. The definitions, required equipment, patient assessment, and critical monitoring are all discussed with an emphasis on the special requirements for children. The next issue will address specific agents used for PSA, specific indications and contraindications for selecting PSA agents, and the use of reversal agents.

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Physicians participate in this continuing medical education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge.

To clarify confusion surrounding any questions answered incorrectly, please consult the source material. After completing this activity, you must complete the evaluation form that will be provided at the end of the semester and return it in the reply envelope provided to receive a credit letter. When your evaluation is received, a credit letter will be mailed to you.

CME Objectives

The CME objectives for *Pediatric Emergency Medicine Reports* are to help physicians:

a.) Quickly recognize or increase index of suspicion for specific conditions;

b.) Understand the epidemiology, etiology, pathophysiology, historical and physical examination findings associated with the entity discussed;

c.) Correctly formulate a differential diagnosis and perform necessary diagnostic tests;

d.) Apply state-of-the-art therapeutic techniques (including the implications of pharmacologic therapy discussed) to patients with the particular medical problems discussed;

e.) Provide patients with any necessary discharge instructions.

CME Questions

41. You are sedating a 7-year-old girl with midazolam and fentanyl to perform a shoulder reduction. She is able to answer the question "What is your name?" if you apply painful stimulation but is otherwise sleepy. What term most correctly describes her sedation state?
    A. Conscious sedation
    B. Deep sedation
    C. Dissociative sedation
    D. Moderate sedation

42. What sedation state is produced by ketamine?
    A. Deep sedation
    B. Dissociative sedation
    C. Moderate sedation
    D. Procedural sedation

43. Which of the following are considered alternatives to procedural sedation?
    A. Distraction by parents or child life specialists
    B. Local analgesia
    C. Not performing the procedure
    D. Systemic analgesia
    E. All of the above

44. Compared to adults, children desaturate:
    A. at approximately the same rate as a 70 kg adult.
    B. at approximately the same rate as a 125 kg adult.
    C. more slowly than a 70 kg adult.
    D. Rarely

45. What is the most common serious adverse event during pediatric PSA?
    A. Aspiration
    B. Hypotension
    C. Hypoxia
    D. Vomiting

46. Which of the following concerning preprocedural fasting is true?
    A. Fasting guidelines no longer have relevance for PSA performed in the emergency department as they unduly affect patient throughput.
    B. PSA should not be attempted unless preprocedural fasting guidelines have been met.
    C. The risks and benefits of immediate versus delayed PSA should be weighed when preprocedural fasting guidelines are not met.
    D. There is good evidence that preprocedural fasting decreases the risk of vomiting and aspiration.

47. Which of the following is true regarding children and pain perception?
    A. Children do not experience pain.
    B. Children are less able to communicate their pain and may have significant anxiety that contributes to their perception of pain.
    C. Pediatric pain is usually overtreated in the ED.
    D. Children typically receive more pain medication than adults for the same type of injury.

48. Children are at increased risk, compared to adults, to suffer complications from PSA because:
    A. of decreased pulmonary reserves.
    B. sedation levels are more difficult to assess.
    C. appropriate resuscitation equipment is less likely to be available.
    D. All of the above

49. Which of the following has been associated with adverse events in PSA leading to devastating consequences?
    A. Dosing errors
    B. Use of three or more agents
    C. Drugs administered by non-medical professionals
    D. All of the above

50. Which of the following should be part of the routine assessment of a patient who has received PSA prior to discharge?
    A. PRISM score
    B. Mallampati score
    C. Mental status
    D. ASA physical status classification

Answers: 41. D; 42. B; 43. E; 44. B; 45. C; 46. C; 47. B; 48. D; 49. D; 50. C

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In Future Issues: **Procedural Sedation: Part II**

PEDIATRIC Emergency Medicine Reports
The Practical Journal of Pediatric Emergency Medicine

Procedural Sedation: Part I

Recommended Terminology and Definitions of Sedation States*

STATE	DEFINITION	SOURCE
Procedural sedation	"A technique of administering sedatives or dissociative agents with or without analgesics to induce a state that allows the patient to tolerate unpleasant procedures while maintaining cardiorespiratory function. Procedural sedation and analgesia is intended to result in a depressed level of consciousness but one that allows the patient to maintain airway control independently and continuously. Specifically, the drugs, doses, and techniques used are not likely to produce a loss of protective airway reflexes."	American College of Emergency Physicians[8]
Minimal sedation (anxiolysis)	"A drug-induced state during which patients respond normally to verbal commands. Although cognitive function and coordination might be impaired, ventilatory and cardiovascular functions are unaffected."	Joint Commission Sedation and Anesthesia Care Standards[2]
Moderate sedation (formerly conscious sedation)	"A drug-induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation. Reflex withdrawal from a painful stimulus is not considered a purposeful response. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is usually maintained."	Joint Commission Sedation and Anesthesia Care Standards[2]
Dissociative sedation	"A trance-like cataleptic state induced by the dissociative drug ketamine characterized by profound analgesia and amnesia, with retention of protective airway reflexes, spontaneous respirations, and cardiopulmonary stability."	Green SM, Krauss B. "The semantics of ketamine"[16]
Deep sedation	"A drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully following repeated or painful stimulation. The ability to independently maintain ventilatory function could be impaired. Patients might require assistance in maintaining a patent airway and spontaneous ventilation might be inadequate. Cardiovascular function is usually maintained."	Joint Commission Sedation and Anesthesia Care Standards[2]
General anesthesia	"A drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation. The ability to independently maintain ventilatory function is often impaired. Patients often require assistance in maintaining a patent airway, and positive pressure ventilation might be required because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. Cardiovascular function can be impaired."	Joint Commission Sedation and Anesthesia Care Standards[2]

* Table adapted from Krauss B, SM Green. Procedural sedation and analgesia in children. *Lancet* 2006;367(9512):766-80.

Topical Anesthetics' Onset, Duration, and Comments

TOPICAL ANESTHETIC	ONSET OF ACTION	DURATION OF ACTION	COMMENTS
TAC/LET*			Not useful for intact skin.
Tetracaine 4% gel (amethocaine, Ametop)	30-45 min	4-6 hours	Not yet approved by the U.S. Food and Drug Administration.
Topical lidocaine (available in 2% or 5% concentration)			Max area of application should not exceed 100 cm^2 in children and 600 cm^2 in children weighing greater than 10 kg or adults.
Lidocaine 4% micro-emulsion (Tropicaine)	30 min		Max area of application should not exceed 100 cm^2 in children and 600 cm^2 in children weighing greater than 10 kg or adults.
Liposomal lidocaine 4% (L.M.X 4)	30 min		Max area of application should not exceed 100 cm^2 in children and 600 cm^2 in children weighing greater than 10 kg or adults.
2.5% lidocaine and 2.5% prilocaine (EMLA cream)	1-3 hours	2 hours	For infants 3 months or younger or less than 5 kg, a max dose of 1 g can be applied over a maximal surface of 10 cm^2. For children 3-12 months weighing more than 5 kg, a max dose of 2 g can be applied over a maximal surface area of 20 cm^2. For children 1-6 years and weighing more than 10 kg, a max dose of 10 g can be applied over a maximal surface area of 100 cm^2. For children 7-12 years, a max dose of 20 g can be applied over a maximal surface area of 200 cm^2.

* TAC = tetracaine, Adrenaline [epinephrine], cocaine; LET = lidocaine, epinephrine, tetracaine

Physical Status Classification of American Society of Anesthesiologists*

CLASS	DESCRIPTION	EXAMPLES
1	A normal, healthy patient	Unremarkable past medical history
2	A patient with mild, systemic disease (no functional limitation)	Mild asthma, controlled seizure disorder, anemia, controlled diabetes mellitus
3	A patient with severe systemic disease (definite functional limitation)	Moderate-severe asthma, poorly controlled seizure disorder, pneumonia, poorly controlled diabetes, moderate obesity
4	A patient with severe systemic disease that is a constant threat to life	Severe bronchopulmonary dysplasia; sepsis; advanced pulmonary, cardiac, hepatic, renal, or endocrine disease
5	A moribund patient who is not expected to survive without the operation	Septic shock, severe trauma

* Table adapted from: Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002;96(4):1004-17.

Factors Contributing to Devastating Outcomes with PSA

- Dosing errors
- Use of three or more agents
- Drugs administered by non-medical professionals
- Inadequate observation time
- The use of agents with a long half life (i.e., chloral hydrate)
- Inadequate resuscitation
- Delayed recognition of complications
- Failure to use or appropriately interpret pulse oximetry
- Lack of an independent observer dedicated to patient monitoring during the procedure

Discharge Criteria*

- ❏ Mental status: alert, age-appropriate, at baseline
- ❏ Vital signs: normal and stable post-procedure
- ❏ Responsible adult available for monitoring of complications after discharge
- ❏ Pain: well-controlled, with clear plan for post-discharge pain management
- ❏ Written discharge instructions: including diet, activity, medications; and clear, procedure specific return precautions and follow-up plan

* Table adapted from: Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: addendum. *Pediatrics* 2002;110(4):836-8; and Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002;96(4):1004-17.

Adverse Drug Events Associated with PSA

SERIOUS

Hypoxia
Stridor
Laryngospasm
Aspiration
Apnea
Hypotension
Permanent neurologic injury
Death

MINOR

Nausea
Emesis (without aspiration)
Rash
Agitation
Emergence reactions
Dizziness
Fussiness
Abdominal pain
Headache
Dystonia

Suggested Equipment for Procedural Sedation

- Continuous pulse oximetry monitor (audible)
- End tidal CO_2 monitor (optional)
- Oxygen
- Non-rebreather mask
- Nasopharyngeal airway
- Oral airway
- Suction
- BVM (bag-valve-mask) attached to oxygen source
- Airway cart with intubation equipment (available)
- Blood pressure monitor with appropriate cuff
- Cardiac monitor
- Broslow tape
- IV supplies
- ACLS/PALS meds available
- Defibrillator if patient has a history of cardiovascular disease
- Reversal agents

Guidelines and Standards Pertaining to Pediatric Sedation and Analgesia

The Joint Commission

— Joint Commission on Accreditation of Healthcare Organizations. Pain standards for 2001. 2001.
— Joint Commission on Accreditation of Healthcare Organizations. *Comprehensive Accreditation Manual for Hospitals: The Official Handbook.* 2005, Joint Commission Resources, Inc., Oakbrook Terrace, IL.
— *Revisions to Anesthesia Care Standards: Comprehensive Accreditation Manual for Hospitals.* 2001, Joint Commission on Accreditation of Healthcare Organizations Department of Publications, Oakbrook Terrace, IL.

American College of Emergency Physicians

— Godwin SA, et al. Clinical policy: procedural sedation and analgesia in the emergency department. *Ann Emerg Med* 2005;45(2):177-96.

American Academy of Pediatrics

— Committee on Drugs. American Academy of Pediatrics. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: addendum. *Pediatrics* 2002;110(4):836-8.
— American Academy of Pediatrics Committee on Drugs: Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures. *Pediatrics* 1992;89(6 Pt 1):1110-5.
— Guidelines for the elective use of conscious sedation, deep sedation, and general anesthesia in pediatric patients. Committee on Drugs. Section on anesthesiology. *Pediatrics* 1985;76(2):317-21.

American Society of Anesthesiologists

— Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002;96(4):1004-17.
— Practice guidelines for sedation and analgesia by non-anesthesiologists. A report by the American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists. *Anesthesiology* 1996;84(2):459-71.

Essentials of the Preprocedure Assessment

HISTORY

❑ Last oral intake
❑ Allergies
❑ Family and personal history of previous sedation/anesthesia
❑ History of previous airway procedures
❑ History of significant renal or hepatic disease
❑ History of cardiopulmonary disease (asthma, congenital heart disease)
❑ History of snoring/obstructive sleep apnea/stridor
❑ Current infectious symptoms (including URI)

PHYSICAL EXAM

❑ Airway (edentulous, obesity, abnormal facies, facial hair)
❑ Mallampati score
❑ Neck (short neck higher risk of difficult airway)
❑ Chin (small chin higher risk of difficult airway)
❑ Jaw and neck mobility (limited mobility higher risk of difficult airway)
❑ Cardiovascular exam
❑ Respiratory exam

Emergency Department Uses of Procedural Sedation

- Wound care
- Laceration repair
- Burn debridement
- Incision and drainage
- Reductions
  - Dislocation
  - Fracture
  - Hernia
  - Paraphimosis
- Diagnostic imaging
  - CT scan
  - MRI
- Chest tube placement
- Suprapubic catheter placement
- Cardioversion
- Lumbar puncture
- Arthrocentesis
- Foreign body removal
- Foley catheter placement
- Slit lamp examination
- Sexual assault exam

Supplement to *Pediatric Emergency Medicine Reports*, May 2007: "Part I. Pediatric Procedural Sedation: Personnel, Monitoring, and Patient Assessment." Authors: N. Ewen Wang, MD, Assistant Professor of Surgery, Associate Director of Pediatric Emergency Medicine, Stanford University Hospital, Stanford, CA; and Jonathan Vlahos, MD, Stanford-Kaiser Emergency Medicine, Stanford, CA; *Peer Reviewer:* Susan B. Promes, MD, FACEP, Associate Professor and Program Director, Duke University Emergency Medicine Residency Program, Durham, NC.*Pediatric Emergency Medicine Reports' "Rapid Access Guidelines."* Copyright © 2007 AHC Media LLC, Atlanta, GA. **Senior Vice President and Group Publisher:** Brenda Mooney. **Editor-in-Chief:** Ann Dietrich, MD, FAAP, FACEP. **Associate Publisher:** Lee Landenberger. For customer service, call: **1-800-688-2421.**
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Vol. 8, No. 3

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May/June 2007

Emergency department physicians frequently assess and manage patients with potential hip fractures. Fractures of the hip may have devastating consequences and are associated with substantial morbidity and mortality, approximately 15% of patients die within one year of fracture and patients who survive may suffer from limited physical mobility. The mechanism of injury for sustaining a hip fracture are divergent; elderly patients may have minimal trauma and younger patients typically have high-velocity injuries. This article focuses on a discussion and review of proximal femur fractures including classification systems, radiographic evaluation, and ED management.

— The Editor

Hip Fractures: Evaluation and Management

Authors: **Robert Corder, MD,** Assistant Professor, University of Maryland School of Medicine, Department of Emergency Medicine, Baltimore, MD; and **Michael K. Abraham, MD,** Chief Resident, Department of Emergency Medicine, University of Maryland School of Medicine, Baltimore, MD.

Peer reviewer: **Jonathan Singer, MD, FAAP, FACEP,** Professor of Emergency Medicine and Pediatrics, Boonshoft School of Medicine, Wright State University, Dayton, OH.

Introduction

Hip fractures are a commonly encountered problem in the emergency department (ED). The majority of hip fractures in elderly patients occur with minimal trauma, such as a fall. In contrast, younger healthy adults do not typically sustain a hip fracture without a high-velocity injury, such as a motor vehicle collision or falls from very significant heights. Hip fractures may result in significant consequences for an afflicted individual, including an approximate mortality rate of 15% within one year of fracture. Morbidity associated with hip fractures include persistent pain, decreased physical mobility, and protracted recoveries.

The goal of the emergency physician (EP) is to stabilize the patient and then identify any potential fractures. Following fracture identification the physician must then stabilize the fracture, provide patient comfort, and perform appropriate diagnostic studies. Timely and appropriate referral to the orthopedic consultants also assist in preserving or restoring function and preventing

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complications. Potential areas of liability for the practicing clinician include: failure to keep a patient with a stress or incomplete femoral neck fracture non-ambulatory, failure to diagnose a stress femoral neck fracture in a young patient with hip or knee pain, and failure to consider an incomplete femoral neck fracture in an older patient.

This article will focus on fractures of the hip limited to the proximal femur, from the femoral head to the greater and lesser trochanters. An overview of the anatomy, epidemiology, classification systems for proximal femur fractures, radiographic evaluation and ED management will be presented.

Anatomy

The hip joint is comprised of the pelvic acetabulum articulating with the proximal femur from its head to approximately 2-3 inches below the lesser trochanter, forming a ball and socket. *(See Figure 1.)* It is surrounded by a strong fibrous capsule that attaches proximally around the acetabulum and inserts distally to the intertrochanteric line anteriorly, and posteriorly onto the neck of the femur proximal to the intertrochanteric crest. *(See Figure 1.)* Fractures occurring on that part of the femur, which lie within the capsule, are known as intracapsular fractures of the hip. They involve the femoral head and neck. Extracapsular hip fractures involve the trochanteric, intertrochanteric, and subtrochanteric regions. The bone of the femoral head, neck, and intertrochanteric regions is primarily cancellous. Bone distal to the intertrochanteric region is primarily cortical.

The vascular supply to the femoral head is derived primarily from epiphyseal or retinacular arteries off branches of the obturator, medial femoral circumflex, lateral femoral circumflex, and superior and inferior gluteal arteries. These course beneath the capsular reflection on the femoral neck and along the ligamentum teres. The artery of ligamentum teres is another source of blood supply to the femoral head and neck. This is significant since displaced intracapsular fractures carry with them higher rates of avascular necrosis, nonunion, and malunion compared to nondisplaced intracapsular and most extracapsular fractures.

The hip is one of the strongest and most mobile joints in the body. The major ligaments that help to assure stability and function are the iliofemoral, pubofemoral, and ischiofemoral ligaments. The muscle groups allow the hip to move powerfully in flexion, extension, rotation, adduction, and abduction. The most powerful hip flexor is the iliopsoas muscle, which gets assistance from the rectus femoris, pectineus, adductor longus, gracilis, tensor fascia lata, and sartorius muscles. The gluteus maximus and hamstring muscles (biceps femoris, semitendinosus, and semimembranosus muscles) provide for hip extension. Medial rotation is achieved using the tensor fascia lata, gluteus medius, gluteus minimus, and gracilis muscles. The piriformis, obturator internus, obturator externus, superior and inferior gemelli, and quadratus femorus muscles work to provide lateral rotation. Hip adduction uses the gracilis, pectineus, adductor magnus, adductor brevis, adductor longus, and hamstring muscles. The muscles involved with hip abduction include sartorius, tensor fascia lata, gluteus minimus, and gluteus medius.

The nerve innervation of the hip primarily is provided by branches of the femoral and sciatic nerves arising from the second through fourth lumbar nerve roots and the fourth lumbar through third sacral nerve roots, respectively. *(See Figure 2.)*

Figure 1. Hip Anatomy

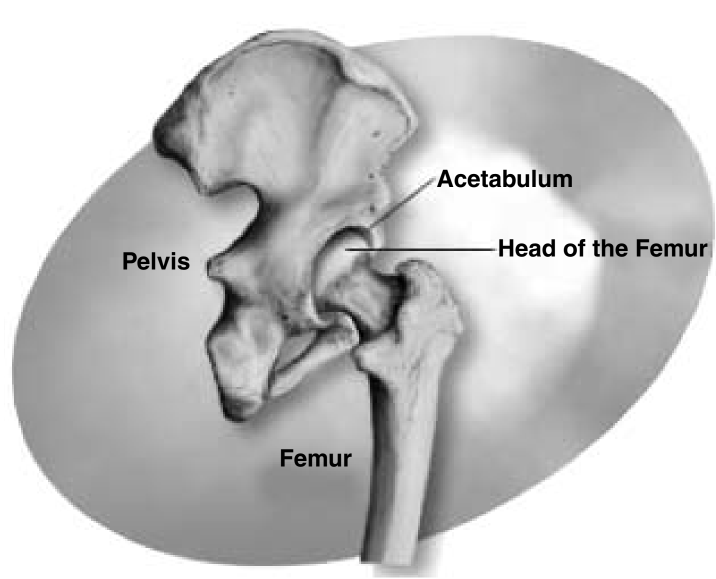

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Figure 2. Sciatic Nerve Relationship to the Hip

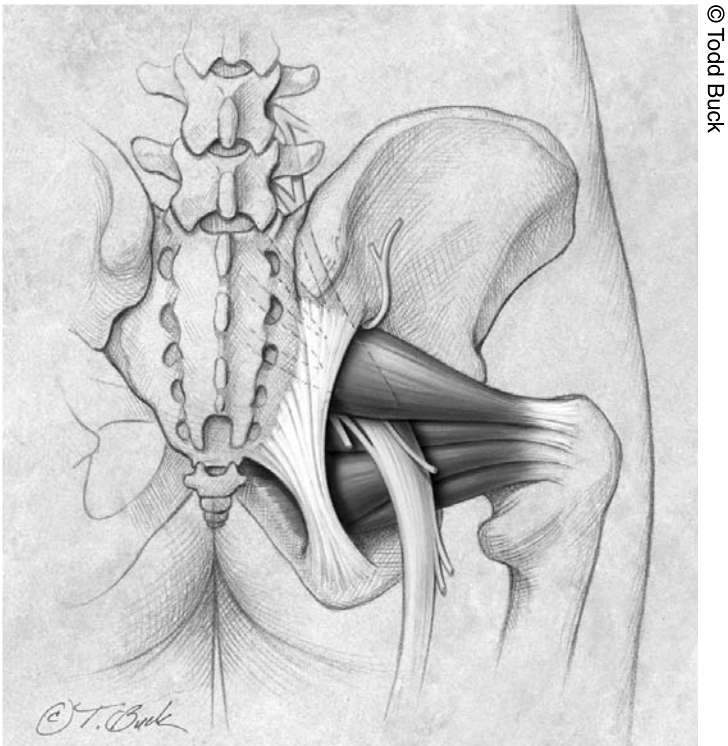

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Table 1. Risk Factors for Hip Fractures

- Osteoporosis
- Smoking
- Visual impairment
- Excessive alcohol consumption
- Physical inactivity
- Institutional living
- Maternal history of hip fracture
- Dementia
- High caffeine intake
- Use of medications that decrease bone mass or contribute to unsteady ambulation
- Low body weight
- Tall stature
- Previous fracture of hip, wrist, or vertebrae

Familiarity with the anatomy of the hip will assist the EP in considering specific injuries and possible neurovascular complications and to anticipate diagnostic testing.

Epidemiology

Hip fractures are a significant individual, familial, and public health concern in most industrialized countries. They account for more than 300,000 hospitalizations and 60,000 nursing home admissions in the Unites States annually.[1] According to Popovic, most patients with hip fractures are hospitalized for approximately one week.[2] However, institutionalization of at least a year is needed for almost 25% of older adults who sustain a hip fracture and were previously living in the community.[3] According to the Centers for Disease Control and Prevention (CDC), Medicare costs in 1991 were estimated to be $2.9 billion.[4] The estimated cost of medical treatment for this injury in 1995 was $8.86 billion.[5] Patients older than 50 years of age account for an estimated 90% of proximal femur fractures.[6] The U.S. Bureau of the Census estimates an increase of people ages 65 and older from 34.8 million to 77.2 million in the years 2000 to 2040.[7] The fastest growing segment of the population is the 85 year old and older age group. Given the aging population of the United States, the incidence of hip fracture is estimated to exceed more than 500,000 cases by the year 2004.[8]

In addition to the financial costs, there are high costs with regard to morbidity and mortality. In their Position Statement on hip fractures in the elderly in 1999, the American Academy of Orthopaedic Surgeons and American Association of Orthopaedic Surgeons reported a mortality rate of 4% during a patient's initial hospitalization, and that 24% of patients die within the first year of injury.[9] Morbidity associated with hip fracture is vast.

Complications associated with immobility include the development of pneumonia, deep vein thrombosis, pulmonary embolism, and general deconditioning. The multisystem trauma patient with hip fracture and concurrent intra-abdominal, intrathoracic, soft tissue, or other skeletal injuries suffers the additive effects of morbidity from those medical conditions.

There also are complications inherent to corrective surgical procedures, including intolerance to anesthesia, postoperative infection, malunion, and nonunion of fracture sites. Loss of independence due to the inability to return to a pre-injury level of ambulation is another significant morbidity factor effecting a patient's quality of life. In fact, losing the ability to walk after hip fracture has been reported to be as high as 50% in a study by Wolinsky and colleagues.[10]

Due to the higher rate of osteoporosis in whites, there is a 2 to 3 times greater incidence of hip fractures in Caucasians when compared to non-Caucasians. With regard to a person's sex, females have a 2 to 3 times greater fracture rate than males; this results in 75-80% of all hip fractures occurring in females. There is an approximate 15% and 5% lifetime risk of hip fracture in white females and males, respectively.[11] Risk factors associated with the probability of suffering a hip fracture in ones' lifetime are presented in Table 1.

Many risk factors are modifiable and have been the focus of several efforts toward hip fracture prevention. The elderly are not the only ones affected by fractures of the hip. High energy physical trauma is the usual cause of proximal femur fractures in younger patients, with a higher incidence of concurrent injury to multiple body systems. However, younger children and adolescents presenting with limp or hip pain should be evaluated for either Legg-Calvé-Perthes disease or slipped capital femoral epiphysis (SCFE). Legg-Calvé-Perthes disease is an ischemic condition affecting the proximal femur leading to infarction, necro-

Figure 3. Legg-Calvé-Perthes Disease

Courtesy of Dr. Ann Dietrich

sis, and often fracture of the femoral head. It is more common in females and in children ages 4 to 9 years. *(See Figure 3.)* SCFE typically is a gradual, chronic process, but acute presentations may occur. It is more common in males; African-Americans; and obese adolescents, ages 11 to 15 years. SCFE is a Salter-Harris type 1 fracture through the proximal femoral physis typically resulting when stress around the hip causes a shear force to be applied at the growth plate. Obesity is a predisposing factor in the development of SCFE and hormones are believed to play a role. The fracture occurs at the hypertrophic zone of the physeal cartilage secondary to stress on the hip causing the epiphysis to move posteriorly and medially. The clinical presentation may be challenging, with only 50% of patients presenting with hip pain and 25% presenting with knee pain. Diagnostic errors are common, and approximately 25% of patients experience delay in treatment. The outcome of SCFE is related directly to the severity of the slip at the time of treatment. An anterioposterior (AP) pelvis and lateral frog-leg radiographs are usually all that is needed to make the diagnosis. *(See Figure 4.)* CT scan is a sensitive method of measuring the degree of tilt and detecting early disease, but is rarely indicated. MRI may be used to detect the slippage earliest, and MRI can demonstrate early marrow edema and slippage. *(See Figure 5.)* The treatment of SCFE entails stabilizing the hip, through the use of pins, screws, and wires to cross the physis and fix the epiphysis. Both entities need proper diagnosis and orthopedic referral for proper management. Diligent pursuit of the etiology of a patient's hip pain, while keeping in mind these epidemiologic facts, will assist the EP in the assessment and management of hip fractures.

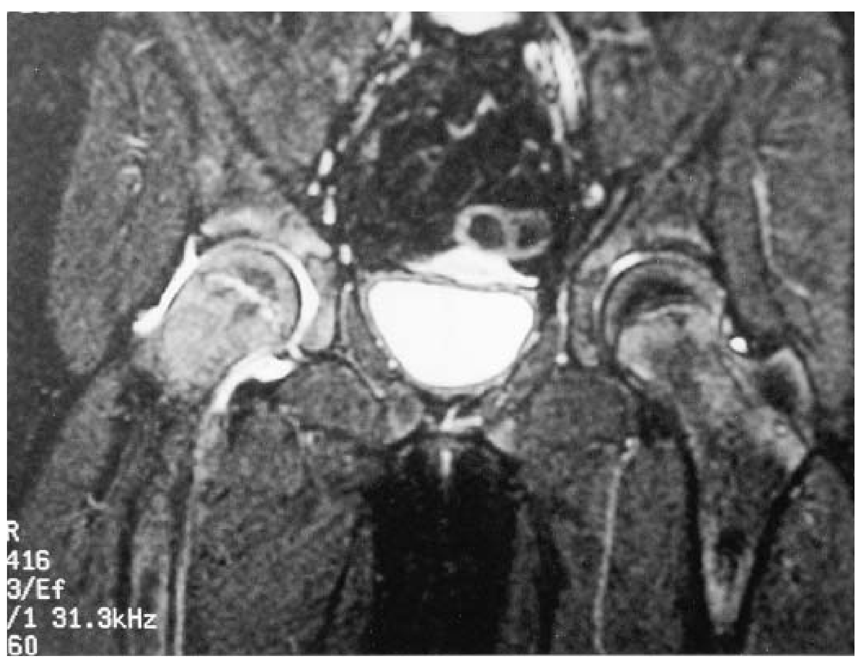
Initial Emergent Care

Evaluation and recognition of possible hip fractures in the ED can be challenging. Presentations vary from a hemodynamically unstable, multisystem trauma patient to an elderly patient with hip pain and difficulty ambulating for several days. From an emergency medicine perspective, the approach to all varieties of hip fractures is the same. Anatomic findings may differ, but the

Figure 4. Slipped Capital Femoral Epiphysis (SCFE)

Courtesy of Dr. Howie Werman, Ohio State University College of Medicine and Public Health

Figure 5. MRI of Slipped Capital Femoral Epiphysis (SCFE)



Courtesy of Dr. Howie Werman, Ohio State University College of Medicine and Public Health

EP must approach each entity equipped with a broad knowledge base and with attention to detail.

The initial evaluation by both emergency medical services (EMS) and EP's is the same: a primary assessment of airway, breathing, and circulation. Typical EMS pathways for patients suspected of having significant life threatening injuries include securing a patient's airway via endotracheal intubation, use of airway adjuncts, or less invasive oxygen supplementation. For patients who are hypotensive or tachycardic, resuscitation is started using large bore intravenous catheters and initial crystalloid fluid boluses. For patients with possible intertrochanteric and subtrochanteric fractures, the potential for significant blood loss exists and patients must be carefully assessed and monitored. The neck and spine are frequently immobilized using rigid cervical collars and backboards if the EMS provider determines there is a possibility for associated spinal injuries based on mechanism of injury, and brief physical and neurologic exams.

Injuries with bleeding are addressed by using direct pressure dressings and elevation if possible. The affected extremity is immobilized and a splint is applied with traction unless there is concern for sciatic nerve injury or the fracture is open.[12] A recent survey of trauma physicians, in accordance with Advanced Trauma Life Support (ATLS) protocol, recommended pneumatic anti-shock garments (PASG) in patients with an identifiable pelvic fracture and hypotension. This has been shown to decrease mortality.

Consultation within the EMS communication network with regard to administering intravenous analgesics and other resuscitative medications is performed. Transporting patients to a facility offering the appropriate Level I or II trauma care also is discussed and initiated based on local EMS protocols.

Once the patient is under the care of the EP, stabilization continues. As with every patient being treated in the ED, ensuring respiratory, ventilatory and hemodynamic competence is a primary concern. Intertrochanteric fractures generally require fluid resuscitation and subtrochanteric fractures frequently require large volumes of fluid resuscitation. Thorough histories and physical examinations are completed to the degree the medical situation allows. This is supplemented by family recall, ancillary medical personnel reports, and from other individuals having firsthand knowledge of the circumstances. The EP will acquire lab data, diagnostic imaging and orthopedic consultation; administer medications to support adequate physiologic requirements and provide patient comfort; anticipate further needs associated with both operative and non-operative interventions; and provide proper disposition communication and documentation.

Unless the fracture has a complication requiring emergent intervention, trauma protocols will call for a prioritized approach for the patient with multisystem trauma. One major area the EP should focus is on analgesia, since pain management may significantly improve the physical exam.

Compounding matters are the comorbid conditions of the patient and the clinical scenario. Parenteral analgesia or nerve blockade can be used for pain control. Nerve blockade may be preferred in the setting of hypotension, thereby mitigating some of the systemic effects of opiates. However, a thorough neurological examination must be performed prior to the blockade. The EP must evaluate for contributory medical conditions such as myocardial ischemia, cerebrovascular accidents, and arrhythmias as events that could have lead to a fall in the elderly patient. Subsequent sections in this article will address more specific evaluation and treatment approaches based on the anatomic location of the hip fracture.

Case 1

A 30-year-old male involved in a head-on motor vehicle collision is brought to the ED by EMS. On initial examination, the patient has multiple lacerations on his face. His breath sounds are clear; his abdomen is soft; and his left leg is shortened, internally rotated, and adducted.

- What is the first step in his evaluation?
- What type of dislocation does the exam correlate with?
- What type of fracture is he at risk for?

Femoral Head Fractures

Shearing forces from hip dislocations are the most common cause of femoral head fractures. Isolated femoral head fractures are unusual. Posterior hip dislocations comprise 70-80% of all hip dislocations. They generally result from forces applied to a flexed knee with hip flexed, adducted, and internally rotated. *(See Figure 6.)* In this scenario, there is a 10-16% association with fracture of the posteroinferior and inferomedial aspect of the femoral head.[13] Anterior hip dislocations result when strong forces are applied with the hip flexed, and leg abducted, and externally rotated. *(See Figure 7.)* This accounts for 20-30% of hip dislocations and carries with it a 22-77% rate of fracture to the posterosuperior and lateral aspects of the femoral head.[14] The cause of the majority of these injuries is motor vehicle collisions involving younger patients, and carries with it a significant rate of associated major injuries to the other extremities, skull, face, thorax, and abdomen. Older patients involved in similar incidences are more likely to sustain femoral neck fractures, in addition to the other associated injuries. *(See Table 2.)*

The patient will typically complain of severe pain and hold the hip joint immobile in positions characteristic of the position of dislocation. The leg is shortened, internally rotated, and adducted when posteriorly dislocated. The affected leg appears flexed, externally rotated, and abducted with the inferior type of anterior dislocations; and extended and externally rotated in the superior type. Other common ipsilateral injuries to consider associated with hip dislocations include acetabular and femoral neck fractures, sciatic nerve injury, arterial injury, venous thrombosis, hematoma, and knee ligamentous tears and fractures.

Orthopedic consultation should be obtained in the ED. The treatment focus for patients with dislocations is reduction of femoral head and fracture fragment as soon as possible to avoid avascular necrosis. Small fracture fragments, if present, may need to be removed. If a single attempt at closed reduction fails, then open reduction and internal fixation are indicated.

Figure 6. Posterior Hip Dislocation

Courtesy of Dr. Ann Dietrich

Figure 7. Anterior and Posterior Hip Dislocations

Courtesy of Dr. Ann Dietrich

Case 2

An 85-year-old white female was brought in by ambulance from an assisted living facility after a fall. The patient is awake and alert, and her vital signs are stable. The patient is complaining of mild pain in her hip region but she is unable to ambulate.

- What type of fracture is this population at risk for?
- What are some of the main complications from this type of fracture?
- What type of imaging may be necessary?

Femoral Neck Fractures

Femoral neck fractures are more common in older adults with underlying osteoporosis or osteomalacia. They typically result from minor trauma or torsional mechanisms associated with falls. *(See Table 2.)* This fracture is not as common in younger patients, but when present, is a result of high energy impact and is associated with other significant concurrent injuries. Potential complications are similar to those in adults, in addition to premature growth plate closure, leg length inequality, and coxa vara.[15] These fractures are intracapsular and occur between the end of the articular surface of the femoral head and the intertrochanteric region.

Femoral neck fractures are classified by the amount of displacement. The most commonly cited system is the Garden system. There are four grades of fracture which are based on appearance of initial x-rays prior to reduction. A Garden I fracture is an incomplete, impacted fracture with intact trabeculae in the inferior femoral neck. The patient may complain of only minor pain, often of the medial aspect of the knee or groin, and may be ambulatory. On inspection, the affected leg may appear slightly shortened, with possible induration and swelling at the anterior hip. There may be tenderness on palpation of the anterior hip and reported discomfort with passive movement of the hip in flexion and internal rotation.

There are both operative and non-operative approaches to management. However, advocates of internal fixation report a lower incidence of avascular necrosis, and fewer complications from immobilization compared with longer immobilization times when a non-surgical approach is chosen.[16] There is up to a 20% incidence of avascular necrosis regardless of the approach chosen.

Garden II fractures are complete but non-displaced. The symptoms and signs are similar to those of the Garden I fracture. These fractures are prone to displacement due to the loss of structural integrity; therefore, they are routinely internally fixated. Garden II fractures have outcomes and incidences of avascular necrosis similar to Garden I fractures. A CT scan, focused MRI, or bone scan are possible

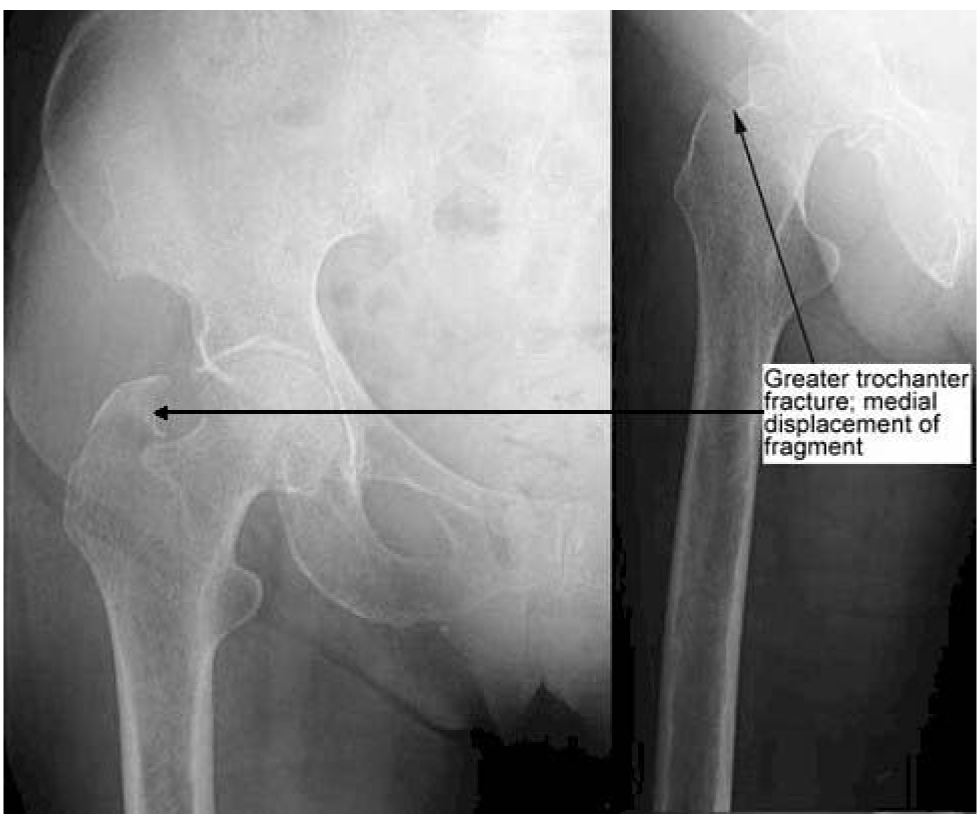
Table 2. Fracture Site, Mechanism, and Physical Findings

FRACTURE SITE	MECHANISM	PHYSICAL FINDINGS
Femoral Head	Posterior Dislocation	Shortened, internally rotated, adducted
	Anterior dislocation Inferior	Flexed, externally rotated, abducted
	Superior	Extended, externally rotated
Femoral Neck	Elderly with osteopenia High energy impact	Shortened, possible induration Pain with passive movement Inability to ambulate
Intertrochanteric	Fall in elderly with bone loss	Shortened with marked external rotation

Figure 8. Type III Garden Fracture

Courtesy of Dr. Ann Dietrich

Figure 9. Greater Trochanter Fracture



Courtesy of Dr. Howie Werman, Ohio State University College of Medicine and Public Health

adjuncts in patients whose x-rays are not diagnostic.

Garden III fractures involve the complete femoral neck and are partially displaced. *(See Figure 8.)* Garden IV fractures are complete and appear totally displaced, with no continuity between bone fragments.

Displaced fractures are more noticeable on anteroposterior (AP) views of the hip; however, a standard, lateral view for exact position should be obtained. The patient with a displaced femoral neck fracture is unable to walk. Inspection may show a shortened leg, abducted and in external rotation. Complaint of pain in the entire region is common. Varying degrees of edema, erythema and ecchymosis will be present.

Surgical treatment should be initiated as soon as possible. Complications of femoral neck fractures are significant, but can be decreased if the patient has surgical intervention within a 6 to 12 hour time frame, barring other traumatic or medical concerns that require intervention prior to correcting the hip pathology. In this case, external reduction and traction will be employed until the patient is ready for their orthopedic procedure.

Trochanteric Fractures

Greater trochanter fractures *(see Figure 9)* typically result from avulsion injuries at the site of insertion of the gluteus medius. It is usually not an isolated injury and most commonly is a component of an intertrochanteric fracture. Orthopedic consultation in the ED is appropriate. If displacement is less than 1 cm and there is no tendency to further displacement, treatment may be bedrest with the affected extremity in balanced suspension until the acute pain subsides. In these patients activity is encouraged as rapidly as symptoms permit, with full weight bearing permitted as soon as healing is apparent. If displacement is greater than 1 cm, these fractures typically are managed with reduction and internal fixation unless the patient is older or debilitated. If that is the case, conservative therapy may be used.

Lesser trochanter fractures may be caused by avulsion injuries of the iliopsoas secondary to forceful contraction. This type of injury typically occurs in children and young athletes. Lesser trochanteric fractures commonly occur as a component of an intertrochanteric fracture. *(See Figure 10.)* Fracture of the lesser trochanter, along with a subtrochlear or intertrochlear fracture, is by definition unstable. Orthopedic consultation in the ED is appropriate. If displacement is less than 1 cm and there is no tendency to further displacement, treatment may be conservative. If displacement is greater than 1

Figure 10. Intertrochanteric and Lesser Trochanter Fractures

Courtesy of Dr. Ann Dietrich

cm, these fractures are typically managed with reduction and internal fixation unless the patient is older or debilitated. If that is the case, conservative therapy may be used.

Intertrochanteric Fractures

Intertrochanteric fractures affect an estimated 150,000 patients in the United States every year. These patients are usually elderly, most often women with deficits of bone quality, and the fractures frequently occur as a result of a fall. These fractures are defined as extracapsular, with the affected bone having a relative abundant blood supply. As a result, rates of avascular necrosis are reduced with this fracture; however, significant morbidity and mortality still exists. Mortality rates of 18% have been reported after surgical correction, with rates of 34% if it is treated non-operatively. Corrective surgery for this type of fracture is the most commonly performed surgical procedure for the orthopedic surgeon.

Patients will be nonambulatory and complain of significant pain if medically able. The affected leg will appear shortened. *(See Table 2.)* Owing to the strong rotational force of the iliopsoas muscle, the leg will be in marked external rotation. A thorough primary and secondary survey of the patient should be performed, as well as a complete physical exam, paying particular attention to joints distal and proximal to the primary injury, and the neurovascular status of the affected extremity. Many classification systems exist with the primary purpose of stratifying fractures based on stability, surgical approaches, and probable outcomes. However, almost all intertrochanteric fractures are surgically reduced and fixed unless medical circumstances or premorbid conditions prohibit surgical intervention.

Stable fractures are two-part fractures running from lateral and cephalad to medial and caudad. *(See Figures 11 and 12.)* Unstable fractures involve posteromedial comminution, reverse obliquity, or subtrochanteric extension. *(See Figure 13.)*

The EP's approach to patient stabilization and evaluation is the same for intertrochanteric fractures as it is for the other hip fracture varieties. Demographically, this patient is older, has comorbid medical considerations, and generally has better outcomes if there is prompt surgical intervention. Prognosis for intertrochanteric fractures is predicated on approach to surgical fixation, the extent of any osteoporosis, and the general condition of the patient prior to surgery.

A study on hip fracture outcomes by Eastwood and coworkers showed that 33-37% of patients returned to their previous level of function with regard to self care, transfers, and locomotion by six months, and that only 24% were completely independent in locomotion at six months.[17] It has been reported that after an intertrochanteric fracture, only 51% are ever able to regain their premorbid level of ambulation.[18] In the pediatric population, non-displaced or minimally displaced fractures *(see Figure 14)* can be managed with a spica cast for 6-8 weeks, but internal fixation is preferred for displaced fractures.

Diagnosis

The diagnosis of these fractures should be suspected based on a patient's age, mechanism of injury, and physical examination. AP and lateral radiographs of the affected side will demonstrate most fractures. If there is a high degree of suspicion for a fracture, but it is not radiographically obvious, look for alteration of the Shenton line and compare it to the other hip. In addition, the neck shaft angle should be assessed (measure the angle created by lines drawn through the centers of the femoral shaft and femoral neck) and is normally approximately 120 to 130 degrees. For patients in whom a femoral neck fracture is suspected, but the initial radiographs are negative, an AP view with internal rotation may provide an enhanced view of the femoral neck.

If the standard views on plain radiography prove inadequate, focused CT scan or MRI can be employed. If the situation permits, and a CT scan is indicated for other injuries, the study can be easily extended through the femur as well. Fracture of the femoral head must be considered in all patients with hip dislocations. Initial x-rays to be obtained include AP view of the pelvis, as pelvic fractures are present in approximately 10% of the cases of hip dislocations.[19] AP and lateral x-rays of the involved hip should be obtained. The head of the femur is medial and inferior to the acetabulum in anterior dislocation, and lies lateral and superior to the acetabulum in posterior dislocation. *(See Figure 7.)*

If there is concern for moving the affected hip, a Johnson lateral view taken from the opposite side with the contralateral thigh flexed can be performed. The oblique or Judet view also is useful in cases where the AP pelvis view is indeterminate. However, it may be technically difficult in the setting of trauma, fur-

Figure 11. AP of Two-part Intertrochanteric Fracture

Source: http://www.gentili.net

Figure 12. Lateral of Two-part Intertrochanteric Fracture

Source: http://www.gentili.net

ther highlighting the utility of the CT scan in the patient's management. There is evidence that MRI may soon be the primary modality for the diagnosis and classification if the plain films are initially negative but the clinical picture is concerning.

A thorough physical examination should note the passive position of the extremity, presence of open wounds and foreign bodies, active bleeding, and expanding ecchymoses and hematomas. Apart from observing a pale, cold extremity, arterial competency can be assessed by palpation or use of a Doppler device in the femoral, popliteal, posterior tibial, and dorsalis pedis arterial positions.

Traumatic nerve injuries are more common in penetrating trauma, but may occur as a result of a fracture-dislocation of the hip. Deficits can result from direct nerve injury and from extraneural pressure exerted from displaced bone or a hematoma. Sciatic and femoral nerve injury have been well documented in cases of proximal hip injury. It is imperative that a complete sensory and motor examination be performed to rule out traumatic neuropathies.

Sciatic nerve injury has a higher incidence in posterior hip fracture-dislocations, and typically manifests as a partial neuropathy. The most sensitive and common neurologic finding in this event is weakness in the extensor hallucis longus muscle, signifying a sciatic nerve injury in its common peroneal nerve distribution. If the sciatic nerve is completely compromised, there will be paralysis of all muscles below the knee and of the hamstrings above the knee. The deep tendon reflex at the ankle will be absent or diminished. Femoral nerve injury will manifest as knee extension weakness, diminished or absent patellar deep tendon reflex, and a sensory deficit superior and medial to the patella.

The presence of neurovascular deficits will require the EP to

Figure 13. Unstable Intertrochanter Fracture

Courtesy of Dr. Ann Dietrich

Figure 14. Intertrochanteric Fracture

Courtesy of Dr. Ann Dietrich

involve orthopedic and/or neurosurgical consultation on an emergent basis. Laboratory screening decisions are based on the stability of the patient, associated injuries, comorbid medical problems, anticipated diagnostic imaging studies, and the need for surgical or non-surgical intervention. The blood work is sent upon the patient's arrival in the ED and typically does not delay or interfere with obtaining initial screening radiographs and subsequent evaluation.

Patients sustaining proximal femur fractures require hospitalization and most undergo surgical repair. A large amount of literature regarding the timing of surgery has been written, with a general consensus that surgical intervention within hours of injury will result in less morbidity and mortality than if surgery is delayed several hours to days.[20] Complications associated with operative delay include recurrent hip dislocations, post-traumatic arthritis, myositis ossificans and aseptic necrosis (8% in anterior fracture dislocations, and 10-20% in posterior fracture dislocations). Preoperative labs generally include a CBC, chemistries, coagulation studies, and type and screen/cross depending on the clinical situation. Consideration for reversing effects of anticoagulants prior to surgery also must be made in certain patients. Anesthesiology typically requires a screening ECG and chest x-ray.

Definitive Therapy and Ongoing Management

After the patient is stabilized and the pathology is identified and classified, the definitive treatment can begin. As discussed earlier, analgesia should be attained immediately allowing for proper examination. Dislocations are true emergencies and must be reduced. Closed reduction of the dislocation is usually achieved with the assistance of the orthopedic consultant. If the clinical situation allows, adequate analgesia can be obtained through conscious sedation. This allows for both analgesia and muscle relaxation which may increase the effectiveness of the reduction.

Appropriate monitoring should include continuous pulse oximetry, cardiac rhythm monitoring, and serial vital signs. Several methods for closed reduction have been described including the Allis, Stimson, reverse Bigelow and leg crossing maneuvers, Whistler technique, and longitudinal traction. Incidence of avascular necrosis increases with repeated, unsuccessful attempts at closed reduction with some recommendations limiting attempts to three before open reduction should be considered.

Other indications for open reduction include, femoral head or shaft fracture, neurovascular deficits subsequent to closed reduction, and persistent joint instability after reduction. Approximately 10% of hip dislocations cannot be reduced using a closed technique.

Post-reduction series of x-rays are required to determine reduction success and presence of fracture. Femoral head fractures can be subtle on post-reduction films. Attention should be directed to the transchondral and lateral posterosuperior areas on the femoral head for lucency, depressions, or flattening. If x-rays are inconclusive and there is continued concern for fracture, a focused CT scan with thin cuts through the acetabulum and proximal femur is needed. Presence of fracture commonly interferes with complete reduction, necessitating surgical reduction and fixation.

If relocation is successful without presence of fracture, the legs should be immobilized in slight abduction using a pad between the legs preventing adduction, until traction can be achieved. Prophylactic antibiotics are indicated for all open fractures and for patients being prepared for immediate internal fixation. Guidelines typically require parenteral administration within 30 minutes of surgery. An IV bolus of 2 grams of a first generation cephalosporin is recommended for closed fractures, as well as for open fractures associated with lacerations of 1 cm or less if there are no contraindications.

If there is moderate contamination, an associated laceration greater than 1 cm, or if soft tissue injury is extensive, a loading dose of an aminoglycoside should be added to the cephalosporin. A penicillin should be added for clostridial coverage if the injury occurs in an environment that is highly contaminated. A meta-analysis of seven studies of prophylactic antibiotic use prior to surgical repair of acute hip fractures showed a 44% risk reduction in post-operative infections.[21]

Femoral head fractures also occur in the pediatric population but are uncommon and usually result from high energy impacts. The same general approach to stabilization, resuscitation, and evaluation apply, abiding by standard pediatric trauma protocols and algorithms.

Summary

This article has served as a general overview for the EP for the evaluation and treatment of patients sustaining fractures of the hip, from the femoral head to the intertrochanteric region. Emphasis has been placed on the epidemiology associated with hip fractures.

Most patients will be elderly and have isolated orthopedic problems. Some will be younger and have significant, multiple trauma concerns. Medical and traumatic comorbidities may complicate the stabilization, evaluation, and treatment of the patient. ATLS and Advanced Cardiac Life Support (ACLS) protocols always should be followed. An organized approach to an appropriately prioritized problem list will facilitate the process. Plain radiography is diagnostic in many cases, but the use of focused CT scan and MRI studies will be definitive in all cases. The EP's primary role is to determine the nature and the extent of the patient's injury, temporize pain and complications, prepare for anticipated treatment, and involve orthopedic consultants early. The EP must recognize femoral head fracture dislocations as emergencies and be familiar with reduction maneuvers of the hip to minimize the incidence of avascular necrosis. In spite of the greatest efforts of the EP and orthopedic surgeon, hip fractures carry with them significant morbidity and mortality. Multidisciplinary approaches have been proposed in an effort to both prevent occurrences and improve outcomes.

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CNE/CME Objectives

Upon completing this program, the participants will be able to:

a.) discuss conditions that should increase suspicion for traumatic injuries;

b.) describe the various modalities used to identify different traumatic conditions;

c.) cite methods of quickly stabilizing and managing patients; and

d.) identify possible complications that may occur with traumatic injuries.

CNE/CME Instructions

Physicians and nurses participate in this continuing medical education/continuing education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material. **After completing this activity, you must complete the evaluation form provided and return it in the reply envelope provided in order to receive a letter of credit.** When your evaluation is received, a letter of credit will be mailed to you.

CNE/CME Questions

1. Which of the following is **not** true regarding hip fractures?
   A. They account for 300,000 hospitalizations and 60,000 nursing home admissions in the United States annually.
   B. Institutionalization of at least one year is needed for almost 25% of older adults living in a community that sustain a hip fracture.
   C. Patients older than age 50 years account for 20% of proximal femur fractures.
   D. Medicare costs were estimated to be $2.9 billion in 1991.

2. Which of the following complications are associated with immobility following a hip fracture?
   a. Pneumonia
   b. Deep vein thrombosis
   c. Pulmonary embolism
   d. All of the above

3. Which of the following is **not** a risk factor for hip fracture?
   A. Osteoporosis
   B. Smoking
   C. Obesity
   D. Low body weight

4. A 13-year-old obese white male presents with right knee pain, hip pain, and difficulty walking after falling in the driveway while playing basketball. What is the most likely diagnosis?
   A. Slipped capital femoral epiphysis (SCFE)
   B. Legg-Calvé-Perthes disease
   C. Septic arthritis
   D. Femoral neck fracture

5. Which of the following fracture types are likely to be associated with the patient requiring fluid resuscitation?
   A. Isolated greater trochanter fracture
   B. Isolated lesser trochanter fracture
   C. Intertrochanteric fracture
   D. None of the above

6. Which of the following is true regarding femoral head fractures?
   A. Posterior hip dislocations are always associated with a fracture to the femoral head.
   B. Anterior hip dislocations are usually associated with a fracture to the posteroinferior and inferomedial aspect of the femoral head.
   C. Posterior hip dislocations typically are associated with fractures to the posterosuperior and lateral aspects of the femoral head.
   D. Isolated femoral head fractures are unusual.

7. Which of the following is true regarding femoral neck fractures?
   A. Femoral neck fractures are more common in older adults with underlying osteoporosis or osteomalacia.
   B. They always occur secondary to significant forceful trauma.
   C. These fractures are classified based on the angle of the fracture.
   D. This type of fracture is usually managed conservatively with bedrest.

8. Intertrochanteric fractures are associated with which of the following?
   A. Usually elderly female patients
   B. Extracapsular involvement, with the bone having a relatively abundant blood supply resulting in lower rates of avascular necrosis compared to femoral head fractures
   C. Mortality rates as high as 18% after surgical correction
   D. All of the above

9. Which of the following is true regarding sciatic nerve injury?
   A. Sciatic nerve injury has a higher incidence in posterior hip fracture dislocations.
   B. The most sensitive and common neurologic finding is weakness in the extensor hallicus longus muscle.
   C. If the sciatic nerve is completely compromised there will be paralysis of all the muscles below the knee and of the hamstrings above the knee.
   D. All of the above

10. Which of the following is true regarding prophylactic antibiotics?
    A. They are indicated for all open fractures and fractures being prepared for immediate internal fixation.
    B. Antibiotics should be administered three hours prior to surgery.
    C. A first generation cephalosporin only is indicated for moderately contaminated wounds.
    D. Prophylactic antibiotics have **not** been shown to reduce postoperative infections.

Answers: 1. C; 2. D; 3. C; 4. A; 5. C; 6. D; 7. A; 8. D; 9. D; 10. A

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3. cite methods of quickly stabilizing and managing patients
4. identify possible complications that may occur with traumatic injuries

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