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This issue is the second part of our discussion on status epilepticus in adults. Continued, prolonged seizures are fortunately uncommon, but frightening when they occur. As with other life-threatening conditions where treatment is necessary before full assessment, the author describes how it is important to have an organized and rational approach to treating status epilepticus. The emergency physician should have a memorized approach useful in most patients and one or two alternatives when the primary plan does not work. As with other rare conditions, many of the authoritative recommendations on treating status epilepticus are based on some data but mostly on consensus opinion. Until comparison studies are performed, this article presents the "best evidence" approach to status epilepticus.

—J. Stephan Stapczynski, MD, FACEP, Editor

Seizures and Status Epilepticus in Adults: Part II

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Medication Trials

There are a few randomized, blinded, prospective trials for status epilepticus. The most notable is the VA Cooperative Trial, when at time of presentation, patients were randomized into one of four treatment arms: phenobarbital (15 mg/kg); lorazepam (0.1 mg/kg); phenytoin (18 mg/kg); and diazepam (0.15 mg/kg) followed by phenytoin (18 mg/kg). These treatment arms were based on treatment protocols commonly used at the time of study design. EEG was obtained as soon as possible after presentation but did not guide study therapy. There were no significant differences between treatment groups with the exception of the arm of phenytoin alone, which fared the worst of the groups. Another interesting aspect of the study was that slightly less than a third of the patients were found to be in "subtle" generalized convulsive status epilepticus when EEG was promptly obtained.[1]

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The pre-hospital trial for status epilepticus (PHTSE) was unique in that treatment was initiated in the prehospital setting using a shortened time definition of generalized convulsive status epilepticus. Essentially, if seizures were the call to dispatch, and the patient was convulsing on EMS arrival, a diagnosis of status epilepticus was established, and the patients (all adults) were randomized to receive a fixed dose of diazepam (5 mg), lorazepam (2 mg), or placebo. It was concluded that either benzodiazepine was effective and safe in the prehospital environment in the doses used. The study found no significant difference between the treatment arms; nonetheless, the investigators recommended that lorazepam be the drug of choice for prehospital treatment of status epilepticus.[2]

Step One Therapy Generalized Convulsive Status Epilepticus. There is consensus in the literature that a benzodiazepine should be the first class of drug to treat acute seizures. Benzodiazepines are consistently effective in terminating status epilepticus, are available in most care settings, and depending on the specific medication, may be administered intravenously, intramuscularly, or rectally. Diazepam, midazolam, and lorazepam all have been studied and found effective for treatment of status epilepticus. Studies generally involved fixed dosage regimens, so it is difficult to extrapolate superiority of one drug compared to another when study results may reflect different dose regimens. Respiratory depression is likely related to rate of administration rather than specific effects of any one compound.

Table 1. Step One Drugs for Treatment of Generalized Convulsive Status Epilepticus in Adults[11,42,43]

STEP ONE

- Lorazepam
  0.1-0.15 mg/kg over 1-2 minutes
  (repeat once if no response after 5 minutes)
  (maximum dose 8 mg)

OR

- Diazepam
  0.2 mg/kg up to 20 mg at 5 mg/min

OR

- Midazolam
  10 mg IV or IM

<u>Note:</u> Lorazepam may be drug of choice because of studies suggesting less respiratory depression than diazepam and longer effective anticonvulsive activity. Midazolam will terminate seizures but is less studied as a first drug. If intramuscular access is the only available access, midazolam is better absorbed IM than other benzodiazepines.

EMS care generally parallels ED care with the exception of available medications and issues with route of administration. Diazepam is employed by many EMS systems and is effective. Diazepam may be given intravenously or rectally. Respiratory depression is likely largely related to rate of administration. Lorazepam administration for status epilepticus may cause less respiratory depression resulting in less frequent intubations than diazepam.[3] Lorazepam poses particular challenges for implementation in an EMS system because of refrigeration requirements and shortened shelf life if unrefrigerated.

Midazolam has not been the focus of studies as often as other benzodiazepines for initial management of status epilepticus, but is increasingly used for control of generalized convulsive status epilepticus. It may be given intravenously, and unique in this class of medications, is well absorbed when given intramuscularly.[4] (*See Table 1.*) Further discussion of midazolam follows in the section on refractory status epilepticus. A summary of generic and proprietary medication names is listed for convenience in Table 2.

Step Two Therapy Generalized Convulsive Status Epilepticus. Most treatment reviews have listed phenytoin as a second-line drug, with the theory that a longer-acting antiepileptic drug needed to be administered, given the observation of the short anticonvulsant properties of diazepam. Recent reviews offer no change in this recommendation, with the possible substitution of fosphenytoin for phenytoin.

Phenytoin is usually administered by infusion pumps. Rate of

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Table 2. Medications

GENERIC NAME	PROPRIETARY NAME
Diazepam	Valium
Lorazepam	Ativan
Midazolam	Versed
Phenytoin	Dilantin
Fosphenytoin	Cerebyx
Carbamazepine	Tegretol
Valproate	Depakote, others
Propofol	Diprivan
Levetiracetam	Keppra
Topiramate	Topamax
Thiopental	Pentothal
Phenobarbital	—

Table 3. Step Two Drugs for Generalized Convulsive Status Epilepticus—Phenytoins

• Fosphenytoin 20 PE/kg infusion at up to 150 PE/minute

OR

• Phenytoin 20 mg/kg infusion at up to 50 mg/minute

PE = phenytoin equivalents

Fosphenytoin is a water-soluble prodrug of phenytoin. The FDA mandated that clinical usage be notated in PE, phenytoin equivalents. Fosphenytoin may be given intramuscularly. All phenytoin products require careful monitoring of blood pressure and cardiac rhythm. Hypotension usually resolves with slowing infusion rate.

infusion should be no faster than 50 mg/min, so loading to the recommended dose in status epilepticus of 20 mg/kg may be lengthy. Hypotension is the most common reason for slowing infusion rates.[5] Cardiac monitoring is required since dysrhythmias are reported. Soft-tissue extravasation may lead necrosis, the so-called purple-hand syndrome.[6] Largely because of the time required to administer the drug, phenytoin is questioned as an ideal second-line drug.

Fosphenytoin has a phosphate moiety attached to the phenytoin, which greatly increases water solubility. The molar weight is changed as well, and with FDA approval came the recommended dosing in phenytoin equivalents (PE) to simplify clinical operations. The recommended rate of administration is faster than phenytoin at 150 PE/minute with a loading dose of 20 PE/kg.[7,8] (*See Table 3.*) Hypotension is still reported, as are rare arrhythmias. The problem of soft-tissue inflammation is eliminated. Improved water solubility also allows for intramuscular administration with rapid absorption; large IM volumes of 10 cc or more have been studied without adverse effects.[9]

Refractory Generalized Convulsive Status Epilepticus. The diagnosis of refractory status epilepticus—again the discussion is confined to generalized convulsive status epilepticus—is, to a degree, arbitrary. Rather than a time-defined categorization, a better working definition might be an operational definition of seizures that have failed to stop, or that are recurring without the patient returning to full consciousness, after optimal dosing of step 1 and step 2 drugs, that is, after adequate dosages of benzodiazepines and phenytoins. This might occur at several different points in the treatment timeline but current thinking is that the sooner status epilepticus is identified and the sooner treatment is initiated, the more likely status epilepticus will be terminated.

Step Three Therapy Generalized Convulsive Status Epilepticus. (*See Table 4.*) In the past, the most commonly recommended third-line drug has been phenobarbital, but there is a trend in treatment moving away from this drug to alternatives of midazolam or propofol.[10] Again, any recommendations for treatment at this point lack high-level supporting evidence. For generalized convulsive status epilepticus, the recommended dosage of phenobarbital has been 20 mg/kg IV at rates up to 100 mg/minute. Hypotension and respiratory depression may be encountered and require supportive care. Current usage patterns are straying away from use of phenobarbital but admittedly this is largely opinion-driven and without high-level evidence to support changes. Further discussion on barbiturate use in refractory status epilepticus follows in the section below.

The Epilepsy Foundation of America recommendations in a 1993 consensus document included increasing phenytoin to a total loading dose of 30 mg/kg for refractory status epilepticus.[11] This was a consensus recommendation without supporting evidence and remains an option in clinical care.

Propofol

Propofol is readily available in many emergency departments and is often used for procedural sedation because of rapid onset of action. Mechanisms of action include $GAGA_{-A}$ receptor activity. Propofol has been reported to be successful in terminating refractory status epilepticus in small case series and case reports and increasingly is being mentioned in recommendations.[12,13] Fewer side effects are reported than with thiopental or other agents.[14,15]

Dose ranges reported typically recommend an initial bolus dose of 1-2 mg/kg (operationally perhaps an induction dose for intubation), followed by a continuous infusion of 2-10 mg/kg/hr.[10] Titration to burst-suppression EEG is recommended when available.[14]

Cautionary notes have been sounded noting a possible higher mortality with propofol infusions compared to midazolam infusions for refractory status epilepticus in these medically complex patients. The propofol infusion syndrome of metabolic acidosis and collapse is reported with prolonged use of propofol infusions in children.[16] There is a call for prospective randomized studies to clarify these issues.[17,18]

Table 4. Step Three Drugs for Treatment of Refractory Generalized Convulsive Status Epilepticus

Propofol or midazolam

- Propofol 1-2 mg/kg bolus followed by infusion 2-10 mg/kg/hr

OR

- Midazolam 0.2 mg/kg bolus then infusion 0.1-0.6 mg/kg/hour

The practitioner may wish to increase total phenytoin dosing to 30 mg (or PE/kg).

If the status epilepticus has not resolved, critical care measures will be necessary including respiratory support and endotracheal intubation. Bolus dosing of either agent may serve as an induction for intubation. Continuous infusion will then be necessary. ICU care, consultations, and ideally EEG monitoring will help adjust infusion rates.

Midazolam

Midazolam is also recommended as a third-line drug for refractory status epilepticus. Continuous IV infusion rates of 0.1-0.6 mg/kg/hour are recommended after a 0.2 mg/kg IV bolus. Less hypotension and ease of titration were reported as advantages.[19] Midazolam has been observed to have a prolonged half-life after sustained infusion.[20]

Critical Supportive Care

Appropriate supportive care will likely be necessary at this juncture. Mechanical ventilation with advanced airway management, namely endotracheal intubation, will be necessary. Intravenous access with multiple lines will likely be necessary for fluid administration, additional medication administration, and possible pressor support.

EEG

With the advent of EEG monitoring, discovery is being made of persistent electrical seizure activity in the absence of observable clinical signs. Because of frequent electrographic seizures and even electrographic status epilepticus, some feel that continuous EEG monitoring is essential after an episode of convulsive status epilepticus when the patient has altered mental status.[21]

There are no studies that systematically look at electrographic monitoring of emergency department patients treated for status epilepticus. Ideally, in the absence of contributing medical conditions, after convulsions have stopped, there should be improvement in mental status within 20 to 30 minutes or so if the patient is not on constant medication infusions. Failure of mental status to improve, or continuing subtle adventitious movements that might represent a forme fruste of convulsions, should prompt consideration of electrographic monitoring to exclude subtle electrographic status epilepticus.

Other Drugs

A number of other medications are reported to be of use in generalized convulsive status epilepticus and are included here for completeness without any recommendation for usage. Like the medications above, most are not FDA approved for this indication.

Lidocaine has been proposed as a third-line drug for the treatment of generalized convulsive status epilepticus, but the supporting case series are small. In adults the initial boluses used to stop seizures are 1-3 mg/kg. Constant infusions are usually recommended following termination of up to 3.5 mg/kg/hr.[22-24] Recent publications about lidocaine and seizures are in the neonatal and pediatric population.[25,26]

Valproate is available in the United States in an intravenous formulation and has been regarded as an emerging option for treating status epilepticus.[27] Like many other drugs discussed, it does not have a specific FDA approved indication for status epilepticus. High-level evidence for efficacy is lacking, although there are many case reports and case series noting efficacy. Some treatment plans from Europe mention valproate as a third-line option for treatment of status epilepticus.[28] Reports also indicate that valproate is often given more rapidly than the FDA-approved rate of 20 mg/min with rates of 6 mg/kg/min reported and loading doses up to 45 mg/kg.[27,29] Loading doses are estimated at 25-30 mg/kg body weight.[29] To date, head-to-head comparisons of valproate to other medications are limited and the call for additional studies is sounded.[27] One study did compare valproate to phenytoin as a second-line drug in the treatment of convulsive status epilepticus. There was a high incidence of symptomatic seizures with CNS infections, stroke, and other structural lesions in the study group. Phenytoin was administered in the standard manner and valproate given as a loading dose at 30 mg/kg infused over 15 minutes with infusion rate kept to 2 mg/kg/min. In this small study in this group, valproate was more effective (66% of status epilepticus terminated) compared to phenytoin (42% terminated). Adverse events were comparable.[30]

Levetiracetam has recently been released in an FDA approved intravenous formulation. In some intensive care unit settings it is used for off-label indications for seizure prophylaxis and to treat seizures as monotherapy. Usage seems to be as an alternative to phenytoin. Prospective studies evaluating long-term safety, efficacy, and outcomes of this usage are needed.[31]

Like many other medications, topiramate also has been reported to be useful in cases of refractory status epilepticus. There is no intravenous formulation, so administration must be orally or by nasogastric tube. Effective doses ranged from 300 to 1,600 mg/day.[32] As with many of these case series, multiple antiepileptic drugs had been administered, and the patient population was heterogeneous.

Older recommendations tended to include a last-resort recommendation of "general anesthesia," and undoubtedly anecdotal experience was gained as some of these agents were employed as anesthetic therapy. Patients are intubated and receiving mechanical ventilation. Pressors may be required. These have generally been reported in the ICU setting with continuous electrographic monitoring and titration of medications to a burst-suppression EEG pattern.

It is theorized that only patients without underlying brain disease are likely to benefit from prolonged anesthesia to suppress status epilepticus.[33] Reported experience with inhaled anesthetics is limited. Logistical issues about delivery of inhaled anesthetics outside the operating room for prolonged periods are noted.[34]

Barbiturate anesthesia using thiopental or pentobarbital has been reported but problems with hypotension and prolonged recovery are encountered.[35,36] Thiopental has been reported to be useful with an initial bolus of 5 mg/kg and repeat boluses of 1-2 mg/kg every 3 to 5 minutes until EEG burst-suppression. Infusions in the range of 5 mg/kg/hr are reported with EEG titration.[35]

Small cases series of both ketamine and etomidate for refractory status epilepticus exist with initial bolus dosages then infusions. In theory, ketamine is an antagonist at the NMDA subclass of the excitatory neurotransmitter glutamate. Again, cases are complex with many other pharmacologic agents involved.[37-39]

Many anecdotal and frankly experimental therapies for experimental status epilepticus have been reported. Some reflect experimental animal work while others have been used clinically in a few patients with the usual caveats, i.e., heterogeneous patients, multiple other medications involved, and lack of outcomes data. Some of these studies are summarized for completeness of discussion. Experimentally in an animal model, hypothermia was observed to diminish motor convulsions but not alter epileptic EEG discharges. Diazepam did seem to be effective at a lower dose in this animal model.[40] Electroconvulsive therapy has been reported rarely in the treatment of prolonged, refractory status epilepticus.[41]

Future Directions

What does the future hold? Research in status epilepticus is difficult to conduct because of the sporadic nature of the process, the multifactorial causes, and consent issues. The end-point of seizure control—EEG monitoring—is debated as well.

Phenytoin, the consensus second drug recommended for years for treating generalized convulsive status epilepticus, has problems with side effects (frequent hypotension, unusual soft-tissue damage, rare dysrhythmias) and time required for administration. If time is a major factor in terminating status epilepticus and in limiting morbidity, the time of administration may be simply too long. Fosphenytoin solves some of the issues, but is not free of some of the adverse effects of phenytoin.

The role of antiepileptic drugs that have recently been available in intravenous formulation, notably levetiracetam and valproate, remains to be defined in the treatment of generalized convulsive status epilepticus. High-level comparison studies have yet to be constructed.

The role of early electrographic monitoring also has yet to be defined. Although often discussed, practice barriers to obtaining EEG rapidly with interpretation remain. The role of novel EEG technologies remain unclear as well. Ideally, principles of ICU care will be transferred from the neurointensive care units to the emergency department and into prehospital care.

Summary

Rather than major changes in drug administration, major changes in recognition and prompt treatment summarizes the newer treatment strategies for status epilepticus. Rapid, optimal benzodiazepine administration, followed with administration of a phenytoin remain the consensus practice at the time of this writing. Beyond these points, there is little consensus other than prompt treatment of the generalized convulsive status epilepticus should occur while investigating etiologies on a priority basis. Propofol and midazolam are assuming prominent roles for treatment of refractory generalized convulsive status epilepticus.

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Physician CME Questions

101. In a prehospital trial for status epilepticus, investigators recommended which of the following drugs be the treatment of choice for prehospital treatment of status epilepticus?
   A. Phenytoin
   B. Midazolam
   C. Lorazepam
   D. Diazepam

102. Which of the following characteristics make benzodiazepines the first class of drugs to treat acute seizures?
   A. They are consistently effective in terminating status epilepticus.
   B. They are available in most care settings.
   C. They can be administered intravenously, intramuscularly, or rectally.
   D. All of the above.

103. Diazepam, midazolam, and lorazepam have all been studied and reported equally effective for the treatment of status epilepticus.

A. True
B. False

104. What is a working definition of refractory status epilepticus?
A. Seizures that fail to terminate within 30 minutes
B. Seizures that fail to stop after administration of adequate benzodiazepines
C. Seizures that fail to stop after administration of adequate benzodiazepines and phenytoin
D. Seizures that fail to stop after the administration of adequate phenobarbital

105. Which of the following is a side effect of phenytoin?
A. Frequent hypotension
B. Unusual soft-tissue damage
C. Rare dysrhythmias
D. All of the above

106. Which of the following characteristics pose a challenge in implementing lorazepam in an EMS system?
A. Its effectiveness
B. Refrigeration requirements
C. Studies suggesting increased respiratory depression
D. Routes of administration

107. Which of the following statements concerning the use of phenobarbital for refractory generalized convulsive status epilepticus is *false*?
A. Its effectiveness is well documented.
B. The recommended dose is 20 mg/kg IV.
C. Hypotension and respiratory depression may occur.
D. The infusion rate can be up to 100 mg/minute.

108. Which class of medications is the consensus drug of choice for treatment of refractory generalized convulsive status epilepticus?
A. High dose phenytoin
B. Benzodiazepine constant infusion
C. Propofol

Emergency Medicine Reports
CME Objectives

To help physicians:
- quickly recognize or increase index of suspicion for specific conditions;
- understand the epidemiology, etiology, pathophysiology, and clinical features of the entity discussed;
- apply state-of-the-art diagnostic and therapeutic techniques (including the implications of pharmaceutical therapy discussed) to patients with the particular medical problems discussed;
- understand the differential diagnosis of the entity discussed;
- understand both likely and rare complications that may occur.

D. There is no consensus of pharmacologic therapy for refractory generalized convulsive status epilepticus.

109. Among its class of medications, what is unique about midazolam?
A. It can be administered intravenously.
B. It is well absorbed when given intramuscularly.
C. It has been extensively studied as a first-line drug.
D. It causes purple hand syndrome.

110. EEG monitoring is required to detect:
A. generalized convulsive status epilepticus.
B. partial seizures with complex symptomatology.
C. subtle generalized convulsive status epilepticus.
D. myoclonic seizures.

CME Answer Key

101. C; 102. D; 103. A; 104. C; 105. D; 106. B; 107. A; 108. D; 109. B; 110. C

CME Instructions

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 evaluate 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 certificate of completion.* When your evaluation is received, a certificate will be mailed to you.

Emergency Medicine Reports
The Practical Journal for Emergency Physicians

Seizures and Status Epilepticus: Part II

Step One Drugs for Treatment of Generalized Convulsive Status Epilepticus in Adults

STEP ONE

- Lorazepam
  0.1-0.15 mg/kg over 1-2 minutes
  (repeat once if no response after 5 minutes)
  (maximum dose 8 mg)

OR

- Diazepam
  0.2 mg/kg up to 20 mg at 5 mg/min

OR

- Midazolam
  10 mg IV or IM

Note: Lorazepam may be drug of choice because of studies suggesting less respiratory depression than diazepam and longer effective anticonvulsive activity. Midazolam will terminate seizures but is less studied as a first drug. If intramuscular access is the only available access, midazolam is better absorbed IM than other benzodiazepines.

Medications

GENERIC NAME	PROPRIETARY NAME
Diazepam	Valium
Lorazepam	Ativan
Midazolam	Versed
Phenytoin	Dilantin
Fosphenytoin	Cerebyx
Carbamazepine	Tegretol
Valproate	Depakote, others
Propofol	Diprivan
Levetiracetam	Keppra
Topiramate	Topamax
Thiopental	Pentothal
Phenobarbital	—

Step Two Drugs for Generalized Convulsive Status Epilepticus—Phenytoins

- Fosphenytoin 20 PE/kg infusion at up to 150 PE/minute

OR

- Phenytoin 20 mg/kg infusion at up to 50 mg/minute

PE = phenytoin equivalents

Fosphenytoin is a water-soluble prodrug of phenytoin. The FDA mandated that clinical usage be notated in PE, phenytoin equivalents. Fosphenytoin may be given intramuscularly. All phenytoin products require careful monitoring of blood pressure and cardiac rhythm. Hypotension usually resolves with slowing infusion rate.

Step Three Drugs for Treatment of Refractory Generalized Convulsive Status Epilepticus

Propofol or midazolam

- Propofol 1-2 mg/kg bolus followed by infusion 2-10 mg/kg/hr

OR

- Midazolam 0.2 mg/kg bolus then infusion 0.1-0.6 mg/kg/hour

The practitioner may wish to increase total phenytoin dosing to 30 mg (or PE/kg).

If the status epilepticus has not resolved, critical care measures will be necessary including respiratory support and endotracheal intubation. Bolus dosing of either agent may serve as an induction for intubation. Continuous infusion will then be necessary. ICU care, consultations, and ideally EEG monitoring will help adjust infusion rates.

Supplement to *Emergency Medicine Reports*, November 12, 2007: "Seizures and Status Epilepticus in Adults: Part II" *Author:* **J. Stephen Huff, MD**, Associate Professor of Emergency Medicine and Neurology, University of Virginia Health System, Charlottesville, VA. *Emergency Medicine Reports' "Rapid Access Guidelines."* Copyright © 2007 AHC Media LLC, Atlanta, GA. **Editors:** Sandra M. Schneider, MD, FACEP, and J. Stephan Stapczynski, MD. **Senior Vice President and Group Publisher:** Brenda Mooney. **Associate Publisher:** Lee Landenberger. **Specialty Editor:** Shelly Morrow Mark. For customer service, call: **1-800-688-2421.** This is an educational publication designed to present scientific information and opinion to health care professionals. It does not provide advice regarding medical diagnosis or treatment for any individual case. Not intended for use by the layman.

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Evidence-Based Medicine for the ED

Trauma Reports

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Supplement to *Emergency Medicine Reports* and *Pediatric Emergency Medicine Reports*

Nov./Dec. 2007

Blunt Trauma Evaluation and Management: Pitfalls to Avoid

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Trauma patients frequently present to the emergency department for evaluation. Early identification of injuries, a thorough diagnostic evaluation, and timely management improve outcomes. Understandably, high-risk patients with the potential for decompensation on missed injuries mandate a thorough and comprehensive evaluation. This article identifies and reviews areas where diagnostic errors may occur.

— *The Editor*

Overview

Major trauma is one of America's most pervasive and expensive health care concerns. In this environment of rising costs and diminishing resources, care must be delivered in the most cost-effective manner while also ensuring that significant injuries are not missed. Clinicians should recognize the limitations of, indications for, and contraindications to diagnostic testing. *(See Table 1.)* In addition, interpreting certain studies completed in the trauma setting should be done cautiously, with an awareness of limitations. This article will discuss the caveats in the evaluation and management of blunt trauma patients in both the community hospital and trauma center.

Don't Get Unnecessary Labs

Patients who warrant laboratory evaluation include those with decreased systolic blood pressure, altered mental status, or abnormal respiratory rate secondary to a higher-than-expected frequency of electrolyte abnormalities. Patients with significant co-morbid disease, such as renal failure, diabetes, or cardiac disease, or those patients on anticoagulant medications, warrant more extensive laboratory testing.

Protocol-driven evaluation of trauma patients is routine in most trauma centers and is a practice-guideline of the advanced trauma life support (ATLS) course. Protocol testing is variable but may include arterial blood gas, lactate, complete blood count, serum chemistries, blood type and screen, coagulation panel, urinalysis, blood alcohol level, and urine drug screen. Some institu-

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Table 1. Do's and Don'ts of Trauma Evaluation

- ❏ Don't get unnecessary labs.
- ❏ Don't miss occult trauma in high-risk patients.
- ❏ Don't overestimate the utility of plain films of the cervical spine.
- ❏ Don't ignore abnormal vital signs (tachycardia).
- ❏ Do beware of a "negative" CT scan of the abdomen.
- ❏ Don't worry about oral contrast.
- ❏ Don't overestimate reliability of FAST (focused abdominal sonography in trauma).
- ❏ Don't ignore the ventilator alarm.
- ❏ Do transfer patients appropriately.

tions may include liver enzymes. Routine trauma laboratory protocols are frequently costly and unnecessary and their utility is questionable, especially in patients with minor trauma.[1]

A prospective study by Namias and colleagues evaluated 500 admissions to a trauma service. Electrolytes, amylase, and coagulation parameters were obtained. No interventions were made for abnormalities in sodium, bicarbonate, BUN (blood urea nitrogen), or creatinine. One patient had potassium administered for hypokalemia. Hyperglycemia was seen in known diabetics and in patients with severe neurologic injuries.[2]

Tortella and coworkers found that routine chemistries only rarely revealed clinically significant abnormalities.[3] In the study by Namias et al, an intervention was made as a result of abnormal chemistry findings in only 5 of 1023 patients.[2] The bulk of the abnormalities found in these patients are clinically insignificant in the trauma resuscitation setting and do not lead to clinical interventions.[1]

Chu and colleagues prospectively evaluated 1155 patients who were tested based on protocol versus those who were given selected labs based on clinical need. They found no statistically significant change in the percentage of lab tests leading to interventions between the two groups (7% versus 8%). In the protocol group, the average lab charge was $748. In the group treated based on clinical need, the charge was reduced by 93%; this gave an estimated annual savings of $1.5 million. No adverse event was noted when selective laboratory evaluation was used.[4]

Hypokalemia is common in trauma patients (50-68%) and is likely due to catecholamine effect and/or acid base status. It is not a body depletion of potassium but rather a shift. In one study, hypokalemia was responsible for 92% of the lab abnormalities in trauma patients.[2] In a prospective study of 133 patients with blunt trauma, it was noted that hypokalemia occurred within one hour of trauma and returned to normal within 24 hours without significant potassium replacement.[5] Hypokalemia in trauma patients has been reported to correlate with the severity of the insult.[2,6-7] It is not clinically significant and typically corrects with resuscitation or benign neglect.[8]

Hyperglycemia also is very common. Some degree of hyperglycemia is expected as part of the physiologic response to trauma.[2] Treatment for a glucose level of less than 300 usually is unnecessary. However, if the patient is a known or suspected diabetic, electrolytes should be checked to ensure that the patient is not in diabetic ketoacidosis.

Mure et al[9] and Buecher et al[10] concluded that amylase and lipase lack the sensitivity and specificity and predictive value to be useful in the setting of blunt abdominal trauma. Elevated amylase was nondiagnostic and triggered no interventions in another study.[2] Liver transaminases may be elevated after blunt liver injury or they may be normal. The level of elevation does not correlate with the severity of injury. Transaminases have not been shown to be useful as a screening tool to exclude the need for a CT (computed tomography) scan of the abdomen.

Hemoglobin and blood type and cross match are indicated if there is evidence of significant bleeding. If the patient is on warfarin sodium, a coagulation panel is necessary. Alcohol and toxicology screens are not usually necessary. They are generally ordered on a delayed basis when other explanations for altered mental status cannot be identified.[4]

Severely injured patients are the exception to the rule of minimal laboratory utilization in trauma. Anemia, acidosis, and coagulopathy are very real concerns in these patients and should be aggressively identified. Abnormal coagulation parameters can be seen in conjunction with hypotension, respiratory depression, and altered mental status.

Don't Miss These Injuries: Occult Trauma in High-risk Populations

Several groups of patients are at increased risk for injury that may be occult or not apparent upon their initial presentation.

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Patients with head injuries, substance abusers, or those with distracting injuries are at highest risk for missed injuries.[11] Other high-risk categories of patients include the elderly; coagulopathic patients; those with neurological disease; patients who are rude, obnoxious, or uncooperative; and the mentally ill.[12] Patients who are coagulopathic are at risk for significant bleeding with even trivial trauma. Patients with alcoholism and the elderly tend to have cerebral atrophy that puts them at greater risk for subdural hematoma because of increasing tension on the cerebral bridging veins.[12]

Blunt Abdominal Trauma. Missed intra-abdominal injuries are common, with a reported incidence of missed injuries in the adult population as high as 65%.[11] A common error in this instance is under-appreciation for the mechanism of injury. Patients with trivial mechanisms of injury still may be at risk for major intra-abdominal pathology.[11]

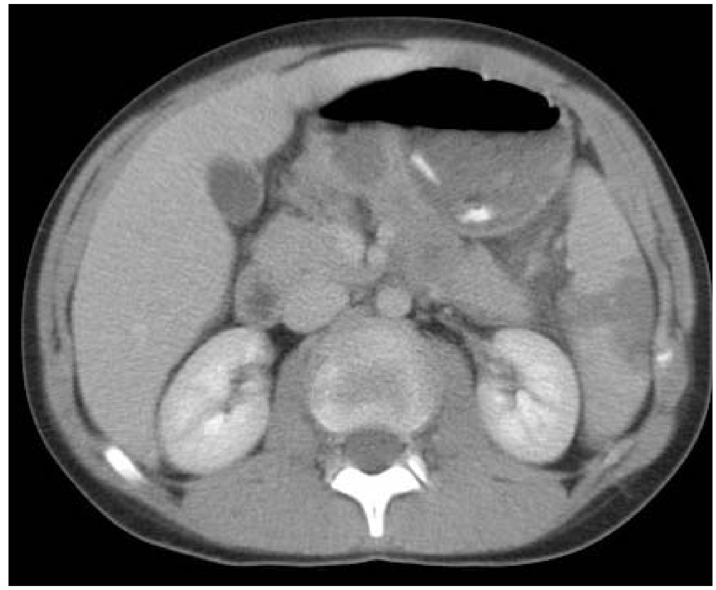
Even in patients with a normal mental status, it may be difficult to elicit abdominal tenderness despite the presence of significant intra-abdominal pathology.[11] Lack of appreciation for a pertinent physical finding or false reassurance from a benign exam often contributes to this. For example, a seat belt abrasion on the abdomen is associated with significant bowel injury in 21% of cases.[13] In patients with intra-abdominal trauma, the sensitivity and specificity of abdominal pain or tenderness is estimated at 82% and 45%, respectively.[14] *Approximately 40% of patients with significant intra-abdominal pathology may have no signs and symptoms on initial presentation to the emergency department*.[15-17] The finding of a negative or equivocal exam is less reliable in patients who have an altered level of consciousness that is secondary to head injury, intoxication, or distracting injuries.

The presence of any rib fracture significantly increases the risk of a splenic or hepatic laceration.[18,19]

Solid Organ Injury. The spleen is the most commonly injured organ in blunt abdominal trauma. It can be injured from relatively minor mechanisms. In a retrospective study of 30 patients with splenic trauma, it was noted that just more than half of them did not have any abdominal pain.[20] *(See Figure 1.)* An injury involving the bare area of the liver may be clinically silent because the bare area lacks a peritoneal covering and may not produce peritoneal signs or abdominal pain.[19]

Renal injuries may be difficult to predict and may be silent on physical examination due to the retroperitoneal location of the kidneys. The kidneys are somewhat mobile; thus, they are susceptible to deceleration injury from a motor vehicle accident, fall, or from a direct blow. No accurate markers for renal injury exist. In all types of renal trauma, the degree of hematuria is not indicative of the severity or extent of injury.[21] Adult patients at risk of major renal lacerations will have either gross hematuria or microscopic hematuria with hypotension (less than 90 mmHg) in either the field or in the emergency department.[21,22] However, hematuria may be absent in renal pedicle injuries.[23] Children can sustain major renal injuries even with a normal urinalysis, so imaging based on the mechanism of injury is paramount. Intravenous contrast-enhanced CT scan is the study of choice to identify urologic injuries.[21,22]

Figure 1. CT Scan of a Splenic Injury



Elderly Patients

Trauma is the fifth leading cause of death in patients older than age 65.[24] The elderly sustain a disproportionate amount of fractures and serious injuries; they account for about 28% of all deaths due to trauma, while representing only 12% of the overall trauma population.[25,26] The elderly often have significant co-morbid conditions and take medications that may mask physiologic changes typically associated with injury, such as tachycardia.[25] Injuries to the brain, spine, and chest, as well as skeletal injuries, increase dramatically with age; however, injuries to the abdomen do not.[25] Elderly patients with low-level falls have an increased risk of cervical spine injury from the occiput to C2. A reasonable strategy is to obtain a CT scan of the cervical spine in all elderly patients who require CT scan of the head.[25] This issue will be discussed in detail in a subsequent section.

Elderly patients with rib fractures have nearly twice the mortality of younger patients with the same injury.[25]

The abdominal exam is less reliable in the elderly. This is demonstrated by the lack of sensitivity of abdominal findings for surgical disease in non-traumatic conditions.[27] Liberal use of CT scan is recommended.

Isolated hip fractures are common presentations in the elderly, and they are especially prevalent after a fall. A typically encountered clinical scenario is persistence of hip pain and negative radiographs. *(See Figure 2.)* One study found that about 5% of such patients had a hip fracture.[28] Hip fractures most commonly occur as a result of relatively minor trauma to an already weakened, osteoporotic bone.[12] The absence of a visible fracture on standard radiographs in an elderly patient with hip pain after a fall is not sufficient to exclude a fracture. Fractures of the acetabulum can be occult on plain films as well. Fractures may be missed initially due to an impacted fracture, nondisplaced fracture, or underlying osteoporosis.[12] MRI (magnetic resonance

Figure 2. Hip Film

A 68-year-old male complaining of pelvic pain after his legs "gave out"; plain radiograph of the pelvis shown here was read as normal by a radiologist.

imaging) is superior to CT scan for the detection of occult fractures, but CT scan is adequate in most patients. *(See Figure 3.)* A reasonable strategy is admission, bedrest, and further imaging such as bone scan, CT scan, or MRI.

Don't Overestimate the Utility of Plain Films of the Cervical Spine

The incidence of adult cervical spine injury in blunt trauma is 2-6%.[29-31] Pain, neurologic deficit, distracting injuries, altered consciousness, and high-risk mechanism of injury have been shown to be appropriate, highly sensitive clinical indications for spinal imaging.[32]

Evaluation of patients for cervical spine injury has significantly changed over the last 30 years. Before 1970, a single lateral view was considered adequate for cervical spine evaluation. In 1981, Shaffer and Doris noted that up to 10% of cervical spine injuries would be missed with only a lateral view.[33,34] They recommended adding AP (anteroposterior) and open-mouth views. In 1993, Woodring and Lee reported that 15% of blunt cervical spine fractures were missed when only the lateral view was obtained.[35] In 1996, Nunez and Quencer noted that 42% of injuries were missed when the lateral view was obtained as the sole film.[36] The American College of Radiology 2005 Appropriateness Criteria recommend a three-view study for cervical spine evaluation that should be supplemented by CT scan when necessary;[37] oblique views are not needed.

Standard three-view series of the cervical spine include lateral, open mouth, and anterior-posterior. A five-view series includes oblique views. A swimmer's view is sometimes added to visualize the cervicothoracic junction. Flexion/extension views add nothing to the initial screening series.[29,38]

What is the most efficient imaging method? There is considerable evidence in the radiology literature to show that CT scan is superior to plain radiography for detecting cervical spine fractures.[33,36,39-43] *(See Figures 4-6.)* The sensitivity of plain films ranges from 39% to 94%, with variable specificities.[44-51] There is wide disparity about the adequacy of the three-view film series in detecting cervical fractures. In a review of 3034 total patients in several studies, cervical spine injury was identified only 53% of the time with plain radiographs; however, CT scan was 98% sensitive.[33] Nguyen and coworkers found that plain radiography was 93% sensitive and CT scan was 100% sensitive for detecting fractures.[51] Other authors report sensitivities as low as 53% for plain films.[51-53]

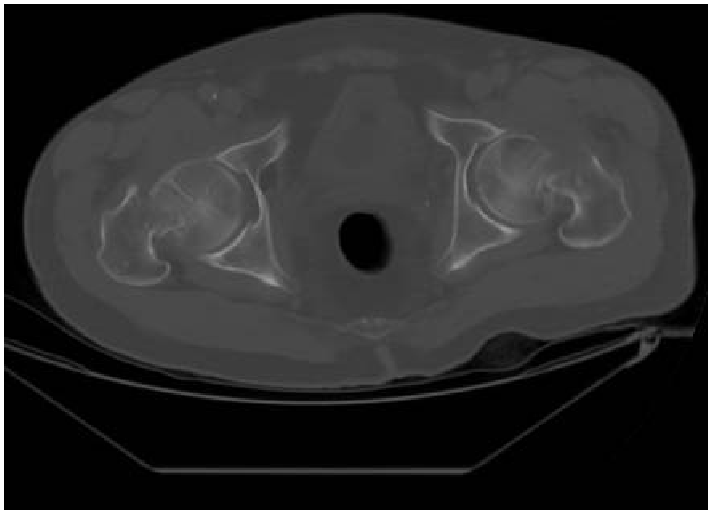
Reasons for missed injuries include inadequate radiographs, associated injuries, inaccurate clinical examination, and patient co-morbidities.[36]

The sensitivity of CT scan for cervical fracture detection has been reported to be between 90% and 99%, with specificity between 72% and 89%. The limitations of plain films are especially prominent when they are used to evaluate the craniocervical and cervicothoracic junctions. Link and colleagues noted that 8 out of 9 occipital condyle fractures and 13 of 33 C1 and C2 fractures were not seen on plain films.[54,55] CT scan is faster and has improved sensitivity but is more expensive and is associated with more radiation — a 50% increase over plain radiographs.

Helical CT scan is the preferred initial screening test for detection of cervical spine fractures among moderate to high-risk patients in urban trauma centers. The incidence of paralysis resulting from false-negative imaging studies and institutional costs and subsequent litigation and settlement costs from missed fractures and paralysis is reduced by the use of CT scan.[46]

A CT scan is warranted if there is any doubt about an abnormality on a plain radiograph or if the patient has disproportionate

Figure 3. Hip CT Scan



Bone windows of the abdomen and pelvis CT show bilateral femoral neck fractures in this same patient that were not seen in plain radiograph.

neck pain. Practitioners should be familiar with the available scanner. CT scan cuts need to be 3 mm or less to reliably detect occult fracture.[56] CT scan is not perfect, however. It can miss fractures at C2 because the fracture may be in the plane of the scan or

Figure 4. CT Scan: Axial View

CT scan, axial view, of cervical spine of a 25-year-old male in auto versus train; interpreted as normal.

can be obscured by artifacts from dental work.[33,39] Therefore, a single-view lateral film is indicated to evaluate C1 and C2 to complement CT scan. This is especially important in elderly patients who have a higher incidence of upper cervical spine fractures.[57]

Can CT scan detect unstable cervical ligamentous injuries? There are five cardinal findings that may be demonstrated on radiography and/or CT scan that indicate instability: displacement, wide interpedicle distance, wide interspinal (interlaminar) distance, widening of facet joints, and disruption of posterior vertebral body line.[33] CT scan should be adequate to determine the presence or absence of ligamentous injury in the majority of conscious patients; in comatose patients, limited MRI is recommended in the sagittal plane to look for ligamentous injury.[33,39]

Does everyone with cervical trauma need a CT scan? Low-risk patients (no head injury or neurologic deficit, low-energy trauma, normal clinical exam, no neck pain) have a low prevalence of injury. Plain radiographs are an effective tool in these patients.[51] Plain radiography does have limitations when used in the high-risk patient group, however. It is difficult to obtain adequate films in severely injured patients, especially in those who are intubated. High-risk patients would include those who have significant closed head injuries, neurologic deficits, high-energy trauma, unreliable examination secondary to intoxication, and neck pain that is out of proportion to plain film findings.[51] These patients need CT scan evaluations.

Don’t Ignore Abnormal Vital Signs — Tachycardia

There are many causes of tachycardia in a trauma patient. The most common etiologies include pain, anxiety, blood loss, hypoxia, and sympathomimetic drug abuse (cocaine, amphetamines). Once these potential causes have been excluded or treated, the clinician is left to wonder, “Why is this patient still tachycardic? What am I missing?”

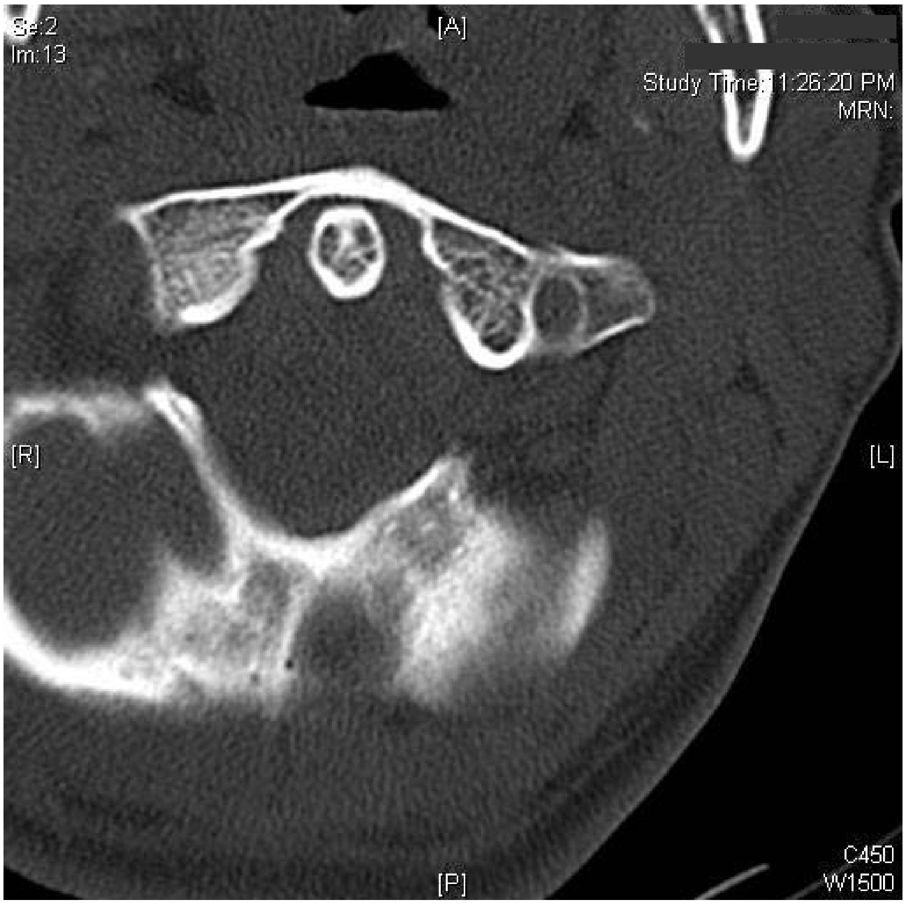
Myocardial contusion is used as a general term encompassing the gamut of blunt cardiac injuries (BCI). There are no widely accepted diagnostic criteria for BCI. The incidence is uncertain as studies differ in diagnostic criteria.[58] BCI can include chamber rupture, contusion, laceration, papillary muscle rupture, and valve rupture.[59]

Outcomes vary from asymptomatic with electrocardiographic changes to cardiogenic shock and death.[58] Associated injuries are common and include rib fracture, sternal fracture, hemothorax, pulmonary contusion, pneumothorax, aortic or great vessel injury, and closed head injury.[60]

The most common complaint of a patient with BCI is chest pain. Examination may reveal hypotension, jugular venous distention, tachypnea, chest abrasion, crepitus, or other evidence of chest trauma.[58] The evaluation begins with a chest radiograph, mainly to exclude other injuries. The most common ECG finding is sinus tachycardia, followed by PACs (premature atrial contractions) or PVCs (premature ventricular contractions).[58]

An abnormal initial ECG (excluding sinus tachycardia) is the most significant independent predictor of a complication, defined as dysrhythmia requiring intervention, cardiogenic shock, valvu-

Figure 5. CT Scan: Odontoid View



CT scan, odontoid view, of the same patient as seen in Figure 4.

lar rupture, or tamponade.[61]

Dysrhythmias are the most common complication associated with BCI.[62] Up to 70% of patients have a rhythm disturbance. Atrial dysrhythmias are the most common.

Cardiac failure may manifest as hypotension, tachycardia, tachypnea, jugular venous distension, rales, or a systolic murmur. Echocardiogram (ECHO) detects pericardial effusion, myocardial contusion, valvular disruption, and wall motion abnormalities. It may assist in defining injury severity and may alter management. Thirty percent of BCI patients have an abnormal ECHO.[63]

The pathophysiology of trauma-induced myocardial necrosis is poorly understood. Therefore, it is difficult to predict the pattern of myocyte enzymatic release and it remains unclear whether a role exists for its routine measurement.[58] Troponin I is only found in the cardiac myocyte. In BCI patients, elevated troponin I has a sensitivity of 23-100% and a specificity of 85-97% for injury.[64-66] By combining ECG and troponin I at eight hours, a negative predictive value of 100% was reached in a prospective study of 333 patients with blunt thoracic trauma. The authors noted that patients with a normal ECG and troponin I can be discharged.[67]

BCI should be suspected in patients with chest pain that is associated with rib or sternal fractures, pulmonary injury, or significant deceleration mechanism.[14,58] Delayed diagnosis can occur in the elderly; patients with pre-existing cardiac disease; those with multiple, severe chest wall injuries; or patients with unexplained hypotension.[61,68]

BCI can be excluded in the following patients if there is a normal initial ECG and a normal set of cardiac enzymes: hemodynamically stable patients without a history of cardiac disease, younger than age 55, and who do not require admission for another diagnosis.[58]

Patients with isolated ECG or enzyme abnormalities represent the largest and most benign subset of BCI patients. These patients should receive telemetry monitoring for 24 hours and may require ECHO, depending on the level of suspicion.

Do: Beware of "Negative" Abdominal CT Scan

In the past 5-10 years, more emphasis has been placed on non-operative management for certain blunt injuries, resulting in increased use of CT scan.[69] CT scan can be used as a screening tool to help identify patients who may be discharged without further evaluation.[70] CT scan is useful for detecting solid organ injuries, such as those to the liver, spleen, and kidney. CT scan does have limitations. It is less reliable for detecting injuries to the bowel and pancreas.

Bowel injury from blunt trauma varies from a minor hematoma to perforation. Hollow viscus injury is uncommon from blunt trauma, but the consequences of a delay in diagnosis or missing an injury are severe. *(See Table 2.)* Abdominal pain and peritoneal irritation may present early after major perforations or develop slowly because bowel contents are not enzymatically active and have low pH and bacterial counts.[24] Small perforations initially may be clinically unrecognized.[71] Physical examination of the abdomen often is unreliable due to head injury, distracting injuries, or intoxication.[72]

CT Scan Diagnostic Criteria for Bowel Injury. A normal CT scan can be seen in 10-17% of patients with perforated small bowel.[73-75] Direct visualization of bowel discontinuity and extraluminal oral contrast material are virtually diagnostic of bowel perforation but are relatively insensitive. The presence of enteric contrast extravasation is an uncommon finding as well. Extravasation of oral contrast in the absence of free air has been reported only once in a recent review of the literature.[76] Free intraperitoneal oral contrast material is 100% specific for bowel perforation unless IV contrast material from the genitourinary (GU) tract perforation is not a confounding factor. However, the sensitivity is 12% or less.[77-79]

When extraluminal air is present, bowel perforation is the most likely etiology; however, it is not diagnostic of bowel perforation.[80,81] The sensitivity of pneumoperitoneum is 44-55%.[77,79] Other causes may include barotrauma from mechanical ventilation, diagnostic peritoneal lavage, or bladder rupture.[82,83] Intramural air presents as discrete bubbles in a thickened bowel wall.

Bowel wall thickening is present in 61% of small bowel mesenteric injury (SBMI) cases.[84] Contusions and lacerations of bowel and isolated mesenteric lacerations that result in ischemia because of disruption of the arterial supply or venous drainage may cause wall thickening. Both major and minor bowel injuries may have findings of bowel wall thickening and free fluid in common. Bowel wall thickening is more sensitive for bowel injury than extravasation of oral contrast or pneumoperitoneum.[77] Bowel wall enhancement is a subjective finding that is suggestive of bowel injury. The proposed mechanism for wall enhancement is reduced perfusion and interstitial leak of contrast material.[79,85]

Mesenteric stranding is defined as the presence of ill-defined, increased attenuation in the normally fatty mesenteric folds caused by perivascular hemorrhage and an inflammatory infiltrate.[86] This is associated with at least a mesenteric injury. If it is associated with bowel wall thickening, it is highly suggestive of bowel injury.[87-89]

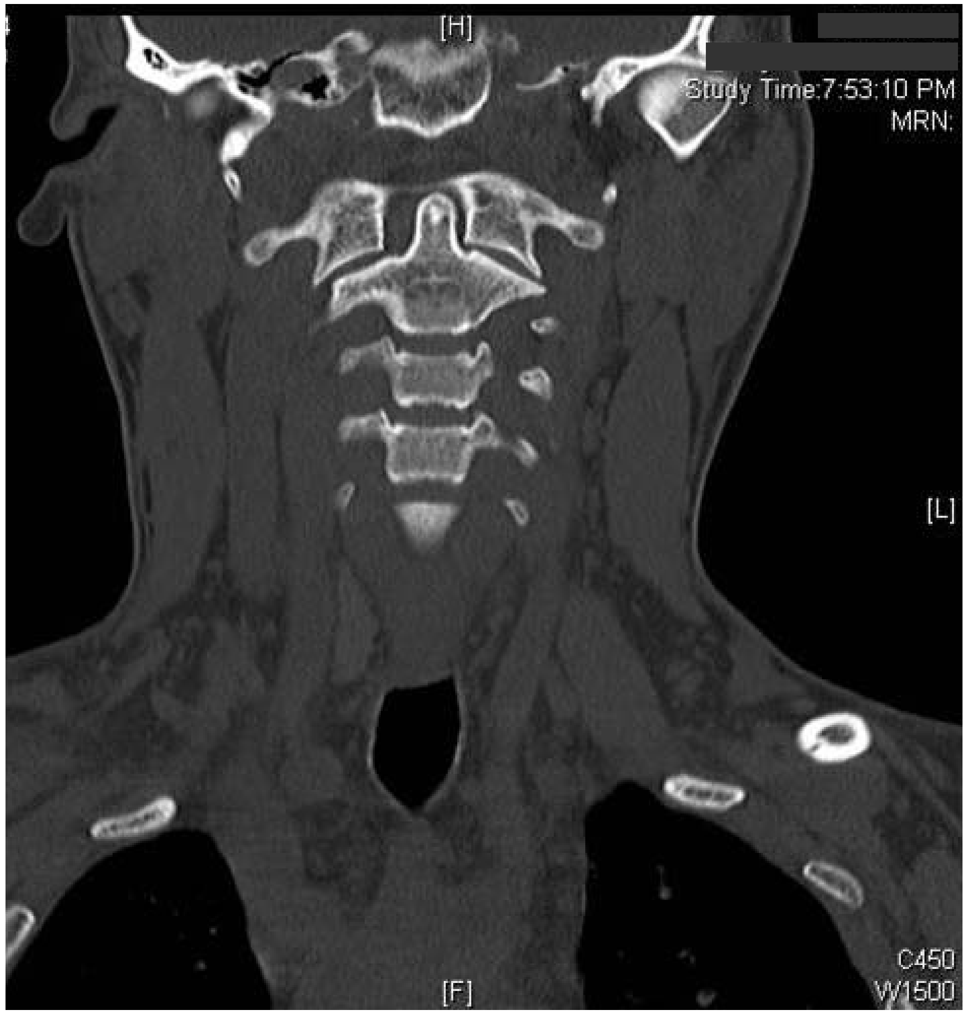
Free intraperitoneal fluid is a common finding in patients with SBMI; it may be the most frequent finding.[89] This fluid may or may not be hemorrhagic. Free fluid is not diagnostic of SBMI; it may produce false positives as high as 67%. This is likely caused by the presence of fluid related to other injuries.[79,90]

The location of the fluid is important. Fluid isolated to the mesentery is an unusual finding in liver or spleen injury and suggests underlying SBMI.[69] Retroperitoneal fluid can be caused by hemorrhage, renal injury, bowel perforation, or pancreatic or duodenal injury.[69] Hemoperitoneum in the absence of solid organ injury implies a bowel or mesenteric laceration as the bleeding source.[79]

Bowel injury may be overlooked when solid organ injury is diagnosed. Concomitant bowel injury is present in 5% of patients with liver lacerations and 4% of patients with splenic lacerations because free fluid is attributed to the solid organ injury.[79,91]

Pancreatic Injuries. Injury to the pancreas is rare in blunt trauma; it occurs in only 1-2% of patients. Handlebar injuries and motor vehicle accidents are the most common mechanisms of injury. Abdominal pain may be absent in 25% of patients with a pancreatic injury. The patient may complain of pain initially that resolves and then returns and worsens several hours after the injury.[11] The failure to develop consistent and localizing physical findings has been attributed to the retroperitoneal location of the pancreas and the inactivation of pancreatic enzymes immediately after injury.[92,93] A normal amylase or lipase is not sufficient to rule out pancreatic injury.[11] Helical CT scan is the indicated test, but it is only has sensitivity of 68%.[94]

Figure 6. CT Scan: Axial View



CT scan, axial view, of the same patient as in figures 4 and 5 four days later when he returned to the ED with continued neck pain; demonstrates lateral subluxation of C1 lateral mass on C2 suggesting ligamentous injury.

Don't Worry About Oral Contrast

Most trauma centers use IV and oral contrast for abdomen/pelvis CT scan. The necessity of oral contrast (OC) is a topic of contention. Stafford and colleagues randomized 394 patients to OC or no OC.[95] The sensitivity for small bowel injury detection was 86% with OC and 100% without OC. The sensitivity for solid organ injury was 84% with OC and 89% without OC.[95] Limitations of this study included lack of optimal time for contrast enhancement and a small sample size. In another study, Clancy and coworkers reviewed the charts of 492 patients.[96] Only eight of those patients had oral contrast prior to CT scan. The overall sensitivity of CT scan without oral contrast was 98% with a specificity of 99.8%.[96]

A randomized, prospective trial of CT scan in blunt trauma demonstrated equivalent sensitivities for the diagnosis of small

Table 2. CT Scan Findings in Hollow Viscus Injury[79]

- ❏ Bowel discontinuity
- ❏ Extraluminal oral contrast
- ❏ Extraluminal air
- ❏ Bowel wall thickening
- ❏ Bowel wall enhancement
- ❏ Mesenteric stranding
- ❏ Free intraperitoneal fluid

bowel injuries in those undergoing CT scan with or without oral contrast.[97]

Although most of these studies are limited by small sample size and/or insufficient time for contrast to transverse the length of the bowel, it is typically not practical to wait for two hours or more to allow for opacification of the entire bowel and the addition of contrast should be reserved for patients with clinical scenarios where contrast would be beneficial.

Don't Overestimate the Reliability of FAST

Focused abdominal sonography in trauma (FAST) is designed to visualize hematoperitoneum in unstable blunt trauma patients. However, limitations exist; there is not free fluid associated with contained solid organ injury and hematomas may appear echogenic if clotted. If FAST is completed early after the traumatic event, it may fail to detect fluid in the setting of a significant injury.

The use of ultrasound as a screening modality may lead to false-negative results.[20] In hemodynamically stable patients with blunt abdominal trauma, FAST has a sensitivity of 42-100%.[98-101] Ultrasound may fail to detect grades 3 and 4 hepatic lacerations and grades 2 and 3 splenic lacerations, especially if the associated bleeding is not brisk.[101] Hahn and colleagues noted that 27% of patients in whom no free fluid was detected required laparotomy.[102] False positives may occur in patients with pre-existing ascites, peritoneal dialysis, or in females with small amounts of physiologic fluid.[103]

FAST doesn't detect bowel/mesenteric injuries, pancreatic or vascular injuries, diaphragm, or adrenal injuries. FAST should be used as a triage tool only, not as a definitive study.

Don't Ignore the Ventilator Alarm

Intubated patients are among the most seriously injured patients in the emergency department (ED), but once stabilized they may not be sufficiently monitored in a busy ED. Intubated patients awaiting admission, surgery, or transfer need to be physically and chemically restrained so they have less chance of dislodging the endotracheal tube. Sedation and paralysis is indicated for patient comfort as well as airway protection. Do not undersedate! Don't ignore the ventilator alarm. It may indicate that the patient is coughing or biting the tube, the tube is occluded with blood or a mucus plug, or that the tube has become dislodged or is kinked. Any of these events, if not promptly recognized and treated, can lead to hypoxia and potential brain injury. Verify the tube position, suction the patient, and provide adequate sedation and/or paralysis as needed to control ventilation.

Do: Transfer Patients Appropriately

If a decision is made to transfer a trauma patient to a higher level of care, attention to detail will make the process smoother and benefit the patient. Send copies of all of the patient's radiographs, especially his/her CT scans. If a radiologist has interpreted these films, send a copy of the written report as well. Radiology house staff may be reluctant and may not be permitted to reinterpret films that have already been evaluated by a board-certified radiologist. This is especially true if a change in interpretation is being considered. With regard to CT scan, send copies of all the images, including reconstructions if they have been done. If any studies are incomplete, they will likely be repeated, thus exposing the patient to more radiation and increased cost. Patients transferred from an outside hospital should be thoroughly evaluated and reports should be reviewed carefully. There should be a formal reinterpretation at the receiving facility or a repeat study to avoid missed injury.[104] This should be balanced with the risk of additional radiation and increased cost.

Initiate the transfer process early in obvious cases in which a higher level of care will be needed, such as possible intracranial hemorrhage. When in doubt, secure the airway prior to transfer. As is necessary, chest tubes should be placed and the patient should be transfused prior to transfer. Be certain that the patient has reliable IV access as well and treat pain adequately. If there will be a delay in transfer, repair lacerations to decrease the likelihood of infection. Place Foley catheters and nasogastric tubes as needed and splint fractures. Appropriate packaging of patients requiring transfer enhances patient care.

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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.

CME/CNE Questions

1. In a previously healthy trauma patient, which electrolyte abnormality requires treatment?
   A. Glucose of 210
   B. Potassium of 3.0
   C. Bicarbonate of 24
   D. None of the above requires treatment

2. In blunt trauma, which of the following statements is true?
   A. Hematuria is a reliable marker of renal injury.
   B. Hypokalemia correlates with the severity of the injury.
   C. Hypokalemia routinely requires correction.
   D. Amylase and lipase are reliably elevated in blunt pancreatic injury.
   E. Elevated liver transaminases are a reliable marker of liver injury.

3. Which statement is *false* regarding trauma in the elderly?
   A. Abdominal pain or tenderness in intra-abdominal injury is present in more than 80% of patients on initial presentation.
   B. The elderly sustain a disproportionate amount of fractures and serious injury from trauma.
   C. The abdominal examination in the elderly is not as reliable as it is in younger patients.
   D. Rib fractures in the elderly are a significant cause of morbidity.
   E. All of above are true

4. Which statement is *not* true regarding imaging of the cervical spine in blunt trauma?
   A. A single lateral view is indicated to evaluate C1 and C2 and to complement CT.
   B. Fractures at C2 may be missed by CT.
   C. Plain films have prominent limitations at the cervicocranial and cervicothoracic junctions.
   D. Helical CT is the preferred initial screening test for detecting cervical spine fractures in high-risk trauma patients.

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 <u>must</u> 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.

E. The American College of Radiology 2005 guidelines recommend a five-view cervical spine series for routine imaging of the cervical spine in blunt trauma.

5. Which of the following is *not* a characteristic finding on CT of cervical ligamentous injury?
   A. Displacement
   B. Wide interpedicle distance
   C. Widening of facet joints
   D. Disruption of posterior vertebral body line
   E. All of the above are characteristic of cervical ligamentous injury

6. CT scan as an initial imaging modality is indicated in all of the following patients with blunt cervical trauma *except*?
   A. A 36-year-old female with shoulder pain after a 25 mph rear-end collision
   B. An 18-year-old intubated male with a severe closed head injury after being ejected from a vehicle
   C. A 79-year-old female with neck pain after a fall
   D. A 47-year-old intoxicated male with no complaints after a high-speed rollover

7. Which statement is *false* regarding blunt cardiac injury?
   A. The most common complaint is chest pain.
   B. Associated injuries such as pneumothorax and pulmonary contusion are common.
   C. The most common ECG finding is atrial fibrillation.
   D. Dysrhythmias are the most common complication associated with blunt cardiac injury (BCI).
   E. An abnormal EKG coupled with suspicion of BCI mandates at least a 24-hour admission.

8. Which of the following is an *uncommon* finding on CT in the setting of bowel injury following blunt trauma?
   A. Mesenteric stranding
   B. Free intraperitoneal fluid
   C. Extraluminal air
   D. Bowel discontinuity
   E. Bowel wall thickening

9. Which of the following injuries would *not* be identified with a FAST scan?
   A. Contained solid organ injury
   B. Pancreatic injury
   C. Bowel injury
   D. Diaphragmatic injury
   E. None of the above injuries would be identified by FAST

10. Which of the following is a reliable marker of solid organ injury?
   A. Amylase
   B. Lipase
   C. Liver transaminases
   D. Creatinine
   E. None of the above are reliable markers for solid organ injury

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

In Future Issues:

Geriatric Trauma