Trauma Certified Registered Nurse (TCRN®) Examination Review

Think in Questions, Learn by Rationales

Kendra Menzies Kent

SPRINGER PUBLISHING COMPANY
Trauma Certified Registered Nurse (TCRN®) Examination Review
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This is a sample from TRAUMA CERTIFIED REGISTERED NURSE (TCRN®) EXAMINATION REVIEW: THINK IN QUESTIONS, LEARN BY RATIONALES

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SPRINGER PUBLISHING COMPANY
NEW YORK

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To my wonderful husband, Robby, and to my parents, Sid and Judy, for all the love and support they have given me.

I also gratefully acknowledge the work of Sarah Miller, who contributed to the review questions and rationales.
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Welcome to the journey toward certification. This book was written to help guide the pathway of the journey. It is written in a question/answer format to encourage you to think in questions when studying for the examination. When you study, I encourage you to ask yourself, “What questions about this particular topic could appear on the certification exam? What would be a good question?” This prepares you for questions; you are not just attempting to memorize content for the certification examination.

The book provides multiple-choice questions similar to the questions that are found on the Trauma Certified Registered Nurse (TCRN®) examination. These questions allow the nurse to practice taking an examination and will assist the nurse with determining areas that require further study prior to taking the TCRN examination. The answers and rationale, including some test-taking skills, are provided for every question, further preparing the nurse for the real examination.

**WHY CERTIFICATION?**

The most important reason for becoming certified is to do it for yourself. Certification is viewed as a mark of excellence in an area of specialty. It can be seen as an achievement and qualification by peers, physicians, health care institutes, and patients/families. Becoming certified takes dedication to trauma nursing and demonstrates a level of competency. The TCRN examination is developed to verify knowledge in trauma nursing.

**Box I.1 Reasons to Become Certified**

| Validate your knowledge of trauma to your hospital and peers |
| Validate your knowledge of trauma to the patients |
| Validate your knowledge of trauma to the physician |
| Promote continuing excellence in the nursing profession |
| Demonstrate competency |
| Promote self-confidence |
| Encourage continuing education |
| Hospital credentialing |
| Monetary benefit (from some hospitals) |

**TCRN EXAMINATION INFORMATION**

The TCRN examination was developed by the Board of Certification in Emergency Nursing (BCEN) and incorporates care of a trauma patient, from prevention and injury to rehabilitation. The examination covers all ages: pediatrics through geriatrics. The examination follows the test plan developed by the BCEN and the test is developed and reviewed...
by experts in trauma nursing. The TCRN Application Handbook can be accessed from the BCEN’s website (www.bcencertifications.org). The examination application can be completed online. The TCRN is a 4-year certification for trauma nurses.

EXAMINATION

The TCRN examination is 150 scored multiple-choice questions, with 25 unscored questions that will not count for or against you. Those 25 questions are included as “tests” for use in future examinations. You will not know which questions count, so complete all 175 questions as if they all do. The test is not arranged per any body system but is randomized. You may have one question on chest trauma and the next one may be on spinal cord injury. The time allowed to complete the examination is 3 hours.

To be eligible to take the TCRN examination one must be a licensed RN: 2 years of practice, at an average of 1,000 practice hours per year, across the trauma continuum are recommend. Trauma practice is defined as providing direct patient care, supervision, education, and advocacy for patients and their families; 20 to 30 hours of trauma-specific coursework across the trauma continuum is recommended.

The TCRN examination is offered year-round as a computer-based test (CBT) through Pearson’s VUE testing centers. Once BCEN receives the application, applicants may schedule an appointment on Pearson’s VUE website to sit for the examination. Immediate test results with score breakdown are available. Following successful completion of the examination, a certificate will be sent in the mail within 3 to 4 weeks.

Renewal of your TCRN certification can be achieved through continuing education (CE) or retaking the examination. The CE requirement is 100 hours. Of the 100 hours of CE, 50 must be from an accredited source and 75 must be within the clinical category. For more details on renewal, use the BCEN’s website for recertification and understanding CE.

EXAMINATION REVIEW

This TCRN examination review is a blueprint for the examination content. Each major body system is divided into subheadings and topics.

Box I.2 TCRN Examination Review

<table>
<thead>
<tr>
<th>Clinical Practice: Head and Neck</th>
<th>29</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Neurologic trauma</td>
<td></td>
</tr>
<tr>
<td>1. Traumatic brain injuries</td>
<td></td>
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<tr>
<td>2. Spinal injuries</td>
<td></td>
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<tr>
<td>B. Maxillofacial and neck trauma</td>
<td></td>
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<tr>
<td>1. Facial fractures</td>
<td></td>
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<tr>
<td>2. Ocular trauma</td>
<td></td>
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<tr>
<td>3. Neck trauma</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical Practice: Trunk</th>
<th>36</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Thoracic trauma</td>
<td></td>
</tr>
<tr>
<td>1. Chest wall injuries</td>
<td></td>
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<tr>
<td>2. Pulmonary injuries</td>
<td></td>
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<tr>
<td>B. Cardiac injuries</td>
<td></td>
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<tr>
<td>1. Great vessel injuries</td>
<td></td>
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<tr>
<td>C. Abdominal trauma</td>
<td></td>
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<tr>
<td>1. Hollow organ injuries</td>
<td></td>
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<tr>
<td>2. Solid organ injuries</td>
<td></td>
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<td>3. Diaphragmatic injuries</td>
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<td>4. Retroperitoneal injuries</td>
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</tbody>
</table>

(continued)
### Clinical Practice: Extremity and Wound

<table>
<thead>
<tr>
<th>Section</th>
<th>Topics</th>
</tr>
</thead>
</table>
| A. Musculoskeletal trauma | 1. Vertebral injuries  
2. Pelvic injuries  
3. Compartment syndrome  
4. Amputations  
5. Extremity fractures  
6. Soft-tissue injuries |
| B. Surface and burn trauma | 1. Chemical burns  
2. Electrical burns  
3. Thermal burns  
4. Inhalation injuries |

### Clinical Practice: Special Considerations

<table>
<thead>
<tr>
<th>Section</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Psychosocial issues related to trauma</td>
<td></td>
</tr>
</tbody>
</table>
| B. Shock | 1. Hypovolemic  
2. Obstructive (e.g., tamponade, tension, pneumothorax)  
3. Distributive (e.g., neurogenic, septic)  
4. Cardiogenic |
| C. SIRS and MODS |

### Continuum of Care

<table>
<thead>
<tr>
<th>Section</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Injury prevention</td>
<td></td>
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<tr>
<td>B. Prehospital care</td>
<td></td>
</tr>
<tr>
<td>C. Patient safety (e.g., fall prevention)</td>
<td></td>
</tr>
</tbody>
</table>
| D. Patient transfer | 1. Intrafacility (within a facility, across departments)  
2. Interfacility (from one facility to another) |
| E. Forensic issues | 1. Evidence collection  
2. Chain of custody |
| F. End-of-life issues | 1. Organ/tissue donation  
2. Advance directives  
3. Family presence  
4. Palliative care |
| G. Rehabilitation (discharge planning) |

### Professional Issues

<table>
<thead>
<tr>
<th>Section</th>
<th>Topics</th>
</tr>
</thead>
</table>
| A. Trauma quality management | 1. Performance improvement  
2. Outcomes follow-up and feedback (e.g., referring facilities, EMS)  
3. Evidence-based practice  
4. Research  
5. Mortality/morbidity reviews |
| B. Staff safety (e.g., standard precautions, workplace violence) |
| C. Disaster management (i.e., preparedness, mitigation, response, and recovery) |

(continued)
Box I.2 TCRN Examination Review (continued)

D. Critical incident stress management
E. Regulations and standards
   1. HIPAA
   2. EMTALA
   3. Designation/verification (e.g., trauma center/trauma systems)
F. Education and outreach for interprofessional trauma teams and the public
G. Trauma registry (e.g., data collection)
H. Ethical issues

EMS, emergency medical services; EMTALA, Emergency Medical Treatment and Active Labor Act; HIPAA, Health Insurance Portability and Accountability Act; MODS, multiple organ dysfunction syndrome; SIRS, systemic inflammatory response syndrome; TCRN, trauma certified registered nurse.

For clinical practice categories, the nursing process will be distributed as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment</td>
<td>18%</td>
</tr>
<tr>
<td>Analysis</td>
<td>31%</td>
</tr>
<tr>
<td>Implementation</td>
<td>31%</td>
</tr>
<tr>
<td>Evaluation</td>
<td>20%</td>
</tr>
<tr>
<td>Recall</td>
<td>21%</td>
</tr>
<tr>
<td>Application</td>
<td>61%</td>
</tr>
<tr>
<td>Analysis</td>
<td>18%</td>
</tr>
</tbody>
</table>

The following are testable nursing tasks on the examination:

I. Assessment
   A. Establish mechanism of injury
   B. Assess, intervene, and stabilize patients with immediate life-threatening conditions
   C. Assess pain
   D. Assess for adverse drug and blood reactions
   E. Obtain complete patient history
   F. Obtain a complete physical evaluation
   G. Use Glasgow Coma Scale (GCS) to evaluate patient status
   H. Assist with focused abdominal sonography for trauma (FAST) examination
   I. Calculate burn surface area
   J. Assessment not otherwise specified

II. Analysis
   A. Provide appropriate response to diagnostic test results
   B. Prepare equipment that might be needed by the team
   C. Identify the need for diagnostic tests
   D. Determine the plan of care
   E. Identify desired patient outcomes
   F. Determine the need to transfer to a higher level of care
   G. Determine the need for emotional or psychosocial support
   H. Analysis not otherwise specified
III. Implementation
   A. Incorporate age-specific needs for the patient population served
   B. Respond with decisiveness and clarity to unexpected events
   C. Demonstrate knowledge of pharmacology
   D. Assist with or perform the following procedures:
      1. Chest tube insertion
      2. Arterial line insertion
      3. Central line insertion
      4. Compartment syndrome monitoring devices:
         a. Abdominal
         b. Extremity
      5. Doppler
      6. End-tidal CO₂
      7. Temperature-control devices (e.g., warming and cooling)
      8. Pelvic stabilizer
      9. Immobilization devices
     10. Tourniquets
     11. Surgical airway insertion
     12. Intraosseous needles
     13. Intracranial pressure (ICP) monitoring devices
     14. Infusers:
        a. Autotransfusion
        b. Fluid
        c. Blood and blood products
     15. Needle decompression
     16. Fluid resuscitation:
        a. Burn fluid resuscitation
        b. Hypertonic solution
        c. Permissive hypotension
        d. Massive transfusion protocol (MTP)
     17. Pericardiocentesis
     18. Bedside open thoracotomy
   E. Manage patients who have had the following procedures:
      1. Chest tube insertion
      2. Arterial line insertion
      3. Central line insertion
      4. Compartment syndrome monitoring devices:
         a. Abdominal
         b. Extremity
      5. End-tidal CO₂
      6. Temperature control devices (e.g., warming and cooling)
      7. Pelvic stabilizer
      8. Immobilization devices
      9. Tourniquets
     10. Surgical airway
     11. Intraosseous needles
     12. ICP monitoring devices
     13. Infusers:
        a. Fluid
        b. Blood and blood products
14. Needle decompression
15. Fluid resuscitation:
   a. Burn fluid resuscitation
   b. Hypertonic solution
   c. Permissive hypotension
   d. MTP
16. Pericardiocentesis
F. Manage patients’ pain relief by providing:
   1. Pharmacologic interventions
   2. Nonpharmacologic interventions
G. Manage patient sedation and analgesia
H. Manage tension pneumothorax
I. Manage burn resuscitation
J. Manage increased abdominal pressure
K. Provide complex wound management (e.g., ostomies, drains, wound vacuum-assisted closure [VAC], open abdomen)
L. Implementation not otherwise specified
IV. Evaluation
   A. Evaluate patients’ response to interventions
   B. Monitor patient status and report findings to the team
   C. Adapt the plan of care as indicated
   D. Evaluation not otherwise specified
V. Continuum of care
   A. Monitor or evaluate for opportunities for program or system improvement
   B. Ensure proper placement of patients
   C. Restore patient to optimal health
   D. Collect, analyze, and use data:
      1. To improve patient outcomes
      2. For benchmarking
      3. To decrease incidence of trauma
   E. Coordinate the multidisciplinary plan of care
   F. Continuum of care not otherwise specified
VI. Professional issues
   A. Adhere to regulatory requirements related to:
      1. Infectious diseases
      2. Hazardous materials
      3. Verification/designation
      4. Confidentiality
   B. Follow standards of practice
   C. Involve family in:
      1. Patient care
      2. Teaching/discharging planning
   D. Recognize need for social/protective service consults
   E. Provide information to patient and family regarding community resources
   F. Address language and cultural barriers
   G. Participate in and promote lifelong learning related to new developments and clinical advances
H. Act as an advocate (e.g., for patients, families, and colleagues) related to ethical, legal, and psychosocial issues
I. Provide trauma patients and their families with psychosocial support
J. Assess methods continuously to improve patient outcomes
K. Assist in maintaining the performance improvement programs
L. Participate in multidisciplinary rounds
M. Professional issues not otherwise specified

PREPARATION

Be positive! Avoid any negative thoughts about passing the examination. These can result in a self-fulfilling prophecy. Set the test date and then establish a realistic schedule for preparing for the examination. Set your priorities: Study those areas you are less familiar with first. Look at the percentage devoted to each body system and establish timelines based on the percentage of questions pertaining to that topic. Know your best method of study—by yourself or in study groups—and follow that method. Flash cards, practice questions, review courses, study books in outline format, and study books in narrative format are available to assist you. Practice your test questions within a set time limit to familiarize yourself with the time limitations. Allow 2 minutes or less per question (remember, the rule is 50 questions per hour).

When using the practice test questions to study, determine several things when reviewing the answers and rationale. Analyze why you missed the question: Did you just not know the content? Go back and restudy the relevant section. Did you misread the question? Did you misread the answers? Did you miss an important element in the question or scenario? Was there a clue based on age, timeline, or symptoms you missed?

DAY OF THE TEST

Eat a healthy meal and limit the amount of liquids you drink (to avoid the need for breaks) before the examination. Remember, restroom breaks are allowed but the testing time does not stop!

Do not try to cram immediately before the test; this will increase your anxiety level. After the examination, make plans to do something special for yourself.

Know how to get to the testing site before the day of your scheduled exam. Plan your route and know how long it will take to get there at the time of day you are scheduled to take the examination. Running late and feeling hurried will increase your anxiety and can poorly affect your test-taking skills. Plus, if you are more than 15 minutes late, they will not let you in to take the examination.

Bring your letter of approval and two forms of identification (one picture ID). You cannot bring anything into the testing room, so leave everything in the car or at home (they will usually have a locker you can put personal items in during the examination).

If you need some assistance with computer-based testing, you are allowed to do a tutorial on the computer before you start your examination. The test time begins once you start the first question of the actual examination. Leaving the testing site without authorization results in an automatic voiding of the test. You will only be allowed 3 hours from the time the test is started.
Results of the examination will be presented onsite at the completion of your examination following a test evaluation.

TEST-TAKING SKILLS

Frequently, the difference between pass and fail depends on test-taking skills. An important reminder: Do not read into the question; take the question and information provided at face value. Answer all questions; do not leave any questions blank. A blank answer will be counted against you. Answering the question, even if it is an “educated” guess, will give you a one out of four chance of being correct.

Key words are important phrases or words used to focus attention on what the question is specifically asking. Examples include always, earliest, first, on admission, best, least, immediately, and initial.

▶ HINT: If the question asks for the “best” response, this is an indication that all answers are probably correct and you will have to determine the best answer for that particular scenario.

Eliminate incorrect options first. Sometimes you will immediately see an answer that is incorrect. Mark through it to narrow down your options and improve your odds. Frequently, you can narrow the choices down to two that are more correct than others.

▶ HINT: Eliminating incorrect options often gives a 50/50 chance for an educated guess of the correct answer.

Avoid those answers with words such as “always” or “never.” There is rarely a time in the medical field that you will always or never do a particular action. If three of the four answers are similar, choose the answer that does not sound similar.

Do not change answers unless you are absolutely certain. You can “bookmark” a question that you are not sure about to return to it at the end of the test. Sometimes you will feel more comfortable with the question after you come back to it.

▶ HINT: First impressions are usually good! Do not take too much time on any one question.

Do not let it worry you if you do not know all the answers. Take a deep breath and keep going. Rejoice in those answers you know and find easy!

▶ HINT: You really are not supposed to know all the answers.

Do not try to establish patterns, such as using “two As in a row” for answers.

If there is a long scenario with large amounts of data, read the question first, then read the scenario, then reread the question. Sometimes erroneous data will be included that is not required to answer the question. Too much time may be spent trying to comprehend the whole scenario and trying to work through all of the information and data can be time consuming.
HINT: Do not forget to reread the question to make sure you read it correctly the first time.

Read all answers before you make a choice; there may be more than one correct answer but one will be the better answer to the question.

HINT: Do not answer the first one that appears to be correct. Choose the most correct answer.

Read the question carefully and answer only the question asked. Do not read into the question or think that you require more information/data to answer the question.

HINT: The question will provide you with all the information needed to correctly answer it.

Time-frame questions are frequently used on the test. Use the time frame to assist with making the correct choice. Example: Which complication of subarachnoid hemorrhage is seen 7 to 10 days after the bleed?

HINT: All answers may be correct but only one will occur more commonly during the time frame provided in the question.

Questions may be worded using the lead-in, “What is the gold standard?” This is not asking what is the most common routine, but which is the most reliable and accurate.

Scenarios: Read the patient’s description word for word. Read the question, then formulate your answer. Read the answer options and choose the one closest to your answer. Reread the question after answering to ensure that you understood the question correctly.

HINT: Once the question is answered, you are done. Move on to the next question. Do not second-guess yourself.

Look for answers that facilitate the patient. Facilitative words include nurture, aid, support, reinforce, encourage, and assist.
This is a sample from TRAUMA CERTIFIED REGISTERED NURSE (TCRN®) EXAMINATION REVIEW: THINK IN QUESTIONS, LEARN BY RATIONALES

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Trauma Certified Registered Nurse (TCRN®) Examination Review: Think in Questions, Learn by Rationales
Thoracic Trauma

MECHANISM OF INJURY

■ The thoracic cavity extends from the first rib to which structure?
  ■ Diaphragm

The thoracic cavity extends from the first rib to the diaphragm. The diaphragm level can vary anywhere from the fourth intercostal space (ICS) on exhalation to the lower costal margin (10th rib) on maximal inhalation.

▶ HINT: A penetrating trauma at the nipple level can result in either chest or abdominal trauma depending on whether the patient took a deep breath in or let a breath out.

■ A patient presents with a sternal fracture. What is the significance of the injury that the trauma nurse should be aware of?
  ■ Force of impact

Fracture of the sternum requires a great force of impact so is associated with significant intrathoracic injuries, such as myocardial contusion and aortic dissection. The trauma nurse should be aware of the correlation between the sternal fracture and significant intrathoracic injuries, which may be life threatening.

▶ HINT: Fractures of ribs 1 to 3, femur, and scapula all require a significant force of impact.

■ Which kind of mechanism causes an open pneumothorax: blunt or penetrating?
  ■ Penetrating

An open pneumothorax is caused by penetrating trauma to the chest. It is also called a sucking chest wound and is caused by a large defect in the chest wall, causing equilibration of pressures between intrathoracic and atmospheric pressure. An open pneumothorax can also accumulate air in the pleural space during inspiration, leading to profound hypoventilation and hypoxia.

▶ HINT: If the penetrating wound to the chest is greater than two thirds the diameter of the trachea, air will flow in and out of the wound (least resistance to airflow).
Which side (right or left) of the diaphragm is more likely to be injured following chest trauma?

Left

The majority of diaphragm injuries from blunt trauma occur on the left side. The most common blunt injury is large posterior lateral tears on left diaphragm. The right diaphragm may be more protected by the liver and requires a greater force of impact to injure, thus resulting in higher mortality. Lateral impact is the most common mechanism of injury to result in a diaphragm injury on the ipsilateral side.

▶ HINT: Penetrating injuries to the diaphragm cause small tears and may have a delayed presentation of weeks to years later as the injury enlarges and gradual herniation of stomach or bowel occurs.

What is the most common mechanism of injury that results in a pulmonary contusion?

Compression–decompression

The mechanism of injury is commonly a compression–decompression impact on the thoracic cavity. This causes the lungs to be compressed between the anterior chest wall and the thoracic spine, increasing the pressure within the lungs. Contusions are a result of the increased pressure.

▶ HINT: Pulmonary contusions are commonly associated with chest wall injuries, including rib fractures.

A trauma patient is identified as having a sternal fracture. What cardiac injury is the most common after a significant blunt force impact to the chest?

Cardiac contusion

Sternal fractures are commonly associated with cardiac contusions (cardiac injury) and pulmonary contusions (pulmonary injuries; Box 4.1).

▶ HINT: Any injury that occurs as a result of a significant force of impact to the chest can be associated with myocardial contusion.

Box 4.1 Associated Injuries With Cardiac Contusions

- Chest wall bruises
- Multiple rib fractures
- Flail chest
- Sternum fracture
- Pulmonary contusion
- Pericardial tamponade
- Coronary artery laceration
- Cardiac valve rupture

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What is a common thoracic injury that occurs because of a sudden deceleration mechanism of injury?

Thoracic aortic transection/aneurysm

The most common mechanism of injury for a thoracic aortic transection or aneurysm is a sudden deceleration mechanism of injury. The ligamentum arteriosum secures the aorta near the aortic arch, called the level of the isthmus. During a sudden deceleration, the aorta moves except at the point of the ligament, causing a transection and, potentially, an aneurysm to form at that level.

▶ HINT: The deceleration can be horizontal (such as in a motor vehicle injury) or vertical (such as in a fall).

TRAUMATIC INJURIES

What is one of the most common injuries that occurs with a blunt trauma to the chest?

Rib fracture

Rib fractures are probably the most common injury in blunt chest trauma. The fractures of ribs 1 through 3 are associated with significant intrathoracic injuries because of the force of impact required to fracture these ribs.

▶ HINT: Associated injuries with fracture of ribs 1 to 3 may include aortic aneurysms, tracheobronchial, and vascular injuries.

What is an associated injury with the fractures of ribs 10 to 12 on the right side?

Liver injury

A fractured rib can be displaced, causing injury to the underlying structures. On the right, ribs 10 to 12 cover the liver and on the left cover the spleen. Fracturing of ribs 10 to 12 can cause injury to liver or spleen, depending on the side involved. Impacting ribs 4 to 12 can cause them to have a “bowing” effect, resulting in a midshaft fracture.

▶ HINT: Shoulder harness seat belts can cause fractures of ribs 10 to 12. The driver is at a greater risk for right-sided rib fractures and liver injury, whereas the passenger is at a greater risk for spleen injuries.

A patient presents in the emergency department with paradoxical chest wall movement following a motor vehicle collision (MVC). What would be the most likely injury the patient has sustained?

Flail chest

A flail chest involves three or more fractures at two or more places resulting in a freely moving segment of chest wall. Paradoxical movement of the chest wall is a hallmark sign in a flail chest (Box 4.2).

▶ HINT: Sternal fractures may also cause a flail chest and paradoxical chest wall movement.
Box 4.2  Signs of Flail Chest

<table>
<thead>
<tr>
<th>Dyspnea</th>
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<tbody>
<tr>
<td>Bruising anterior chest wall</td>
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<tr>
<td>Crepitus</td>
</tr>
<tr>
<td>Positioning to splint chest wall</td>
</tr>
<tr>
<td>Paradoxical chest wall movement</td>
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</tbody>
</table>

▶ HINT: Muscle spasms will splint the ribs, making a flail not always readily recognizable. Muscle relaxants will emphasize the presence of flail chest.

- **An injury to the internal mammary artery can result in what type of injury?**
  - **Hemothorax**

Hemothorax is caused by lung parenchymal lacerations, injuries to intercostal vessels, and injuries to the internal mammary artery. Both blunt and penetrating injuries to the chest can result in hemothorax.

▶ HINT: Hemothorax is a potential source of significant blood loss.

- **What is the most common site of injury in the trachea and bronchial area?**
  - **Bifurcation of mainstem bronchus**

Following blunt mechanism to the chest, the most common site of bronchial injury is at the bifurcation of the mainstem bronchus about an inch from the carina. If the injury does occur below the carina, the chest radiograph will show mediastinal air.

▶ HINT: Injury above the level of the carina can result in a delayed presentation such as unresolved pneumothorax.

- **What pulmonary injury is commonly associated with a flail chest?**
  - **Pulmonary contusion**

A blunt force significant enough to cause rib fractures and a flail chest can also cause the capillary vessels within the lungs to rupture, allowing blood to enter the interstitium and alveoli. Inflammation and edema develop in the lungs within a couple of hours after the injury. Lacerations to the lung tissue can also occur.

▶ HINT: Pulmonary contusions may be small and localized with minimal symptoms, or large, involving one or both lungs with life-threatening symptoms.

- **Which cardiac chamber is most likely to be injured in a blunt mechanism of injury to the chest?**
  - **Right ventricle**

The right ventricle lies closest to the anterior chest wall and, because of its location, is more commonly injured following a blunt chest trauma. The atria are less commonly injured because they are smaller than the ventricles.

▶ HINT: The complication of thrombus formation in the cardiac chambers is most common in the right ventricle because of the involvement of the right ventricle in blunt chest injuries.
ASSESSMENT/DIAGNOSIS

■ What diagnostic examination should be considered in patients with fractures of the first rib?
■ Arteriogram

A diagnostic chest x-ray may have difficulty visualizing the first rib and may miss a fracture in this area. Arteriogram should be considered following fracture of ribs 1 through 3 because the force of impact and the vascular structures underlying those ribs can result in significant arterial injuries, including damage to the subclavian artery or vein.

▶ HINT: Clavicle fracture is not usually serious but a jagged edge of the clavicle bone may also injure the subclavian artery or vein.

■ What is the most definitive diagnosis for a bronchial injury?
■ Bronchoscopy

An injury above the level of the carina may not demonstrate mediastinal air on chest radiograph. The most definitive diagnosis is with a bronchoscopy.

▶ HINT: Bronchial injuries are commonly diagnosed by the presence of symptoms.

■ What is an obvious sign of a diaphragm injury with bowel herniation?
■ Bowel sounds in chest

On assessment, bowel sounds heard in the chest, especially on the left side, indicate a significant diaphragm injury and bowel herniation into the thoracic chest. This is commonly associated with increased work of breathing and diminished breath sounds.

▶ HINT: Diaphragmatic injuries are associated with hemothorax. Chest tubes should be placed cautiously to avoid injury to the herniated bowel.

■ What radiographic examination is most specific to diaphragm injury?
■ MRI

The most prominent feature found on a chest radiograph is elevation of hemidiaphragm and potentially a bowel pattern in the chest.

■ What is the finding on a chest x-ray that indicates the presence of a pulmonary contusion?
■ Infiltrates may be unilateral or bilateral and have the appearance of acute respiratory distress syndrome (ARDS). This is caused by fluid in both the pulmonary parenchyma and alveoli.

▶ HINT: Severe pulmonary contusions can progress into ARDS.
What is the most specific diagnostic study used to identify a thoracic aortic aneurysm?

Arteriogram

A chest x-ray is a screening tool used on trauma patients and can identify a widened mediastinum (Box 4.3), but is not specific to a thoracic aortic aneurysm. An arteriogram is recommended to visualize the aorta. An invasive aortagram is the most specific study for an aortic injury but a CT arteriogram is less invasive and is used as a screening tool.

▶ HINT: The most common site for a traumatic aortic injury is the level of the isthmus.

Box 4.3 Findings on Chest X-Ray for Thoracic Aortic Injury

<table>
<thead>
<tr>
<th>Finding</th>
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<tbody>
<tr>
<td>Widened mediastinum</td>
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<tr>
<td>Loss of aortic knob</td>
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<tr>
<td>Presence of left apical cap</td>
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</table>

A patient is admitted for 24-hour monitoring following an MVC with a result of a bent steering wheel. What injury may be suspected in this patient?

Cardiac contusion

Cardiac arrhythmias, including life-threatening ventricular arrhythmias, may occur following cardiac contusion and require cardiac monitoring for at least 24 hours.

▶ HINT: Other workup of a patient with suspected cardiac contusion includes 12-lead EKG, cardiac enzymes, and an echocardiogram.

What diagnostic technique is commonly used to evaluate the chest for the presence of pericardial blood?

Focused assessment sonography for trauma (FAST) technique

FAST is an ultrasound technique used to evaluate both abdominal and thoracic cavities. It is used to detect the presence of blood or fluid (effusion) in the pericardial space.

▶ HINT: FAST has the advantage of being able to be performed rapidly in the emergency department for hemodynamically unstable trauma patients.

MEDICAL/SURGICAL INTERVENTIONS

Following the placement of a chest tube in a trauma patient, the nurse notes 1,500 mL of bloody output immediately on placement. What would the nurse expect the physician to do to manage this injury?

Thoracotomy

A hemothorax with greater than 1,000 to 1,500 mLs of blood on the initial insertion of a chest tube or greater than 200 mL/hr for 4 hours indicates the need for a thoracotomy. Accumulation of blood in the pleural space with a hemothorax can compromise ventilatory effort by compressing the lung tissue, resulting in hypoxemia as well as hemorrhagic shock as a result of excessive loss of blood.
Early surgical management for a large hemothorax is recommended to prevent complications of ongoing blood loss, empyema, and late fibrothorax.

What is the priority of care in patients with diaphragmatic injuries and herniated bowel?

Airway and breathing

The herniation of bowel into the chest cavity increases the thoracic pressures and interferes with ventilation. The cornerstone of treatment of diaphragmatic injuries is intubation and ventilation to protect the airway.

Placement of a nasogastric tube can assist with decompression of the bowel and limit herniation.

What type of mechanical ventilation may be considered in trauma patients with severe unilateral pulmonary contusion and severe hypoxemia?

Independent lung ventilation (ILV)

ILV is considered in patients with significant unilateral pulmonary contusion and severe hypoxemia that cannot be corrected. Positive end-expiratory pressure (PEEP) is recommended in managing patients with pulmonary contusions, but in patients with unilateral lung involvement, the unaffected lung can become overdistended and the affected lung underventilated. This is called maldistribution of ventilation.

Pressure control modes of ventilation and high-frequency oscillatory ventilation (HFOV) may be used in patients with bilateral pulmonary contusions who have failed with conventional ventilation.

Following a paracentesis, the blood aspirated is placed in a container and agitated. It does not form clots. This indicates the blood was aspirated from which space?

Pericardial space

Blood aspirated from the pericardial space is defibrinated, so the blood does not clot. If the needle would have punctured the ventricle and aspirated blood is from the ventricular chamber, then the blood will clot.

Blood from the pleural space is defibrinated and does not clot.

A patient with cardiac contusion becomes hypotensive. What pharmacological intervention may be used to improve the patient’s hemodynamic status?

Dobutamine (Dobutrex)

Dobutamine is a positive inotropic agent that increases myocardial contractility. Patients with cardiac contusion frequently experience decreases in myocardial contractility and ejection fractions. Improving contractility will improve blood pressure and hemodynamics.

Administering vasoconstrictive agents to increase blood pressures in patients with cardiac contusions may actually worsen their hemodynamics because of the increase in resistance (afterload) on the heart.
A patient with a thoracic aortic injury presents to the intensive care unit with a blood pressure of 194/98 mmHg and a heart rate of 106 beats per minute. The trauma nurse would expect that the physician would order which class of medication to lower the patient’s blood pressure?

**Beta-blocker**

A beta-blocker will block adrenergic activity and lower the blood pressure. This will lower the risk of further injury to the aorta and aortic rupture. Beta-blockers decrease the heart rate, also limiting injury to the aorta. Alpha-blockers, such as nipride, will lower the blood pressure but cause a reflex tachycardia that may worsen the aortic injury.

▶ **HINT:** Esmolol is a beta-blocker that is short acting and titratable. It is commonly used to manage the blood pressure in patients with traumatic aortic aneurysms.

**In a suspected tension pneumothorax, what intervention can be performed before a chest tube can be placed?**

**Needle thoracentesis**

If the patient is suspected of having a tension pneumothorax and is hemodynamically unstable, a needle thoracentesis can be performed to rapidly reverse the life-threatening symptoms. The 14-gauge (G) needle is placed in the second ICS, midclavicular on the affected side.

▶ **HINT:** The definitive treatment of tension pneumothorax is the placement of a chest tube to decompress the pneumothorax.

**What is a concern of intubating a patient with tracheobronchial injury?**

**Further injury**

The blind placement of an endotracheal tube on a patient with a tracheobronchial injury can cause further injury. A flexible bronchoscope can be useful in guiding the placement of the endotracheal tube, limiting the risk of further injury.

▶ **HINT:** Positive pressure mechanical ventilation can worsen the pneumothorax by forcing air into the pleural space.

**NURSING INTERVENTIONS**

**What is the primary goal for managing a patient with rib fractures?**

**Pain management**

Management of rib fractures includes pain management, usually with oral analgesics, including opioids, nerve blocks, epidural, or intrapleural analgesia if pain is severe.

▶ **HINT:** In patients with flail chest, administration of analgesia will decrease pain and may relax the intercostal muscles, making paradoxical chest wall movement of flail more obvious.
During assessment of a trauma patient in the emergency room, the nurse notes diminished breath sounds on the left side with dullness to percussion. What is the most likely cause?

**Hemothorax**

If diminished breath sounds on the affected side are found, it indicates a collapsed lung and is commonly found with a pneumothorax. The presence of dullness on percussion indicates the presence of fluid or blood such as a hemothorax. A pneumothorax will have hyperresonance with percussion over the affected side.

▶ **HINT:** Clinical presentation of hemothorax includes dullness to percussion, decreased breath sounds on affected side, and flat neck veins resulting from blood loss.

What type of dressing is recommended to manage an open-sucking chest wound before definitive treatment?

**Three-sided dressing**

A three-sided dressing works as a flutter valve. It allows air to leave but not to reenter the pleural space. An occlusive dressing could result in a tension pneumothorax.

▶ **HINT:** A flutter valve may also be used to manage the open pneumothorax.

Following a blunt chest injury, a patient in the trauma intensive care unit demonstrates subcutaneous air, cough, hemoptysis, and persistent subcutaneous emphysema. What is the most likely injury?

**Bronchial injury**

Symptoms of a bronchial injury may be delayed by several days after injury. Bronchial injury commonly recognized by the symptoms, especially an unresolving pneumothorax (Box 4.4).

▶ **HINT:** Tracheobronchial injuries are more likely to be caused by a penetrating trauma and should cause a high suspicion.

**Box 4.4 Symptoms of Tracheobronchial Injuries**

- Noisy breathing
- Dyspnea
- Airway obstruction
- Hemoptysis
- Cough
- Hoarseness
- Subcutaneous emphysema: neck, face, or suprasternal
- Progressive mediastinal air
- Persistent pneumothorax
- Tension pneumothorax
A patient in the emergency room presents with a penetrating trauma of the left chest. If the patient continues to be unresponsive to fluids and remains hemodynamically unstable, then the trauma nurse should suspect which injury?

Pericardial tamponade

Penetrating trauma is the most common mechanism of injury for pericardial tamponades. A pericardial tamponade commonly presents with hemodynamic instability despite adequate fluid resuscitation. The development of tamponade produces a reduction of filling of ventricles during diastole and a decrease in output.

▶ **HINT:** Cardiac tamponade is caused by bleeding into the pericardial sac caused by a ruptured coronary artery, lacerated pericardium, or an injury to the myocardium in trauma patients.

What is considered the Beck’s triad associated with cardiac tamponade?

• Increased jugular venous distension, hypotension, and muffled heart sounds

The increased jugular venous distension is caused by impedance to filling the ventricle during diastole, hypotension is caused by decrease in cardiac output, and muffled heart sounds occur because of the accumulation of blood in the pericardial sac. If the patient has other associated injuries with significant blood loss, the jugular venous distension will be absent (Box 4.5).

▶ **HINT:** Diminished amplitude of the QRS complex may also be associated with pericardial tamponade because of the fluid collection around the heart.

**Box 4.5** Symptoms of Pericardial Tamponade

- Increased jugular venous distension
- Hypotension
- Muffled or distant heart sounds
- Pulsus paradoxus
- Pulsus alternans
- Cyanosis
- Dyspnea
- Pulseless electrical activity (PEA)
- Tachycardia
- Pericardial friction rub

▶ **HINT:** Pulsus paradoxus is the decrease in systolic blood pressure during inspiration, whereas pulsus alternans is an alternating weak and strong pulse.

A trauma patient is admitted to the trauma intensive care unit following a blunt trauma to the chest. The patient was intubated in the emergency room and is on a mechanical ventilator. One day posttrauma, the nurse notes an increase in peak inspiratory pressures (PIP). What would be the most likely cause?

Pulmonary contusion

The combination of atelectasis, blood and fluid, and interstitial edema produces a decrease in pulmonary compliance and an increase in peak inspiratory pressures. The findings of
pulmonary contusions frequently occur within 24 to 48 hours after injury and are commonly associated with a blunt chest injury. The triad of physiological changes associated with pulmonary contusion is hypoxemia, intrapulmonary shunting, and reduced pulmonary compliance (Box 4.6).

▶ HINT: ARDS may also present with an increase in PIP but will commonly occur 48 to 72 hours after a traumatic injury.

Box 4.6  Symptoms of Pulmonary Contusion

- Shortness of breath
- Diffuse crackles
- Tachypnea
- Hypocarbia
- Blood-tinged or bloody sputum
- Wheezes
- Increased work of breathing
- Increased peak airway pressures
- Infiltrates on chest x-ray
- Tachycardia
- Hypoxemia

Following fluid resuscitation and patient stabilization, what is the most appropriate fluid management to prevent worsening of pulmonary contusions?

Limit fluid intake

Trauma patients should not have excessive restrictions of fluid replacement while the patient is unstable and requiring fluid to manage hemodynamics. After the trauma patient is stabilized hemodynamically, then restriction of fluids may limit pulmonary contusions and associated complications.

▶ HINT: Restricting fluids initially in a hemodynamically unstable patient following a trauma can significantly decrease tissue perfusion and worsen outcomes.

A driver of a motor vehicle involved in a front-end collision suddenly develops short runs of ventricular tachycardia. What would be the most likely cause of the arrhythmias?

Cardiac contusion

Complications of myocardial contusions include arrhythmias. These arrhythmias can range from supraventricular tachycardia and rapid ventricular response atrial fibrillation to lethal ventricular arrhythmias. Atrioventricular (AV) blocks may also be associated with cardiac contusions (Box 4.7).

▶ HINTS: The most common arrhythmia with myocardial contusion is sinus tachycardia. Cardiac contusion can cause signs of decreased perfusion to tissues because of the decrease in ejection fraction and cardiac output.
Box 4.7  Signs of Cardiac Contusion

- Tachycardia
- Decreased urine output
- Hypotension
- Chest pain
- Increased jugular venous distention
- Arrhythmias
- ST segment changes (elevation)
- T-wave changes

■ **A patient with multiple rib fractures on the right is noticed to have rapid shallow breathing and limited movement. What is the most appropriate intervention by the trauma nurse?**

■ Provide pain management

Patients with multiple rib fractures experience significant pain and breathing deeply increases the painful response. Managing the patient’s pain can allow the patient to breathe deeper and more effectively with less splinting. Splinting places the patient at an increased risk for atelectasis and pneumonia.

▸ **HINT:** The use of multimodal pain management is recommended to manage pain to allow deeper breathing without the respiratory depression of opioids.

**COMPLICATIONS**

■ **What is the life-threatening complication of a pneumothorax?**

■ **Tension pneumothorax**

In a tension pneumothorax, the air builds in the pleural space, becomes trapped, and the increased pressure causes the mediastinum to shift. The shifting of the mediastinal structures causes the compression of the aorta and inferior vena cava. This results in a life-threatening hemodynamic instability. Needle decompression, with 14- to 18-gauge angiocath at the second to third ICS midclavicular, is the emergency treatment until a chest tube can be placed.

▸ **HINT:** The trauma nurse should palpate the trachea for deviation. The trachea will be deviated away from the side of the tension pneumothorax.

■ **What is a long-term pulmonary complication of pulmonary contusions?**

■ **Pulmonary fibrosis**

Contused lungs from trauma commonly demonstrate fibrosis on chest x-ray within 1 to 6 years after injury. The vital capacity and air volumes are also significantly decreased because of the fibrosis. Patients with pulmonary contusions are more likely to develop ARDS.

▸ **HINT:** The fibrosis can also be found in ARDS, which has very similar physiological effects following the injury or insult.
An echocardiogram may be used to evaluate a patient with a myocardial contusion several days after injury. What late complication of a cardiac contusion can be identified with an echocardiogram?

- Intracardiac thrombus

The decrease in contractility and ejection fraction, which occurs with contusion of the myocardium, can lead to blood stasis in the cardiac chambers and thrombus formation. The use of echocardiogram can identify the thrombus in the cardiac chambers. The identification of depression of myocardial contractility and cardiogenic shock can be identified early with echocardiogram and are complications of cardiac contusion.

▶ HINT: Transesophageal echocardiogram is more sensitive than a transthoracic approach in identifying intracardiac thrombus.

A trauma patient experiences pulseless electrical activity (PEA) during fluid resuscitation. What traumatic injury is most likely to have occurred?

- Pericardial tamponade

One of the causes of PEA is pericardial tamponade. This is caused by the pericardial restriction of the heart, which limits filling of the cardiac chambers and the ability for mechanical contractility. Electrical activity is not affected so the patient has a discernable rhythm on the monitor, but no mechanical activity.

▶ HINT: Pericardial tamponade is considered to be a constrictive cardiomyopathy.

Which blunt cardiac injury has one of the highest mortalities?

- Cardiac rupture

Blunt forces to the chest increase the intrathoracic pressure resulting in the rupture of a cardiac chamber. This carries a high mortality. Transection of the ascending aorta is fatal in most cases.

▶ HINT: Emergency thoracotomy on a patient with blunt trauma cardiac arrest is rarely successful.
Questions

1. The nurse receives a patient following a motor vehicle collision. The driver was unrestrained and the airbag did not deploy. The patient has a respiratory rate of 42 breaths per minute, obvious paradoxical movement of the chest wall, and presents in severe respiratory distress requiring intubation. The nurse is suspecting what type of injury?
   A. Three or more fractures in two or more places
   B. Fracture of the sternum
   C. Rib fractures involving ribs 4 to 6
   D. Clavicle fracture

2. A patient was stabbed in the right lateral chest. The patient presents in the emergency department moaning in pain and breathing 40 breaths per minute. The nurse finds the patient has hyperresonance on the right side. After radiographic studies are completed, it is confirmed that a pneumothorax is present on the right. The nurse assists in setting up for chest-tube insertion. After the chest tube is placed, the nurse notes that there is continuous bubbling in the water-seal chamber. Which of the following is the best method for the nurse to use to address this problem?
   A. Place the chest tube below the level of the chest to facilitate drainage
   B. Pinch the chest tube at the insertion site and determine whether the bubbling stops
   C. Replace the chest drainage unit immediately
   D. Obtain a chest x-ray immediately

3. Rib and sternal fractures are commonly associated with other severe injuries. Which of the following correctly matches the location of the injury to the associated complications?
   A. Left lower rib fractures and hepatic lacerations
   B. Right lower rib fractures and splenic rupture
   C. Sternal fracture with cardiac contusion
   D. Left lower rib fracture with great vessel injuries

4. A patient presents to the emergency department with dysphonia and dyspnea after aspirating a fish bone. The physician suspects that the patient has a tracheal rupture and begins to prepare for intubation. What is the most definitive way to confirm the diagnosis of a tracheal rupture?
   A. Bronchoscopy
   B. Chest x-ray
   C. CT of the chest
   D. Ultrasound

5. A patient comes into the emergency room after involvement in a motor vehicle collision. The car was traveling at a high speed of about 90 miles per hour and ran into a telephone pole. The patient was unrestrained and there were no airbags in the vehicle. The patient is unresponsive on arrival with a blood pressure of 80/40 mmHg, absent pedal pulses, and bounding radial pulses. There is severe chest wall ecchymosis and a loud systolic murmur. What is this patient’s expected injury?
A. Descending aortic injury
B. Pericardial tamponade
C. Blunt cardiac injury
D. Ascending aortic injury

6. A patient comes in after a T-bone motor vehicle collision during which the patient was struck on the right lateral side. The patient has a blood pressure of 91/60 mmHg, a heart rate of 119 beats per minute, with cool, clammy skin. CT of the abdomen revealed a liver laceration with evidence of active bleeding and the CT of the chest revealed widened mediastinum. What is the priority of care in this situation?

A. Control the abdominal hemorrhage
B. Prepare for the operating room for repair of the aortic transection
C. Prepare for a pericardial window to be performed
D. Blood pressure control

7. Which of the following patients presenting with an aortic injury would require immediate surgery to repair the aorta?

A. Patients who need to be transferred to other facilities for treatment
B. Associated severe brain injury
C. Stable injury less than 5 cm
D. Expanding aortic transection

8. Mr. Carson comes into the emergency room with a machete lodged in his chest. He is hypotensive and is displaying pulsus paradoxus. The nurse is actively transfusing the patient with blood products and intravenous fluids are being administered. Mr. Carson now becomes unconscious and cyanotic. Which intervention would be most appropriate in this situation?

A. Pericardiocentesis
B. Expedited transfer to the operating room
C. Open thoracotomy
D. Obtain an emergency arteriogram of the aorta

9. A patient with a pulmonary contusion has a decrease in pulmonary compliance and an increase in airway pressures. This is related to all of the following except:

A. Interstitial edema
B. Hypercarbia
C. Atelectasis
D. Presence of blood and fluid

10. A patient who suffered a femur fracture is 2 days postoperative and begins to report chest pain on inspiration. The nurse assesses the patient and discovers an oxygen saturation of 92% on 2 L via nasal cannula, a respiratory rate of 27 breaths per minute, and a heart rate of 112 beats per minute. All of the following imaging studies may be used to diagnose a pulmonary embolism (PE) except for which one?
A. Computed tomography angiogram (CTA) of chest  
B. Pulmonary angiogram  
C. Chest x-ray (CXR)  
D. Ventilation perfusion scan

11. Ventilation techniques used in the treatment of patients with pulmonary contusions include all of the following except:
   A. Increasing positive end-expiratory pressure (PEEP)  
   B. Maintaining low plateau pressures  
   C. Decreasing respiratory rates  
   D. Utilize pressure control ventilation

12. Myocardial cell necrosis, infiltration of leukocytes, absorption of hemorrhage, and healing by scar formation make myocardial contusions very similar to what other disease process?
   A. Myocardial infarctions  
   B. Hemorrhagic contusions  
   C. Pulmonary contusions  
   D. Liver lacerations

13. What is the physiological difference between a myocardial contusion and a myocardial infarction?
   A. There is no necrotic zone in myocardial contusions.  
   B. There is no ischemic zone in myocardial contusions.  
   C. There is no healthy cardiac tissue in myocardial infarctions.  
   D. There is no necrotic zone in myocardial infarctions or myocardial contusions.

14. A patient comes in with a cardiac contusion and multiple rib fractures following a motor vehicle collision. The trauma nurse performs a 12-lead EKG and draws blood for cardiac enzyme studies. What other diagnostic procedures would be appropriate for this patient?
   A. Echocardiography  
   B. Radionuclide angiography  
   C. Transesophageal echocardiogram (TEE)  
   D. All of the above

15. A trauma patient comes into the emergency room with a traumatic aortic transection, and is lethargic and difficult to arouse. The spouse is at the bedside and the physician explains that immediate surgery is necessary. The spouse is contemplating whether or not to sign the consent form for the procedure. The nurse should disclose:
   A. This surgery is necessary and will decrease the mortality rate for the patient.  
   B. The surgery will not make much of a difference at this point, the mortality rate is high with or without surgical intervention.  
   C. The surgery is not really an emergency and can wait until the patient wakes up.  
   D. The surgery is necessary and will decrease the mortality rate for the patient from 90% to 40%.

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16. The nurse is caring for a patient who sustained a fall from a second-story home. The patient’s voice begins to get hoarse and the nurse notices some swelling over the base of the neck. Which of the following assessments is indicated to assess for aortic injuries?
   A. Pupillary reactions
   B. Pulses in upper and lower extremities
   C. Bowel sounds
   D. Skin color changes

17. All of the following are screening or diagnostic tests for diagnosing patients with traumatic aortic aneurysms except:
   A. Computerized tomography angiography (CTA)
   B. Aortography
   C. Sonography
   D. x-ray

18. A patient admitted with a traumatic aortic aneurysm is most likely to have which one of the following performed during the surgical repair of the aorta to prevent complications?
   A. Autotransfusion from the chest tube
   B. Clamped aorta without distal canalization
   C. Partial left heart bypass
   D. Aortic bypass with autologous graft

19. During cross-clamping to surgically manage a traumatic aortic aneurysm, hypotension can occur below the clamp, whereas hypertension can occur above the clamp. What are the possible complications caused by the cross-clamping?
   A. Right lung pneumonia
   B. Myocardial infarction
   C. Graft infection
   D. Atelectasis