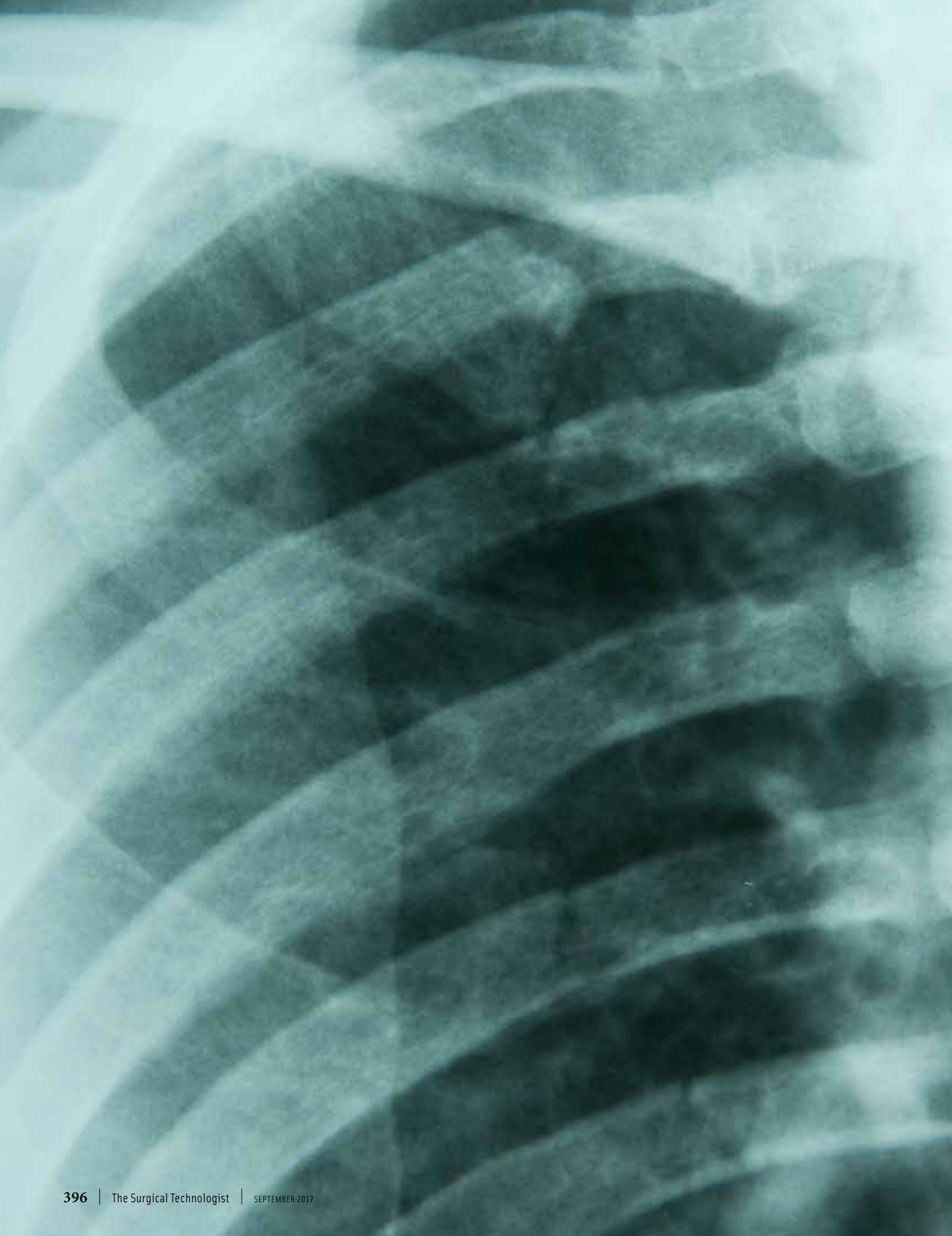

Surgical Rib Fixation

Julie Beard, CST

Treatment for rib fractures has changed over time. The traditional form of treatment has been pain management and rest while the fractures heal. Non-surgical stabilization of the fracture site is difficult given the constant anatomical movement of respiration, which results in slow healing.

Surgical intervention, however, can minimize the time a patient spends in the ICU, their need for mechanical ventilation and a reduced recovery time. K-wires into the medulla of the rib, sewing the fractures or the use of sternal wires to secure the ribs together have provided mixed results. These treatments require large incisions and have the general risks associated with major surgical intervention. More recently, however, the use of specifically designed plates and screws have given surgeons a way to stabilize the fracture while yielding better results and a smaller incision. With the creation of a lower profile, the anatomically contoured plating systems have been designed to follow rib anatomy and provides for a better solution than wires and suture.

ANATOMY

The sternum, ribs, rib cartilage and xiphoid process create the framework of the thoracic cage and protects the organs during respiration

LEARNING OBJECTIVES

- Discuss how surgical intervention of fractured ribs can help the patient heal
- List the elements that create the framework of the thoracic cage
- Identify the sets of ribs and what they are comprised of
- Pinpoint which ribs are most easily fractured as well as the ones that fracture the least
- Define flail chest and the symptoms associated with this condition

and circulation. The sternum, made out of bone, consists of three parts: the upper piece or manubrium, the middle piece or gladiolus, and the lower piece, or the xiphoid process (or the appendix). The ribs are elastic arches of bone, with 12 on each side of the thoracic cavity. The first seven ribs, referred to as true ribs, each attach to the sternum with a piece of cartilage. The next five ribs (8-12) are called false ribs, with ribs 8-10 attaching by cartilage to the sternum via a common costal cartilage. Ribs 11 and 12 are free at the anterior border and are called floating ribs.[2] The space in between the ribs is called intercostal spaces. Ribs are comprised of cancellous bone tissue and also have three sections: a posterior vertebral, anterior or sternal, and the shaft of the rib in between.

In most places, the ribs are covered by the large muscle of the chest wall: specifically, the pectoralis major and minor anteriorly, and the latissimus dorsi, serratus posterior, trapezius and rhomboid muscles posteriorly. Furthermore, the scapula and its muscles cover the upper posterior ribs. There is relatively little muscle coverage of the ribs laterally, with the exception of the serratus anterior. For this reason, the ribs can be most easily palpated in the lateral area of the chest wall. There are a few bony landmarks that help with counting the ribs to delineate specific rib numbers. First, the second rib articulates anteriorly at the angle of the sternum. Next, the tip of the scapula is generally located over the 7th rib. Finally, the 11th and 12th ribs usually can be identified by palpation due to their lack of articulation with the sternum anteriorly.

The ribs are surrounded in muscle, including the diaphragm, triangularis sterni, levatores costarum, infracostales and the internal and external intercostals. The internal and external intercostals depress and raise the ribs during respiration and work in concert with the diaphragm as the chief muscle for inspiration.

The diaphragm is a fan-shaped muscle that lies obliquely in the upper third of the body trunk,[2] which is considered a dome-like structure due to it separating the floor of the thorax and the roof of the abdomen from the organs below. It is not only assists in breathing, but in expelling feces, urine and vomiting. Along the front, the muscle fibers of the diaphragm insert into the xiphoid process and run along the costal margin (the lower edge of the thoracic cage at the ribs) and laterally into ribs 6-12. Along the back, the fibers attach into the vertebrae at T12 and with two tendinous appendages – the right and left crus – downward into the lumbar vertebrae at L1 and L2. The diaphragm consists of muscular fibers and contains three openings to accommodate the aorta, the esophagus and the inferior vena cava.[1] The aortic opening lies in the very posterior aspect of the diaphragm, slightly to the left and at beginning of L1 between the right and left crus. The esophageal opening is located at the level of T10, while the opening for the inferior vena cava lies at T12. The diaphragm is supplied by the intercostal and phrenic nerves.

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During breathing, the diaphragm contracts and the volume of thoracic cavity increases as the air is drawn into the lungs, creating negative pressure. The diaphragm, along with its tendons and nerves, acts as a stabilizing structure for the ribs and thoracic cage. When ribs are fractured, the design and function of breathing are compromised. The constant contraction and expanding movement causes instability and pain.

The 11 pairs of external intercostals run from the lower border of each rib to the upper border of the rib below. They consist of muscle fiber and are supplied by the intercostal nerves.

The internal intercostals, also 11 pairs, begin at the sternum and run in between the cartilages of the true ribs, and from the anterior border of the false ribs to the vertebral

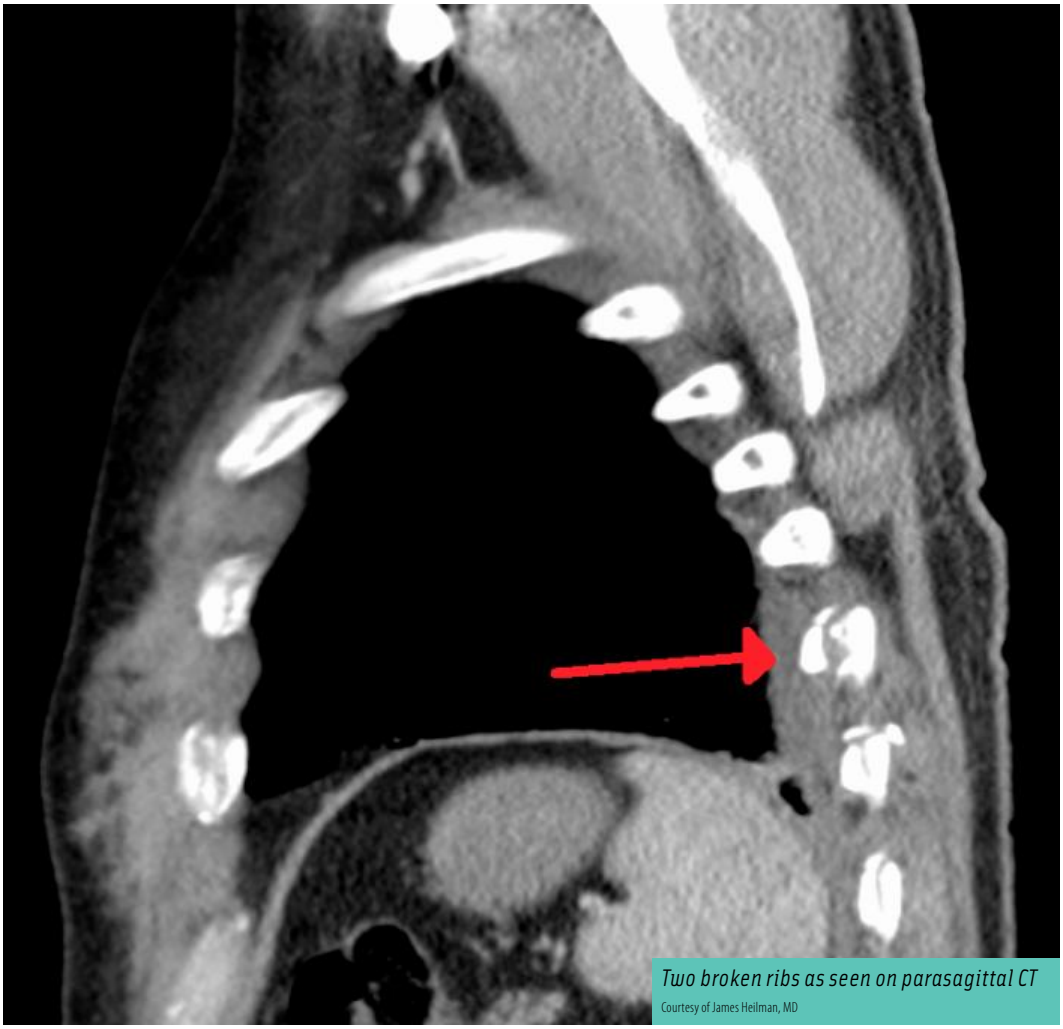
column. The internal intercostals consist of muscle fibers that are thinner than the external intercostals and supplied by the intercostal nerves.

The infracostals, which are comprised of muscular and aponeurotic fascia and vary in number, are located on the inner surface of the rib where the internal intercostals end. They cover the surface of one rib and extend down to the inner surface of the ribs below, and are supplied by the intercostals nerves.

The triangularis sterni muscle covers the lower third of the sternum, and then upward and outward to the 2nd through 6th ribs. They are tendinous and muscular bundles, and supplied by the intercostal nerves.

The levatores costarum muscles, also tendinous and muscular bundles, begins at the 7th cervical and 11th upper dorsal vertebrae, fanning obliquely down and out to the upper border of each rib. The levatores costarum is supplied as well by the intercostal nerves.

The ribs create the thoracic cage and protect the lungs. Each lung is covered individually in a sac of two thin membranes: the pleura pulmonalis and the pleura costalis. The space in between these two layers is the pleural cavity, which is normally two layers that are in contact with each other with no separation. A small amount of pleural fluid lies within the pleural space, which serves as a lubricant for the lung to slide along the pleural. Mediastinum is the space between the lungs when they are housed in their sacs and also contains the viscera of the thorax.[2]



Two broken ribs as seen on parasagittal CT
Courtesy of James Heilman, MD

FRACTURES

The nature and structure of the sternum and ribs is elastic and springy.[2] Due to this, the sternum is not often prone to fracture. When a dislocation or fracture of the sternum does occur it is commonly in the upper portion between the manubrium and gladiolus. The ribs, however, are more frequently broken due to blunt force injury. The 1st and 2nd ribs are rarely broken due to the support given by the clavicle and shoulder girdle. The 11th and 12th are also rare to fracture as they are smaller and free floating. Ribs 3-10 are the most likely to break at their weakest point when subjected to blunt force injury and trauma. When observed, the affected side with the fractures may not expand and appear stiffened, while the unaffected side will expand and contract with each breath.[3] A flail chest is when three or more ribs fracture in more than two places, and can be observed during the patient's breath as paradoxical motion.

When multiple, sequential ribs are fractured, patients are at risk for developing a hemothorax, which is blood in the pleural cavity from the damaged intercostal, pleural, mediastinal or lung vessels. A pneumothorax – or air in the pleural cavity – often is seen in addition to the hemothorax. A patient's respiration typically becomes labored as their lung cannot expand and contract with each breath. They also may appear to be gasping for air. A chest tube may need to be inserted in the intercostal space between the 5th and 6th space to relieve the hemothorax. This particular space is selected due to its location, which allows for a decent space in between the ribs.[2] In addition, intubation often is required in an effort to stabilize the patient's breathing and support the patient's respiration. However, patients who require intubation are at risk for longer stays in the ICU and developing pneumonia.

Pain associated with a rib fracture varies as some patients experience little discomfort while others with similar fracture patterns are completely disabled. For those who are seriously affected by the fracture, or have chronic shortness of breath and discomfort, a return to the same level of activity before the fracture is difficult. More than one half of patients with flail chest who do not undergo rib stabilization will have chronic pain, shortness of breath, and in the long term, pneumonia and respiratory insufficiency. Chest wall deformities may result as well.

SURGICAL FIXATION

Positioning for rib fracture repair is dependent on the location of a patient's fracture. Anterior repair places the patient supine, lateral fractures place the patient in lateral decubitus and posterior fractures places the patient in the prone position. Considerations will need to be taken into account of other injuries when positioning the patient.

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Once the patient is placed on the OR table, and cleared by anesthesia, the surgeon will perform a bronchoscopy using a flexible bronchoscope. Specimens, such as a bronchial alveolar lavage, may be taken at this time. The surgical technologist will complete their set up and counts during this time. Given the size of the incision, a full count of all soft goods and instruments will be made, with the exception of the surgical fixation tray and drills. The tray sets will include a major instrument set, a self-retaining retractor set, the surgeon's choice for fixation system and a drill system. A pediatric Bookwalter set is ideal with the smaller rings and blades and works well as a self-retaining retractor.

Following the incision, hemostasis and removal of any hematoma will be achieved, and the location of the fracture will be exposed with a goal of minimal interruption of the overlying muscles. Maintaining the muscle integrity will be desired to return the patient to their the normal respiratory function. A CT scan will be displayed during the surgery to help with the identification and location of the fractures. Using the reduction forceps from the fixation set, the reduction of the fractures will be made, and a plate will be selected. (Plates in the rib fixation system are pre-contoured to follow the natural curvature of a rib, are designed for both the left and right chest and have a length to cover multiple fractures of the individual rib. Plates can be bent or cut as needed.) The selection of the plate will be made to allow fixation with at least three screws above and below the fracture. A small incision will be made in the intercostal space above the fracture to allow a caliper to be inserted to measure the rib thickness. The surgeon will need avoid damage to the nerve bundles that lie along the inferior border of the rib if possible.

Once the plate fits to the surgeon's satisfaction, and the thickness has been measured, the surgeon will drill the first hole and place a screw. This process will be repeated until the surgeon is satisfied that the reduction and stabilization of the fracture has been achieved. The use of a 90-degree, or right-angle, drill and screwdriver specially designed to complement the fixation system may be used for hard-to-reach spaces.[4]

A pain management catheter will be inserted in the subscapular space (above the ribs, but below the latissimus and serratus muscles) for pain control during the hospital stay. An additional pain management system utilizing silver nitrate to freeze the nerve bundle also may be used, which will act as a long-term pain management.

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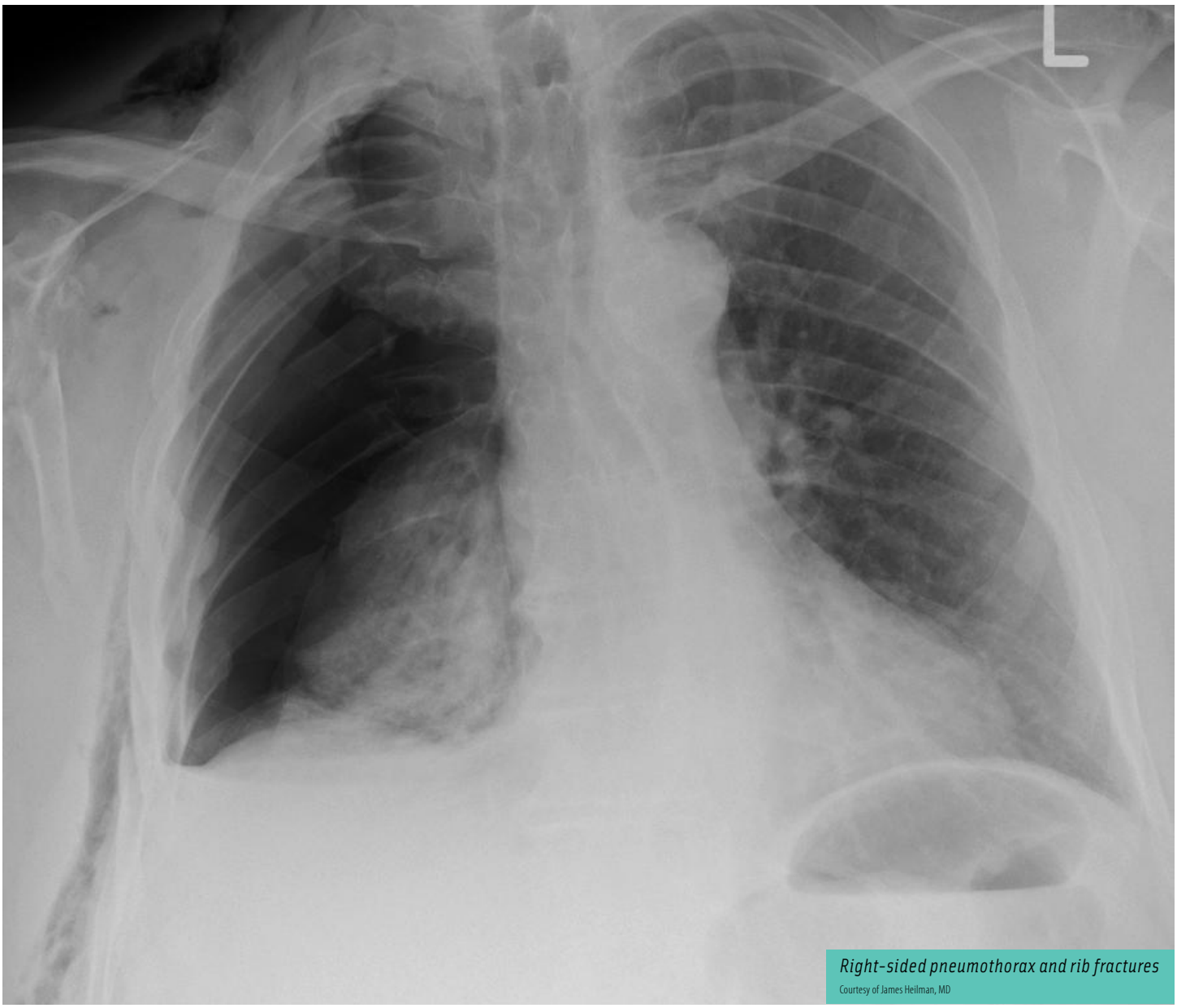

Right-sided pneumothorax and rib fractures
Courtesy of James Heilman, MD

After the surgeon has achieved hemostasis, any muscles will be closed with a 0 polyglactin 910 suture and the dermis will be closed with 2-0 polyglactin 910 sutures. A final count of softs and instruments will need to be completed when closure begins, with an additional soft count performed before the final skin closure. The skin will be closed with a skin stapler, and sterile dressings will be placed over the incision sites.

An X-ray of the surgical area will be taken before the patient is extubated to ensure reduction of their fractures. The surgical technologist will need to maintain sterility of their Mayo stand and backtable until the patient is safely out of the OR suite.

Another consideration the OR team will need to be aware of is if the patient needs to undergo a bilateral fixation. In this case, the patient may need to be repositioned for a second and separate surgery if their fractures need repair on the opposite sides of the ribs. If this is the case, the surgical technologist will need to anticipate additional draping supplies, gloves and gowns, and soft goods such as laps and sutures. The circulating nurse and surgical technologist will need to complete all counts on the initial side, and maintain sterility of the Mayo stand and backtable while the patient is repositioned and prepped for the second repair. During the closure and counting, and repositioning of the patient, it is advised that the surgical technologist and circulating nurse not be relieved and remain in the OR suite to ensure that no inadvertent contamination of the area occur and all supplies have been accounted for from the initial surgery.

Unless other injuries to the patient require additional stay and attention, the patient can be transferred to the medical intensive care unit for observation and pain control.

AUTHOR BIO

Julie Beard, CST, has worked as a surgical technologist for 12 years, all at Denver Health Hospital in Denver, Colorado, with eight of those years as the chief surgical tech for general surgery.

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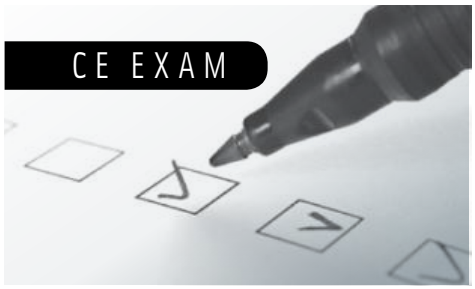

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Surgical Rib Fixation

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1. The thoracic cage is comprised of:
a. The sternum
b. The ribs
c. The xiphoid process
d. All of the above

2. Which set of ribs are called false ribs?
a. 1-7
b. 8-12
c. 8-10
d. 11 and 12

3. The ribs have three sections. Which of the following is not one of them?
a. The shaft in between the ribs
b. The posterior vertebral
c. The costal cartilage
d. The anterior

4. Which muscle is fan-shaped?
a. The diaphragm
b. The triangularis sterni
c. The levatores costarum
d. The pectoralis major

5. Which sets of ribs are most likely to break due to blunt force injury?
a. 11 and 12
b. 3-10
c. 8-11
d. 1 and 2

6. A flail chest is when at least ___ ribs fracture in more than ___ places.
a. 1, 2
b. 3, 4
c. 3, 1
d. 3, 2

7. If a chest tube needs to be inserted, it will be placed in the intercostal space between the ___ and ___ space.
a. Third and fourth
b. Fifth and sixth
c. Seventh and eighth
d. Tenth and eleventh

8. Which instrument will reduce the fractures?
a. Self-retaining retractor
b. A drill system
c. Reduction forceps
d. Bookwalter retractor

9. When multiple, sequential ribs are fractured, patients are at risk for developing (a) _____?
a. Pneumothorax
b. Hemothorax
c. Pneumonia
d. Chest wall deformities

10. The levatores costarum muscles begin at the _____.
a. Eleventh dorsal vertebrae
b. Third external intercostal
c. Seventh cervical vertebrae
d. Both a and c

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