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Review Article

A Few Words about Ribs

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Abstract

The skeletal system is one of the least appreciated organ systems in our body. Bones are usually considered quite static and do not contribute much to overall health. However, the bones are one of the most dynamic organs in the body and are constantly changing to help the body cope with the pressures they encounter. The ribs are long, slender, curved bones. Human bing, regardless of gender, has 12 pairs of ribs (or 24 ribs). The first seven are cartilaginally associated with the sternum. The next three pairs, known as "false ribs," share a cartilaginous attachment to the sternum. The last two pairs are called liquid or vertebral ribs because they are related only to the spine and not to the sternum or cartilage of the sternum. Some people miss one of the last two pairs of ribs, while some have a third pair. Rib removal is a surgical procedure for the separation of ribs for therapeutic or cosmetic reasons. The chest is separated from the abdominal cavity by a pulmonary diaphragm that also regulates respiration.

Keywords: *Ribs; Bones; Thorax*

Introduction

A hollow medullary cavity filled with yellow marrow runs the length of the diaphysis of a long bone [1].

Bone is one of the hardest substances found in the human body, second only to the enamel of the teeth [2]. However, bone is also a living tissue, undergoing constant change. It consists of cells embedded in an abundant, hard intercellular material.

The functions of bone include (1) structural support for the mechanical action of soft tissues, such as the contraction of muscles and the expansion of lungs, (2) protection of soft organs and tissues, as by the skull, (3) provision of a protective site for specialized tissues such as the blood-forming system (bone marrow), and (4) a mineral reservoir, whereby the endocrine system (the group of ductless glands that secrete hormones) regulates the level of calcium and phosphate in the circulating body fluids.

Cage

The rib cage, or thoracic basket, consists of the 12 thoracic (chest) vertebrae, the 24 ribs, and the breastbone, or sternum [2].

Cartilage is a resilient, semirigid, avascular type of connective tissue that forms parts of the skeleton where more flexibility is necessary (e.g. the costal cartilages that attach the ribs to the sternum) [3]. The articulating surfaces of bones participating in a synovial joint are capped with articular cartilage, which provides smooth, low-friction gliding surfaces for free movement of the articulating bones. Cartilage is avascular and therefore its cells obtain oxygen and nutrients by diffusion. The proportion of bone and cartilage in the skeleton changes as the body grows; the younger a person is, the greater the contribution of cartilage. The bones of a newborn infant are soft and flexible because they are mostly composed of cartilage.

Ribs

The 12 ribs of the thorax are divided into true and false ribs [4]. The first seven ribs are true ribs as they form a complete loop between the sternum and vertebrae. The lower five ribs are considered false ribs as they do not fully reach the sternum anteriorly. Of these lower five ribs, ribs 7 through 10 connect to the cartilage of the rib above them and therefore connect to the sternum indirectly. Ribs 11 and 12 are considered floating ribs.

Ribs 3 through 10 each have a head, neck, and body and are considered typical ribs. Typical ribs (with the exception of rib 10) have two articulations on the head, one connected to the vertebra of the same level and the other connected to the vertebra one level superior. At the junction of the head and neck, there is a tubercle that articulates with the transverse process of the associated vertebra. After the tubercle, the body of the rib continues and at the costal angle starts to wrap around anteriorly heading toward the sternum. The costal angle also marks the lateral extent of the attachment of the deep back muscles. Anteriorly ribs 1 through 6 will connect to the sternum, while ribs 7 through 10 will connect indirectly through their fused cartilages. The remaining ribs (ribs 1 - 2 and 11 - 12) are considered atypical ribs. The first rib is very broad and sharply curved. Its head articulates only with the first thoracic vertebra. The second rib is thinner and slightly less curved, and its head articulates with both the first and second thoracic vertebrae. Ribs 11 and 12 have single articulations with their associated vertebrae and are short, have no neck, and are free-floating.

Fractures

Rib fractures can disrupt the very specific structure of the thoracic cage and therefore interfere with the function of respiration [4]. Rib fractures are also a marker of injury severity. Not only can the rib fractures themselves cause pain with respiration leading to splinting, inability to clear secretions, and pneumonia, but rib fractures can also be a sign of other underlying injuries. Fractures of the first rib are significant because of the high kinetic energy necessary to fracture these ribs. While an isolated, non-displaced first rib fracture is only associated with a 3% vascular injury rate, any other findings such as a concomitant head, thoracic, abdominal, or long bone injury increase this risk to 24%. If the first rib is displaced posteriorly, the fracture involves the subclavian sulcus, there is any evidence of brachial plexus injury, or there are abnormal findings on chest roentgenogram (widened mediastinum, apical capping, hemothorax, tracheal deviation, left main stem bronchus depression, widened paratracheal stripe, loss of the aortopulmonary window, or an abnormal aortic contour), a subclavian artery or aortic injury needs to be ruled out. Second rib fractures are also associated with underlying neurovascular injury and should be treated similarly. Fractures of ribs four through nine may be associated with underlying injuries to the heart, lungs, or bronchi. Although associated abdominal solid organ injury has been classically associated with fractures of ribs 10 through 12, a recent study demonstrates that patients with fractures involving ribs 5 through 12 are at risk for solid organ injury in the abdomen. Furthermore, rib fractures have been associated not only with thoracic injuries but extra-thoracic injuries as well.

Single rib fractures without associated injuries may be safely managed on an outpatient basis in select patients [5]. The adequacy of pain control, reliable follow-up, frailty index, and associated morbidity should be considered. Patients with a higher frailty index, significant morbidity, or poorly controlled pain may require hospitalization or admission to a rehabilitation facility.

Once the diagnosis of multiple rib fractures has been made, the patient's age, trauma burden, and number of ribs fractured are integral to the patient's disposition. Patient's older than 45 with four or more rib fractures should be admitted to a monitored setting. This may either be an intensive care unit (ICU) or an intermediate care unit where the patient's respiratory status may be closely monitored. Patients older than 65 with two or more rib fractures should be treated in a similar manner.

The chest wall of the child is highly elastic and therefore fractures of the rib in children are rare [6].

Injuries

The present is an exciting time in the management of chest wall injuries [7]. Prior to this decade, the approach to such injuries had been somewhat nihilistic, centered upon support of respiratory function using mechanical ventilation as well as analgesia achieved primarily

with narcotics. These strategies have unfortunately lead to the frequent and iatrogenic complications of pneumonia and prolonged respiratory failure in the case of the former and substance abuse and addiction in the case of the latter.

The recognition of the dangers of both prolonged mechanical ventilation and narcotic use has fueled a burst of ingenuity surrounding the management of patients with chest wall injuries. Furthermore, advances in technology have allowed for the creation of rib-specific fixation systems, providing a tailored operative option for select patients with the most severe chest wall injuries. Finally, healthcare providers involved in the management of rib fracture patients have broadened to include additional surgical disciplines, such as orthopedic and thoracic surgery, as well as physical therapists, anesthesiologists, rehabilitation medicine physicians, respiratory therapists, and pulmonologists.

Many of these advancements, however, remain in their infancy and are still met with resistance from practitioners rooted in the aforementioned traditional mentality. Organization and cohesion of the rapidly developing knowledge surrounding rib fractures remains a challenge.

Fixation

Despite the resurgence of research supporting operative rib fixation and the evolving technology in this field, surgeons are still underutilizing rib fixation in patients with severe thoracic trauma [8]. One reason for this is that there are currently no absolute or universally accepted indications for operative rib fixation and there is significant variation in the quality of evidence for its relative indications. The primary aims of operative rib fixation are to decrease the duration and intensity of respiratory support by improving pulmonary mechanics, reducing pain, and preventing restrictive lung pathology associated with severe chest wall deformity. Critics argue that the current literature on the benefits of operative rib fixation is based on three small randomized controlled trials (RCTs), a few prospective studies, and several retrospective studies. Additionally, there is concern that long-term outcomes after rib fixation are unknown. Finally, it is difficult to differentiate the outcomes of patients with specific rib fracture patterns given no studies include only non-flail chest patients or subgroup analyses.

Conclusion

The function of the ribs is threefold. First, they provide protection for the lungs and heart. The ribs, more or less, formed a cage around these very important organs. Second, they are one of the few bones that continue to produce red bone marrow (and thus blood cells) in adults. Third, they serve as a site of attachment to the pectoral muscles involved in breathing. The largest part of the ribs is the bony part, and the smaller part is the cartilage with which the ribs bind to the sternum. Each rib is distinguished by a rib head located at the back and containing an articular surface for attachment to the vertebrae. Since the ribs are wrapped in an arch, this bending angle is called angulus costae. The rib body ends in cartilage. Each rib is distinguished by one groove through which blood vessels and nerves pass.

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