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Case Report

Ultrasound Identifies First Rib Stress Fractures: A Case Series in National Collegiate Athletic Association Division I Athletes

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Isolated first rib stress fractures in athletes are thought to be rare. In this case series, 3 National Collegiate Athletic Association Division I athletes developed isolated first rib stress fractures over the span of 1 year, indicating that these injuries may occur more often than previously understood. These fractures can be easily missed because of the low incidence, lack of clinical suspicion, and vague presentation. Further, radiographs can fail to reveal such fractures. To our knowledge, this is the largest case series of athletes with first rib stress fractures presenting with vague rhomboid interscapular pain. We also demonstrated that ultrasound successfully visualized these injuries; in the hands of an ultrasonographer or clinical provider trained in musculoskeletal ultrasound, this technique offers an advantageous point-of-care screening imaging modality.

Key Words: shoulder pain, rhomboid pain, interscapular pain, diagnostic ultrasound

Key Points

- First rib stress fractures in athletes may not be as rare as previously believed and should be considered in cases of vague, persistent pain over the rhomboid interscapular region that does not improve with rest.
- Such injuries may be radiographically subtle or occult, and ultrasound may be an advantageous point-of-care screening imaging modality.

Stress fractures of the first rib have been considered rare but more prevalent in athletes in sports with repetitive throwing or overhead motions, such as baseball or softball.[1–3] These fractures tend to be initially discovered on radiographs (XRs) and then further delineated by computed tomography (CT) imaging.[2,3] However, the incidence may not be as low as previously thought. Radiographs may not reliably diagnose these fractures, and other imaging modalities may better aid detection. The purposes of this clinical case series were to present key features associated with first rib fractures in athletes that may aid in injury recognition and outline the potential diagnostic utility of point-of-care ultrasound.

Case Series Presentation

This case series consisted of 3 National Collegiate Athletic Association Division I intercollegiate athletes at a single university in a 1-year period.

Case 1. A 21-year-old left-handed female soccer midfielder presented with a 1-month history of insidious posterior left shoulder pain at the rhomboids interscapular region, which was slowly migrating anteriorly. She denied any traumatic injury. At the time of evaluation, the pain severity was 5/10 at rest and could increase to 7/10. All activity worsened the pain, particularly ipsilateral shoulder active range of motion (ROM). On examination, diffuse pain limited left shoulder active ROM, but on passive ROM, a glenohumeral internal-rotation deficit was also noted. She had tenderness to palpation of the left trapezius, splenius capitis, levator scapulae, posterior deltoid, and rhomboid interscapular region (diffusely including the origin, midmuscle, and insertion of the rhomboid major and minor). Rotator cuff testing was normal except for pain with the empty can test. The Hawkins, Neer, and O'Brien tests were negative. Neck ROM was full without pain, upper extremity strength was full, sensation was intact, and the Spurling test was negative.

A complete blood count, comprehensive metabolic panel, and thyroid stimulating hormone level were ordered to evaluate causes of frozen shoulder and were normal. Shoulder XRs were concerning for a nondisplaced stress fracture at the lateral aspect of the left first rib (Figure 1A). Noncontrast CT of the chest with 3-dimensional reconstruction confirmed the diagnosis (Figure 1B). Dual-energy x-ray absorptiometry (DEXA) was normal. Laboratory screening for relative energy deficiency in sport was normal except for a low vitamin D level. Return to sport was

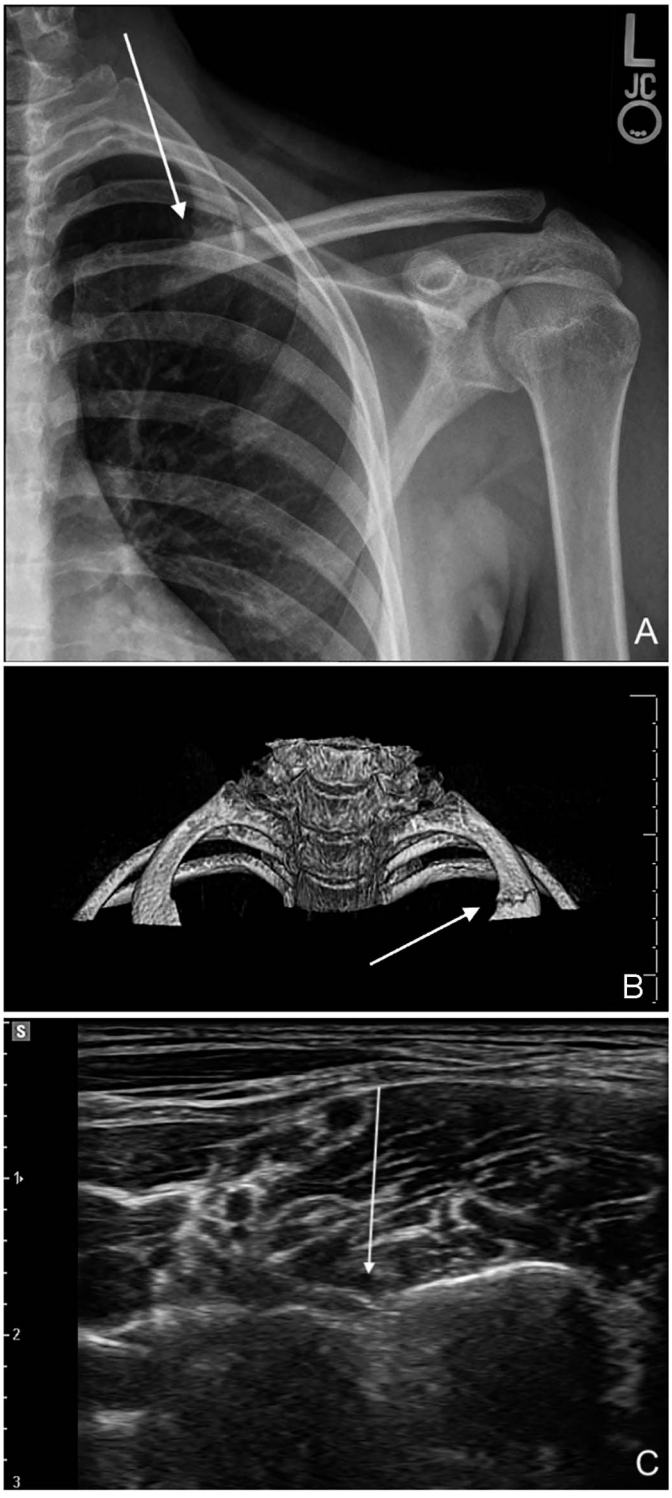

Figure 1. Isolated stress fracture of the left first rib in a 21-year-old female soccer player. A, Shoulder radiograph shows a subtle linear lucency and cortical irregularity at the lateral aspect of the left first rib. B, Noncontrast chest computed tomography with a 3-dimensional reconstructed image demonstrates a nondisplaced stress fracture at the lateral aspect of the left first rib (arrow). C, Bedside ultrasound reveals a cortical irregularity of the first rib (arrow).

prolonged due to multiple recurrences of pain despite rest periods of 2 weeks or longer. The first instance was during week 3 of the running progression, which involved 15 minutes of daily treadmill running for 3 days; the second instance occurred after the athlete's strength coach incorporated upper body kettlebell and weighted activities; the third instance was after the patient unloaded a car; and the fourth instance took place months into the protracted running progression. Follow-up examination with musculoskeletal ultrasound revealed cortical irregularity of the first rib at the site of maximal pain (Figure 1C) during sonopalpation of the brachial plexus. Eight months after initial presentation, the athlete ultimately underwent brachial plexus hydrodissection with immediate resolution of pain and successfully returned to full play thereafter.

Case 2. A 19-year-old right-handed male water polo athlete presented with 2 months of right posterior shoulder pain without a preceding traumatic injury. The pain was not present at rest but could reliably be reproduced with active upper extremity movement. Before his visit to the sports medicine clinic, he had improved somewhat with 2 weeks of light activity and physical therapy, but the pain worsened again as he increased activity. The XRs of the right shoulder (Figure 2A) and ribs and magnetic resonance imaging of the right shoulder were read as normal. After this imaging, he began improving, but the pain acutely worsened after an incident in which his neck was forced into flexion. He presented to the sports medicine clinic after this exacerbation. On examination, the right shoulder ROM was full, although he had mild discomfort at the posterior shoulder with full abduction. The right rhomboid major interscapular region was tender to palpation. Rotator cuff, biceps, and labral tests; neck ROM; and cervicothoracic spine palpatory examination were normal.

Point-of-care ultrasound (Figure 2B) demonstrated cortical irregularity of the lateral right first rib. Retrospective review of the original XRs by the treating physician revealed a subtle cortical irregularity of the right first rib at the site of maximal pain. Subsequent CT of the chest without contrast (Figure 2C) confirmed a nondisplaced stress fracture of the lateral aspect of the right first rib, corroborating the ultrasound findings. He progressed to full play over 8 weeks without difficulty.

Case 3. A 19-year-old left-handed male water polo keeper presented to the sports medicine clinic with 2 weeks of insidious onset of posterior left shoulder pain, severity of 3/10, with active upper extremity movement. Before his clinic evaluation, he was treated by his athletic trainer for a rhomboid strain, and his pain severely worsened while executing "power clean" weightlifting maneuvers, after which he reported to the emergency department. While there, he underwent chest XRs (Figure 3A), shoulder XRs, and noncontrast CT of the chest (Figure 3B). Imaging indicated a nondisplaced fracture of the lateral aspect of the left first rib. On examination in the sports medicine clinic 2 weeks after the emergency department evaluation, he had full ROM of his left shoulder without pain but displayed persistent tenderness to palpation of the left rhomboid major interscapular region. Rotator cuff, biceps, and labral testing and neck ROM were normal. Musculoskeletal ultrasound demonstrated the left first rib fracture with a characteristic cortical step-off (Figure 3C). At 4 to 5 weeks postinjury, activities of daily living were nearly pain free, but mild discomfort of the left rhomboid interscapular region occurred if he "stretched too far." Repeat ultrasound examination revealed callus formation at the fracture site consistent with fracture healing (Figure 3D). At 6 weeks postinjury, he was allowed to resume weighted activities and followed a rapid progression, which he tolerated well.

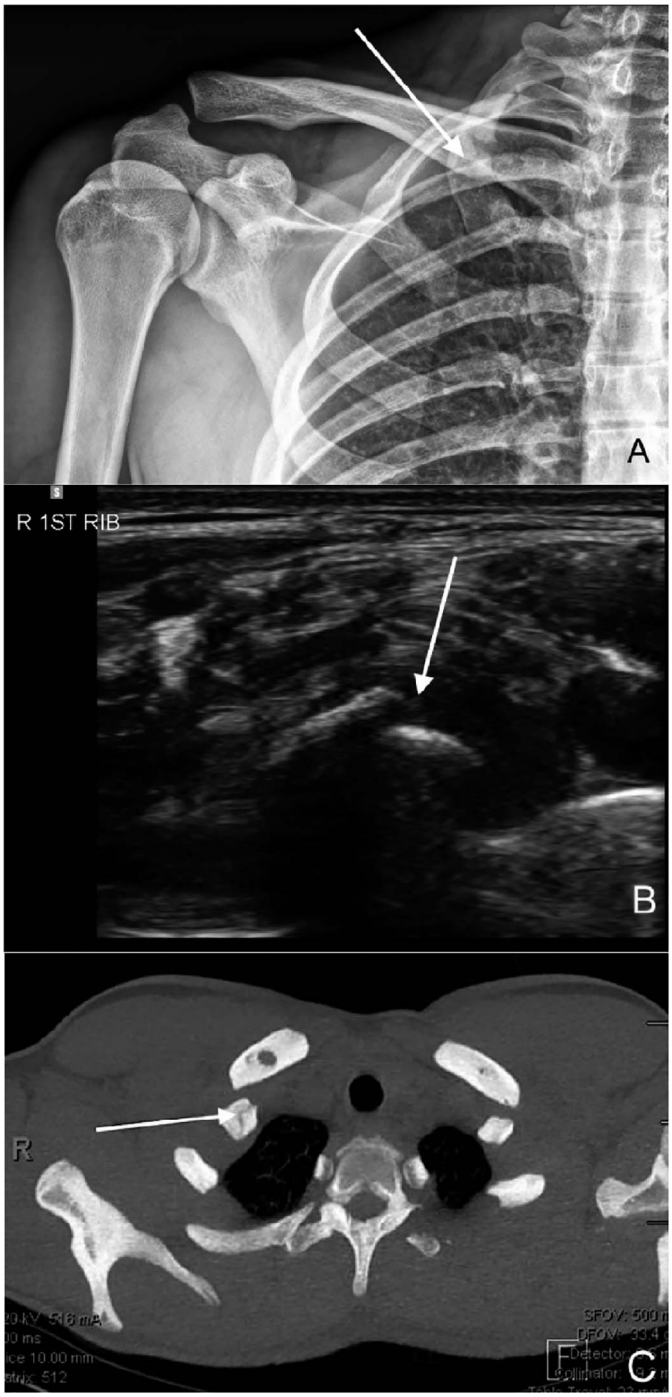

Figure 2. Isolated stress fracture of the right first rib in a 19-year-old male water polo player. A, Shoulder radiograph shows a subtle linear lucency at the lateral aspect of the right first rib (arrow), initially misread as normal. B, Point-of-care ultrasound performed 2 weeks later demonstrates cortical irregularity of the right first rib (arrow). C, Axial chest computed tomography without contrast performed after the ultrasound confirms the nondisplaced right first rib fracture (arrow).

Figure 3. Isolated stress fracture of the left first rib in a 19-year-old male water polo player. A, Chest radiograph (zoomed in) shows a nondisplaced fracture at the lateral aspect of the left first rib (arrow). B, Coronal chest computed tomography chest with contrast (zoomed in) demonstrates the nondisplaced fracture of the left first rib (arrow). C, Musculoskeletal ultrasound reveals the cortical step-off at the left first rib (arrow). D, Repeat ultrasound indicates callus formation at the fracture site (arrow), consistent with fracture healing.

DISCUSSION

Stress fractures are common in athletes, but isolated stress fractures of the first rib are comparatively uncommon and thought to be rare. First rib stress fractures have been reported among athletes participating in a variety of sports.[1–14] However, the incidence is highest in athletes

playing sports that demand repetitive throwing or overhead motions, such as baseball and softball.[1–14] In this case series, we describe 3 Division I athletes participating in sports that are less typical for isolated first rib stress fractures (1 in soccer, 2 in water polo) who presented with these fractures within a 1-year period, suggesting that this injury may occur more often than previously assumed.

Classically, first rib fractures were thought to affect the mid-body segment at the subclavian sulcus due to repetitive contraction and opposing forces of the anterior and middle scalene muscles against the serratus anterior muscle.[1,2,5] Combined with the rib's broad and flat shape, these factors made this a particularly vulnerable section of the bone.[1,2,5] However, Kawashima et al[4] and Funakoshi et al[3] found and proposed classification systems for 3 main fracture line morphologies and locations. They also suggested that different mechanisms may be associated with the various fracture types: Kawashima et al[4] hypothesized that types 1 and 2 were caused by the mechanism detailed earlier in our report, whereas type 3 may be caused by repetitive contact of the clavicle with the first rib during motions such as the late cocking phase of pitching or snatching in weightlifting. Interestingly, both Kawashima et al[4] and Funakoshi et al[5] determined that *type 2* (a center-to-posterior oblique fracture starting just posterior to the anterior scalene and running obliquely across the groove) and the *intrascalene type* (the fracture is within the insertion of the middle scalene) injuries were the most common. In comparison, all 3 of our cases appeared to be *type 1* (a center-transverse fracture starting just posterior to the anterior scalene and running laterally across the groove for the subclavian artery) or *groove type* (the fracture line runs along the subclavian artery groove) injuries. A question is how the fracture pattern correlates with the mechanism. Case 1's sport did not involve any throwing or overhead activity or any specific activity risk factor outside of sport. However, the athlete had a history of multiple bony stress injuries and prior disordered eating, which may have been predisposing factors. Cases 2 and 3 were both water polo athletes with unknown mechanisms of injury. Water polo does involve throwing, though both athletes identified specific episodes associated with acute pain (forced sudden neck flexion in case 2 and during a weightlifting "power clean" in case 3). Increased awareness and diagnosis of first rib stress fractures and further biomechanical studies may be beneficial to elucidate the mechanisms for these fractures.

The reason for the rhomboid interscapular pain in these athletes with center-transverse fracture types is unclear. Possible explanations relate to the dorsal scapular nerve (DSN). The DSN, which provides innervation to the rhomboid muscles, traverses the middle scalene muscle and runs near the first rib before exiting the neck region to its final endpoint along the medial border of the ipsilateral scapula. Although the DSN does not course over the central or lateral aspect of the first rib, it may run near enough that a fracture at this location causes local swelling and inflammation that might affect the DSN. Alternatively, the DSN may become entrapped by contraction or muscular hypertrophy of the middle scalene muscle. Further research into the pathophysiological explanation by which a center-transverse first rib fracture causes rhomboid interscapular pain is needed.

These isolated first rib stress fractures can be overlooked due to the low incidence (and thus low level of clinical suspicion) and vague clinical presentation. In many cases, patients have neck or shoulder pain and tenderness to palpation of or around the supraclavicular fossa.[5–7,9,10,12] However, some authors[1,2,11–14] have described periscapular or back pain as well. The pain may manifest either acutely or insidiously. To our knowledge, this is the largest case series of athletes presenting with vague rhomboid interscapular pain or tenderness, which was previously thought to be atypical. We suggest an increased level of clinical suspicion for these fractures in athletes who have persistent rhomboid pain that does not improve with rest and physical therapy.

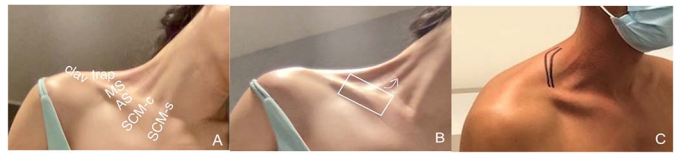

Figure 4. Relevant surface anatomy, ultrasound probe placement, and scanning path for ultrasound evaluation of the first rib. A, Relevant surface anatomy. B, Ultrasound probe placement starting position as indicated by the rectangle. C, Skin marking demonstrating the location of the first rib. Abbreviations: AS, anterior scalene muscle; clav, clavicle; MS, middle scalene muscle; SCM-c, sternocleidomastoid clavicular head; SCM-s, sternocleidomastoid sternal head; trap, trapezius.

When suspicion arises for this fracture, it is important to consider the imaging modality type chosen for further investigation. Chest or shoulder XRs are often obtained, but as seen in case 2 of our series, they may be falsely negative.[7,11] In the series of Funakoshi et al,[3] the visibility of the first rib ranged from impossible to possible for chest XRs and rib XRs, similar for shoulder XRs (though mostly impossible), and definitively possible in cervical spine XRs. Further, they observed that the visibility of the first rib was 46% in shoulder XRs and 97% in cervical spine XRs and thus recommended the latter as the preferred initial imaging modality.[3] Although the American College of Radiology Appropriateness Criteria for bone stress injuries (https://acsearch.acr.org/docs/69435/Narrative) did not specifically recommend the use of musculoskeletal ultrasound of the chest, the document does not comment on the appropriateness of musculoskeletal ultrasound of the neck. Based on our case series and the work of others,[15] we recommend musculoskeletal ultrasound as an alternative imaging approach. Ultrasound displayed excellent ability to visualize the superior cortex of the first rib and confirm the diagnosis of stress fracture, even providing the diagnosis. If the clinician is skilled in using musculoskeletal ultrasound, screening can be immediate and efficient. Ultrasound use for screening may also reduce radiation exposure from multiple XRs. We advise use of a high-frequency linear-array transducer for this examination. The transducer should be placed at the level of the clavicle, just lateral to the insertion of the clavicular head of the sternocleidomastoid. Then, translating the transducer posteriorly and in a cephalad direction, the superior cortex of the first rib is visualized. The entirety of the rib can be surveyed to the costovertebral articulation. A normal first rib displays a uniformly smooth and rounded superior cortex. A fracture is manifested by a cortical step-off, bony callus formation, or both, often with point tenderness on sonopalpation. (The relevant surface anatomy, ultrasound placement, and scanning path are shown in Figures 4 and 5.) Ultrasound

Figure 5. Ultrasound probe placement for scanning the lateral and posterior portions of the first rib in short and long axis.

has been demonstrated as a useful diagnostic modality in the identification of bone stress injuries, allowing optimization of patient care and reductions in costs, time lost due to injury, and complications.[15] Although CT is generally considered the criterion standard for definitive diagnosis of first rib fractures, we propose that in the hands of an ultrasonographer or clinical provider trained in musculoskeletal ultrasound, this technique may specifically be useful as a point-of-care, inexpensive imaging screening method for first rib stress fractures. It can also be used to monitor fracture healing as seen in case 3.

Clinical Bottom Line

First rib stress fractures in athletes may not be as rare as previously believed and should be considered in the athlete with vague, persistent pain over the rhomboid interscapular region that does not improve with rest. First rib fractures may be radiographically subtle or occult. Even though XRs may fail to reveal the diagnosis, musculoskeletal ultrasound can reveal them. As musculoskeletal ultrasound offers rapid imaging without the radiation exposure that accompanies traditional imaging such as XRs or CT, we recommend that ultrasound may be an advantageous point-of-care imaging modality to screen for, or monitor, first rib stress fractures.

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