American College of Radiology
ACR Appropriateness Criteria®
Shoulder Pain–Traumatic

Variant 1: **Traumatic shoulder pain. Any etiology. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
X-ray shoulder	Usually Appropriate	☢
CT arthrography shoulder	Usually Not Appropriate	☢☢☢☢
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MR arthrography shoulder	Usually Not Appropriate	O
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
MRI shoulder without IV contrast	Usually Not Appropriate	O
Tc-99m bone scan shoulder	Usually Not Appropriate	☢☢☢
US shoulder	Usually Not Appropriate	O

Variant 2: **Traumatic shoulder pain. Nonlocalized shoulder pain. Negative radiographs. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI shoulder without IV contrast	Usually Appropriate	O
CT arthrography shoulder	May Be Appropriate	☢☢☢☢
MR arthrography shoulder	May Be Appropriate	O
US shoulder	May Be Appropriate (Disagreement)	O
CT shoulder without IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
Tc-99m bone scan shoulder	Usually Not Appropriate	☢☢☢

Variant 3: **Traumatic shoulder pain. Radiographs show humeral head or neck fracture. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
CT shoulder without IV contrast	Usually Appropriate	☢☢☢
MRI shoulder without IV contrast	Usually Not Appropriate	O
CT arthrography shoulder	Usually Not Appropriate	☢☢☢☢
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MR arthrography shoulder	Usually Not Appropriate	O
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
Tc-99m bone scan shoulder	Usually Not Appropriate	☢☢☢
US shoulder	Usually Not Appropriate	O

Variant 4: **Traumatic shoulder pain. Radiographs show scapula fracture. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
CT shoulder without IV contrast	Usually Appropriate	☢☢☢
MRI shoulder without IV contrast	Usually Not Appropriate	O
CT arthrography shoulder	Usually Not Appropriate	☢☢☢☢
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MR arthrography shoulder	Usually Not Appropriate	O
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
Tc-99m bone scan shoulder	Usually Not Appropriate	☢☢☢
US shoulder	Usually Not Appropriate	O

Variant 5: **Traumatic shoulder pain. Radiographs show Bankart or Hill-Sachs lesion. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MR arthrography shoulder	Usually Appropriate	O
MRI shoulder without IV contrast	Usually Appropriate	O
CT arthrography shoulder	May Be Appropriate	☢☢☢☢
CT shoulder without IV contrast	May Be Appropriate	☢☢☢
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
Tc-99m bone scan shoulder	Usually Not Appropriate	☢☢☢
US shoulder	Usually Not Appropriate	O

Variant 6: **Traumatic shoulder pain. Radiographs normal. Physical examination and history consistent with dislocation event or instability. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MR arthrography shoulder	Usually Appropriate	O
MRI shoulder without IV contrast	Usually Appropriate	O
CT arthrography shoulder	May Be Appropriate	☢☢☢☢
CT shoulder without IV contrast	May Be Appropriate	☢☢☢
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
Tc-99m bone scan shoulder	Usually Not Appropriate	☢☢☢
US shoulder	Usually Not Appropriate	O

Variant 7: **Traumatic shoulder pain. Radiographs normal. Physical examination findings consistent with labral tear. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MR arthrography shoulder	Usually Appropriate	O
CT arthrography shoulder	Usually Appropriate	☢☢☢☢
MRI shoulder without IV contrast	Usually Appropriate	O
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
Tc-99m bone scan shoulder	Usually Not Appropriate	☢☢☢
US shoulder	Usually Not Appropriate	O

Variant 8: **Traumatic shoulder pain. Radiographs normal. Physical examination findings consistent with rotator cuff tear. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI shoulder without IV contrast	Usually Appropriate	O
MR arthrography shoulder	Usually Appropriate	O
US shoulder	Usually Appropriate	O
CT arthrography shoulder	May Be Appropriate	☢☢☢☢
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
Tc-99m bone scan shoulder	Usually Not Appropriate	☢☢☢

Variant 9: **Traumatic shoulder pain. Radiographs already performed. Physical examination consistent with vascular compromise. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
CTA shoulder with IV contrast	Usually Appropriate	☢☢☢
Arteriography shoulder	Usually Appropriate	☢☢☢
US duplex Doppler shoulder	May Be Appropriate	O
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MRA shoulder with IV contrast	Usually Not Appropriate	O
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
MRI shoulder without IV contrast	Usually Not Appropriate	O
Tc-99m 3-phase bone scan shoulder	Usually Not Appropriate	☢☢☢

Variant 10: **Traumatic shoulder pain. Radiographs already performed. Neuropathic syndrome (excluding plexopathy). Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI shoulder without IV contrast	Usually Appropriate	O
Tc-99m bone scan shoulder	May Be Appropriate	☢☢☢
CT shoulder without IV contrast	Usually Not Appropriate	☢☢☢
CT arthrography shoulder	Usually Not Appropriate	☢☢☢☢
CT shoulder with IV contrast	Usually Not Appropriate	☢☢☢
CT shoulder without and with IV contrast	Usually Not Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
MR arthrography shoulder	Usually Not Appropriate	O
MRI shoulder without and with IV contrast	Usually Not Appropriate	O
US shoulder	Usually Not Appropriate	O

SHOULDER PAIN–TRAUMATIC

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Summary of Literature Review

Introduction/Background

Traumatic shoulder pain is shoulder pain believed to be directly attributed to a traumatic event, either acute or chronic. This pain may be the result of either fracture (the clavicle, scapula, or proximal humerus) or soft-tissue injury (most commonly of the rotator cuff, acromioclavicular ligaments, or labroligamentous complex). The incidence of traumatic shoulder injuries is difficult to determine because some injury types, such as low-grade acromioclavicular separations or acute rotator cuff tears, are likely under-reported because patients do not seek immediate medical treatment. However, as with many traumatic injuries, traumatic shoulder pain tends to disproportionately involve young adults and male patients [1,2].

The etiology of traumatic shoulder pain can often be made based on clinical examination, radiographs, and mechanism of injury. Traumatic shoulder injuries can generally be separated into injuries requiring acute surgical management and injuries in which conservative management can be attempted prior to considering surgical treatment. Unstable or significantly displaced fractures and joint instability are injuries most likely requiring acute surgical treatment. Most soft-tissue injuries (such as labral tears and rotator cuff tears) can undergo a period of conservative management prior to considering surgery. However, in addition to the specific imaging findings related to a traumatic injury, indications and timing of surgical treatment of many traumatic shoulder injuries are dependent on patient age, comorbidities, current activity level, and expected activity level.

Imaging of chronic shoulder pain is beyond the scope of this topic and is covered in the ACR Appropriateness Criteria® on “Shoulder Pain–Atraumatic” [3].

Discussion of Procedures by Variant

Variant 1: Traumatic shoulder pain. Any etiology. Initial imaging.

Radiography

Radiographs are the preferred initial study performed in the setting of traumatic shoulder pain. They can delineate shoulder malalignment and most shoulder fractures [4,5]. A standard set of shoulder radiographs for trauma should include at least three views: anterior-posterior (AP) views in internal and external rotation and an axillary or scapula-Y view. Axillary or scapula-Y views are vital in evaluating traumatic shoulder injuries as acromioclavicular and glenohumeral dislocations can be misclassified on AP views [6,7]. Radiographs provide good delineation of bony anatomy to assess for fracture and appropriate shoulder alignment, which are the two primary concerns in management of acute traumatic shoulder pain. Radiographs should also be performed upright since malalignment of the shoulder can be under-represented on supine radiographs [4]. Additional views, such as the Bernageau view, have been shown to be effective in demonstrating the degree of bone loss of the glenoid or humeral head [8].

CT

Computed tomography (CT) is better able than radiographs to characterize fracture patterns [9-11]. However, radiographs are preferred over CT for initial evaluation because radiographs are able to diagnose displaced

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fractures and shoulder malalignment, which are the primary concerns in the initial assessment of shoulder trauma. CT is considered inferior to MRI for diagnosing essentially all soft-tissue shoulder injuries.

CT Arthrography

CT arthrogram, although not the initial study of choice, has the advantage of characterizing both bony lesions and significant soft-tissue injuries. CT arthrograms have been shown to be comparable to magnetic resonance (MR) arthrography in diagnosing Bankart, Hill-Sachs, superior labral anterior-to-posterior (SLAP), and full-thickness rotator cuff tears, but inferior to MR arthrography for diagnosing partial-thickness rotator cuff tears [12], including bursal-sided tears. CT arthrography has also only demonstrated modest agreement between observers in diagnosing anterior capsular laxity of the shoulder [13].

MRI

Noncontrast MR imaging (MRI) has been shown to be effective in assessing bony morphology and bone loss in patients with traumatic shoulder injuries [14-18], and noncontrast MRI is effective in diagnosing most traumatic soft-tissue pathologies including labral, rotator cuff, and glenohumeral ligament injuries [17,19,20].

MR Arthrography

MR arthrography is considered the gold standard for imaging traumatic shoulder pain [4,17,19,21]. MR arthrography is comparable to noncontrast MRI in assessment of extra-articular soft tissues, and MR arthrography has been shown to be superior to noncontrast MRI in diagnosing intra-articular pathology like SLAP tears, labroligamentous injuries, and partial rotator cuff tears [17,19]. MR arthrography is comparable to CT in evaluating traumatic osseous lesions, such as bony Bankart and Hill-Sachs lesions [12,18]. However, the need for an invasive procedure makes MR arthrography a suboptimal initial study.

US

Ultrasound (US) has limited usefulness in patients with traumatic shoulder pain that cannot be localized to the rotator cuff or biceps tendon. US is comparable to MRI in evaluating full-thickness rotator cuff tears and rotator cuff atrophy [17,22,23]. However, US is inferior to MRI in evaluating partial-thickness rotator cuff tears and other intra-articular pathology [17,24]. Diagnosis of proximal humerus fractures by US has been described [25], but US is not generally considered a preferred imaging modality for assessing osseous pathology, which are of primary concern in initial assessment of traumatic shoulder pain.

FDG-PET/CT

Positron emission tomography (PET) (usually using the fluorine-18-2-fluoro-2-deoxy-D-glucose [FDG] tracer) imaging is rarely used in assessment of traumatic shoulder pain. FDG-PET is sensitive for inflammation, and a correlation has been found between radiotracer activity and degree of shoulder pain [26]. However, increased radiotracer activity may be due to infectious, traumatic, inflammatory, or neoplastic processes, making this activity a nonspecific finding. FDG-PET imaging as an isolated modality has relatively poor resolution for pathology localization compared with other imaging modalities; however, FDG-PET imaging can be performed in conjunction with MRI or CT for better localization of radiotracer activity. FDG-PET in combination with CT (FDG-PET/CT) is sensitive for identifying fractures, and it has been shown to be reliable in differentiating benign from malignant pathologic fractures [27]. FDG-PET/CT imaging is not routinely performed for characterization of soft-tissue injuries of the shoulder. Indirect identification of symptomatic rotator cuff tears has been described on FDG-PET/CT by decreased radiotracer activity in the muscles of the torn tendons and increased activity of surrounding shoulder girdle muscles due to muscle recruitment [28,29]. Other soft-tissue injuries, such as labral and cartilage injuries, have not been described using FDG-PET/CT.

Bone Scan

Tc-99m bone scintigraphy is rarely used in the assessment of traumatic shoulder pain. Bone scintigraphy demonstrates increased activity in many post-traumatic shoulder pathologies, such as fracture, rotator cuff tear, or adhesive capsulitis [30]. Bone scintigraphy as an isolated modality has relatively poor resolution for pathology localization compared with other imaging modalities; however, bone scintigraphy can be performed in conjunction with MRI or CT for better localization of radiotracer activity. Bone scintigraphy has sensitivity and specificity comparable to MRI in diagnosis of occult bone fractures, and it can be used to identify other foci of bone involvement in pathologic fractures due to metastatic disease [31,32]. Increased radiotracer activity has been associated with symptomatic rotator cuff tears, but bone scintigraphy appearance of other soft-tissue injuries of the shoulder have not been well described [33].

Variant 2: Traumatic shoulder pain. Nonlocalized shoulder pain. Negative radiographs. Next imaging study.

Appropriately positioned radiographs can exclude shoulder dislocation and most displaced fractures as the etiology for post-traumatic shoulder pain. In the setting of normal shoulder radiographs, the most common causes of post-traumatic shoulder pain are soft-tissue injuries such as rotator cuff and labral tears.

MRI

Noncontrast MRI is a reasonable imaging study in the setting of acute nonlocalized traumatic shoulder pain and noncontributory radiographs. In the acute trauma setting, noncontrast MRI may be preferred to MR arthrography, as acute intra-articular pathology will typically produce significant joint effusion for assessment of intra-articular soft-tissue structures. MRI is the preferred imaging modality in assessing extra-articular soft-tissue traumatic pathology such as capsular and ligament tears [34,35]. MRI is also sensitive for diagnosing bone marrow contusion and has been shown to be beneficial in assessing shoulder physeal injuries in pediatric patients [36,37].

MR Arthrography

MR arthrography has been found to be superior to noncontrast MRI in the diagnosis of labroligamentous and partial-thickness rotator cuff tears [17,19]. In the acute trauma setting, however, noncontrast MRI may be preferred to MR arthrography because acute intra-articular pathology will typically produce significant joint effusion for assessment of intra-articular soft-tissue structures. MRI is the preferred imaging modality in assessing extra-articular soft-tissue traumatic pathology such as capsular and ligament tears [34,35]. MRI is also sensitive for diagnosing bone marrow contusion and has been shown to be beneficial in assessing shoulder physeal injuries in pediatric patients [36,37].

US

US has limited usefulness in patients with traumatic shoulder pain that cannot be localized to the rotator cuff or biceps tendon. In the post-traumatic setting, US has been shown to detect abnormalities, including proximal humeral fractures [25]; however, recent studies on US performed for nonspecific shoulder pain have had conflicting results. US for persistent shoulder pain after trauma has been found to diagnose significant pathology, primarily fractures and rotator cuff tears, in 90% of patients [25]. However, 40% of patients presenting with nonspecific shoulder pain were found to have no significant pathology on US [38]. Additionally, US has been demonstrated to be inferior to MRI in assessment of labroligamentous, osseous, and rotator cuff pathology [17]. US can be considered as a screening tool in patients with persistent nonspecific shoulder pain after trauma, particularly in an older patient population in whom rotator cuff tears are more common. However, a low threshold should be maintained for performing additional imaging in the setting of a noncontributory shoulder US examination.

CT

CT has virtually no usefulness in diagnosing common traumatic soft-tissue injuries such as rotator cuff tears, labroligamentous injuries, and muscle tears. Although CT is the gold standard for diagnosing and characterizing fractures, MRI has been shown to be equivalent to CT in diagnosing the nondisplaced fractures that are typically missed on radiographs.

CT Arthrography

CT is inferior to MRI and US in diagnosing virtually all extra-articular traumatic soft-tissues injuries. CT is considered the gold standard in identifying fractures. However, MRI has shown to be equivalent to CT in assessing bone loss [12,18], and MRI is usually adequate for diagnosing the nondisplaced fractures that are typically missed on conventional radiographs. CT arthrography is able to reliably evaluate for glenohumeral cartilage injury, SLAP tears, and labroligamentous injuries [12,39] but is generally considered inferior to MRI in diagnosing rotator cuff and soft-tissue Bankart lesions [12].

FDG-PET/CT

FDG-PET/CT imaging is rarely used in assessment of traumatic shoulder pain. FDG-PET is sensitive for inflammation, and a correlation has been found between radiotracer activity and degree of shoulder pain [26]. However, increased radiotracer activity may be due to infectious, traumatic, inflammatory, or neoplastic processes, making this activity a nonspecific finding. FDG-PET imaging as an isolated modality has relatively poor resolution for pathology localization compared with other imaging modalities, although, FDG-PET imaging can be performed in conjunction with MRI or CT for better localization of radiotracer activity. FDG-PET in combination with CT is sensitive for identifying fractures, and it has been shown to be reliable in differentiating benign from malignant pathologic fractures [27]. FDG-PET/CT imaging is not routinely performed for characterization of soft-tissue injuries of the shoulder. Indirect identification of symptomatic rotator cuff tears has been described on FDG-PET/CT by decreased radiotracer activity in the muscles of the torn tendons and increased activity of surrounding shoulder girdle muscles due to muscle recruitment [28,29]. Other soft-tissue injuries, such as labral and cartilage injuries, have not been described using FDG-PET/CT.

Bone Scan

Tc-99m bone scintigraphy is rarely used in assessment of traumatic shoulder pain. Bone scintigraphy demonstrates increased activity in many post-traumatic shoulder pathologies such as fracture, rotator cuff tear, or adhesive capsulitis [30]. Bone scintigraphy as an isolated modality has relatively poor resolution for pathology localization compared with other imaging modalities; however, bone scintigraphy can be performed in conjunction with MRI or CT for better localization of radiotracer activity. Bone scintigraphy has sensitivity and specificity comparable to MRI in diagnosis of occult bone fractures, and bone scintigraphy can be used to identify other foci of bone involvement in pathologic fractures due to metastatic disease [31,32]. Increased radiotracer activity has been associated with symptomatic rotator cuff tears, but bone scintigraphy appearance of other soft-tissue injuries of the shoulder have not been well described [33].

Variant 3: Traumatic shoulder pain. Radiographs show humeral head or neck fracture. Next imaging study.

Proximal humerus fractures of the head and neck are relatively common. These fractures have a bimodal age distribution, occurring in young patients as the result of high-energy trauma and older patients with low-energy trauma, such as falls from a standing position. The most commonly used classification for humeral head fractures is the Neer classification system. A complete tear of at least one rotator cuff tendon can be seen in up to 40% of humeral head fractures [40]. However, a delay in repair of rotator cuff tears by up to 4 months has not been shown to have adverse outcomes on rotator cuff repair [41], and immediate diagnosis and treatment of soft-tissue injury in the setting of a proximal humerus fracture may not be required.

CT

Nondisplaced fracture planes and complex bony anatomy can result in underappreciation of the extent of proximal humeral fractures on radiographs. Poor agreement between observers has been shown on grading of humeral head fractures on radiographs [10]. CT is the best examination for delineating fracture patterns and has been shown to be equivocal to MRI in identifying nondisplaced fractures, making it the preferred study for characterizing proximal humeral fractures. Contrast is generally not necessary unless there is concern for arterial injury (see Variant 9). 3-D volume-rendered CT images may be obtained to better characterize fracture patterns and humeral neck angulation, which can affect functional outcomes [42].

CT Arthrography

Arthrography is not routinely performed in conjunction with CT in the evaluation of proximal humeral fractures. In the acute setting, glenohumeral hemarthrosis can obscure soft-tissue structures typically evaluated on CT arthrography, and intra-articular iodinated contrast can obscure intra-articular humerus fracture planes. Because of the high association between humeral head fractures and rotator cuff tears, there may be a role for CT arthrogram in a patient with remote proximal humeral fracture having a suspected rotator cuff tear and contraindication to MRI.

MRI

MRI without contrast is inferior to CT in evaluating fracture planes in complex humerus fracture patterns and is, in general, inferior to CT in characterizing proximal humerus fractures. Although MRI can detect rotator cuff tears associated with proximal humeral fracture [43], any significant rotator cuff tear associated with the humeral head fracture is typically addressed during open reduction and internal fixation of the fracture. However, noncontrast MRI may be useful in assessing rotator cuff integrity in patients with proximal humeral fractures that do not undergo surgical fixation.

MR Arthrography

MR arthrography is not indicated in the acute setting of proximal humeral fractures. In the acute setting of proximal humeral fracture, a significant hemarthrosis is typically present, allowing for adequate distention of the glenohumeral joint for identification of intra-articular pathology on noncontrast MRI. MR arthrography is generally preferred over noncontrast MRI for evaluating soft-tissue injuries in patients with remote proximal humeral fracture and persistent pain [17,19].

US
There is no defined role for US in evaluation of proximal humeral fractures. Although fractures may sometimes be visible on US as areas of cortical interruption, US is unable to reliably characterize fracture patterns. In ideal conditions, US is effective at identifying full-thickness rotator cuff tears that may be associated with humeral head fractures [17,22,44]. However, in the acute setting of humeral head fracture, an US examination of the shoulder is significantly limited by decreased patient mobility and swelling.

FDG-PET/CT
FDG-PET in combination with CT has been shown to be reliable in differentiating benign from malignant pathologic fractures [27]. FDG-PET/CT can be used to further assess suspected pathologic fractures of the proximal humerus.

Bone Scan
Bone scintigraphy has sensitivity and specificity comparable to MRI in diagnosis of occult bone fractures, and bone scintigraphy can be used to identify other foci of bone involvement in pathologic fractures due to metastatic disease [31,32]. Bone scintigraphy can be used to characterize proximal humerus fractures suspected to be due to metastatic disease.

Variant 4: Traumatic shoulder pain. Radiographs show scapula fracture. Next imaging study.

There is no consensus on indications for surgical fixation of scapula fractures. In general, isolated scapula body fractures heal well without surgical fixation, although associated rib fractures or higher injury severity score are associated with worse clinical outcomes and may benefit from more aggressive surgical fixation [45]. Scapula fractures involving the glenoid articular surface or glenoid neck may also require surgical fixation.

CT
Because of the scapula's complex osteology and overlying ribs, scapula fractures can be easily missed or underappreciate on conventional radiographs. CT is the best imaging modality for identifying and characterizing scapula fracture patterns. Intra-articular extension, glenopolar angulation, AP angulation, and lateral border offset can all be better assessed on CT compared with conventional radiographs [46-48]. Contrast is generally not necessary, unless there is concern for arterial injury (see Variant 9). 3-D–reformatted CT images can better visualize scapula fracture displacement and angulation [46].

CT Arthrography
CT arthrography is not routinely performed in the setting of scapula fractures. Intra-articular iodinated contrast can obscure intra-articular fracture lines involving the glenoid neck and articular surface. Acute intra-articular fractures are typically associated with significant hemarthrosis, which can limit evaluation of soft-tissue structures on CT arthrography.

MRI
MRI has limited usefulness in assessing scapular fractures. The thin cortex and sparse medullary cavity of the scapula body can make diagnosis of scapula body fractures difficult on MRI [49]. Typical shoulder-specific coils used for MRI are also unable to cover the entire scapula, requiring use of body coils with a larger field of view, which then results in suboptimal resolution for evaluation of scapular fracture displacement and angulation.

MR Arthrography
There is no role for an MR arthrogram in evaluation of scapula fractures.

US
There is no role for US in evaluation of scapula fractures.

FDG-PET/CT
FDG-PET/CT has been shown to be reliable in differentiating benign from malignant pathologic fractures [27]. FDG-PET/CT can be used to further assess suspected pathologic fractures of the scapula.

Bone Scan
Bone scintigraphy has sensitivity and specificity comparable to MRI in diagnosis of occult bone fractures, and bone scintigraphy can be used to identify other foci of bone involvement in pathologic fractures due to metastatic disease [31,32]. Bone scintigraphy can be used to characterize scapula fractures suspected to be due to metastatic disease.

Variant 5: Traumatic shoulder pain. Radiographs show Bankart or Hill-Sachs lesion. Next imaging study.

Bankart and Hill-Sachs lesions are common findings associated with transient shoulder dislocation. Bankart lesions have a particularly high association with transient shoulder dislocations [50], and a transient shoulder dislocation should be presumed if a Bankart lesion is present. A close association exists between Bankart and Hill-Sachs lesions [51], and one should be sought out whenever the other is identified on radiographs. Both Bankart and Hill-Sachs lesions can present as nonosseous lesions that are occult on radiographs and noncontrast CT.

MRI

Similar to MR arthrography, noncontrast MRI is comparable to CT in evaluating glenoid and humeral head bone loss [12,18]. In general, noncontrast MRI performs well in diagnosing labroligamentous injuries [20,52]. However, noncontrast MRI is considered inferior to MR arthrography for assessing labroligamentous pathology frequently associated with Bankart and Hill-Sachs lesions [17,19]. Noncontrast MRI is a good alternative to MR arthrography in the setting of acute injury when significant glenohumeral joint effusion is present to assist in visualization of intra-articular soft-tissue pathology.

MR Arthrography

MR arthrography is the preferred study for evaluating subacute or chronic Bankart lesions because of its soft-tissue contrast. Multiple studies have shown MR arthrography to be reliable in diagnosing labroligamentous injuries [12,17,52] and superior to noncontrast MRI for this indication [17,19]. MR arthrography has been shown to be equivalent to CT in the assessment of glenoid and humeral head bone loss [12,18], while being superior to CT in assessment of labroligamentous injuries [12]. MR arthrography is also able to delineate humeral head and glenoid cartilage, which can be important because some Hill-Sachs lesions affect cartilage only [11].

CT

Noncontrast CT has historically been used to assess Hill-Sachs and bony Bankart lesions. However, MRI has been shown to be equivalent to CT for assessing both glenoid and humeral head bone loss [12,18,53], and CT is limited in the assessment of cartilaginous Hill-Sachs lesions [11]. In addition, CT cannot assess injury to soft-tissue structures like the labroligamentous complex, which further limits its usefulness in evaluating Bankart lesions. CT should be reserved for patients with a contraindication to MRI or patients in whom MRI assessment of bone loss is limited.

CT Arthrography

CT arthrography has shown fair agreement between observers and is comparable to MR arthrography in diagnosing Bankart and Hill-Sachs lesions [12,13]. However, CT arthrography is inferior to MRI in diagnosing other soft-tissue pathology [12]. CT arthrography can be considered a reasonable imaging alternative in patients with contraindication to MRI.

US

There is no role for US in assessment of Bankart or Hill-Sachs lesions. US has been demonstrated to be inferior to MRI in diagnosing both labroligamentous injury and Hill-Sachs lesions [17].

FDG-PET/CT

There is no role for FDG-PET/CT in assessment of Bankart or Hill-Sachs lesions.

Bone Scan

There is no role for bone scintigraphy in assessment of Bankart or Hill-Sachs lesions.

Variant 6: Traumatic shoulder pain. Radiographs normal. Physical examination and history consistent with dislocation event or instability. Next imaging study.

Shoulder dislocation or instability is most common in the anterior direction. Younger patients are more likely to have labroligamentous injury and persistent instability after dislocation compared with older patients [54]. Older patients are more likely to have rotator cuff tears in association with shoulder dislocation [55]. Coexisting humeral avulsion of the glenohumeral ligament and significant glenoid bone loss have been found in up to 10% of patients with recurrent shoulder instability [56], which underscores the need to assess both osseous and labroligamentous pathology in patients with shoulder dislocation or instability. Glenoid morphology and bone loss can play a significant factor in recurrent shoulder dislocations [15,16,57], which may require bone grafting in order to restore stability [57].

MR Arthrography

MR arthrography is the preferred examination for the evaluation of subacute shoulder dislocations or recurrent shoulder instability. MRI has been shown to have similar performance to CT in the evaluation of Hill-Sachs lesions and glenoid bone loss [12,18]. MR arthrography has also been found to be reliable in diagnosing anterior shoulder instability and labroligamentous injuries [58,59]. MR arthrography has specifically outperformed noncontrast MRI in assessment of glenohumeral ligament and anterior labral injuries [17,19], which are commonly seen in shoulder instability. MR arthrography has also outperformed noncontrast MRI in diagnosis of rotator cuff tears [17,19], which is a common associated finding in older patients with shoulder dislocation. However, high sensitivities reported for MR arthrography in the detection of labral pathology may not be applicable to patients with clinically unstable shoulders. A retrospective review of 90 patients with clinically unstable shoulders selected for arthroscopy [60] found that MR arthrography had a sensitivity of 65% for detection of labral tears. The authors proposed that this discrepancy with prior studies was the result of different patient selection criteria (clinically unstable in their study versus less-specific symptoms such as shoulder pain in others) and the interpretation of MR arthrography by experienced musculoskeletal radiologists [60]. For this document, it is assumed the procedure is performed and interpreted by an expert.

MRI

MRI without contrast may be preferred to MR arthrography in the setting of acute shoulder dislocation when a post-traumatic joint effusion is present to provide sufficient visualization of soft-tissue structures. In the subacute or chronic setting, the glenohumeral joint effusion is usually too small to provide adequate joint distention for optimal assessment of soft-tissue structures. Noncontrast MRI has been shown to be inferior to MR arthrography in diagnosing labroligamentous and rotator cuff injuries [17,19]. Noncontrast MRI performs comparably to CT in evaluating glenoid and humeral head bone loss [12,18], which may obviate the need for noncontrast CT.

CT Arthrography

CT arthrography is effective in evaluation of shoulder instability. CT arthrography is comparable to MR arthrography in the diagnosis of Bankart and Hill-Sachs lesions [12], and moderate agreement has been found between readers for diagnosing anterior capsule laxity on CT arthrography. However, CT arthrography has been shown to be inferior to MR arthrography in assessing partial-thickness rotator cuff tears [12], which makes CT arthrography less desirable in older patients with dislocation/instability where rotator cuff tears are common. CT arthrography may be considered in a patient with shoulder dislocation/instability and contraindication to MRI.

CT

Noncontrast CT has historically been performed to assess bone loss in patients with recurrent dislocation or chronic instability. However, recent studies have shown MRI to be equivalent to CT in assessment of glenoid and humeral head bone loss [12,18], which places in question the need for noncontrast CT in the assessment of shoulder instability. Noncontrast CT is also unable to assess rotator cuff and labroligamentous pathology commonly seen in shoulder dislocations/instability. In general, CT should be reserved for patients with a contraindication to MRI or patients in whom MRI assessment of bone loss is limited.

US

There is no defined role for US in the assessment of shoulder dislocation or instability. There is a potential limited role for use of dynamic US in assessing Hill-Sachs lesion engagement [61]. However, this is not common practice, and US has been shown to be inferior to MRI in diagnosing the common structural abnormalities associated with shoulder instability, such as labroligamentous injuries, Hill-Sachs lesions, and partial rotator cuff tears [17].

FDG-PET/CT

There is no role for FDG-PET/CT in assessment of shoulder instability.

Bone Scan

There is no role for bone scintigraphy in assessment of shoulder instability.

Variant 7: Traumatic shoulder pain. Radiographs normal. Physical examination findings consistent with labral tear. Next imaging study.

MR Arthrography

MR arthrography has been reported to have a high sensitivity for detection of labral injury, ranging from 86% to 100% [20,59,62-65]; however, the issue of selection bias is inherent in the design of many of these retrospective studies [60]. For example, patient groups were identified at the time of arthroscopy, which selected patients with proven labral lesions as the study population instead of evaluating all patients with clinically unstable shoulders. Compared to noncontrast MRI, MR arthrography has been shown to have increased sensitivity for detection of anterior labral and SLAP tears [19]. In addition, MR arthrography has been shown to detect unsuspected labral pathology in patients referred for imaging with low or no clinical suspicion of labral pathology [66].

MRI

MRI without contrast may be preferred to MR arthrography in the setting of acute shoulder dislocation when a post-traumatic joint effusion is typically present to provide sufficient visualization of soft-tissue structures. In the subacute or chronic setting, the glenohumeral joint effusion is usually too small to provide adequate joint distention to adequately assess soft-tissue structures. Noncontrast MRI has been shown to be inferior to MR arthrography in diagnosing labroligamentous and rotator cuff injuries [17,19].

CT Arthrography

CT arthrography provides comparable sensitivity and possibly improved specificity in detection of labral lesions compared to MR arthrography [12,67] and can provide improved visualization of the bones in cases of complex trauma. However, interobserver variability in reporting of labral lesions is low [13]. CT arthrography has also been shown to be inferior to MR arthrography in assessing partial-thickness rotator cuff tears [12], which makes CT arthrography less desirable in patients where rotator cuff tears may be suspected. However, CT arthrography may be considered in a patient with shoulder dislocation/instability and contraindication to MRI.

CT

Noncontrast CT is unable to assess rotator cuff and labroligamentous pathology.

US

Although there have been efforts to use US in diagnosis of labral lesions, it currently has no defined role in this setting.

FDG-PET/CT

There is no role for FDG-PET/CT in assessment of suspected labral tear.

Bone Scan

There is no role for bone scintigraphy in assessment of suspected labral tear.

Variant 8: Traumatic shoulder pain. Radiographs normal. Physical examination findings consistent with rotator cuff tear. Next imaging study.

US, MRI, and MR arthrography have similarly high sensitivity and specificity in detection of full-thickness rotator cuff tears. US and MRI have somewhat lower sensitivity for detection of partial-thickness tears when compared to MR arthrography [68]. However, because full-thickness tears are the main decision point on pursuing surgical repair, institutional preference may be the driving force for the selection of imaging modality for assessment of traumatic rotator cuff pathology.

MRI

MRI is generally considered the best modality for adequately assessing most soft-tissue injuries, including labroligamentous, cartilage, and rotator cuff pathology [12,17,69]. It has high sensitivity and specificity in detection of full-thickness rotator cuff tears, but lower sensitivity compared to MR arthrography for detection of partial-thickness tears [68].

MR Arthrography

MR arthrography is generally preferred to noncontrast MRI for assessing intra-articular pathology, particularly in diagnosing labral and partial-thickness rotator cuff tears [17,19,54]. MR arthrography may have increased sensitivity for detection of partial-thickness articular surface supraspinatus tears compared with conventional MRI [19].

CT Arthrography

CT arthrography has similar performance as MR arthrography for detection of full-thickness rotator cuff tears, but has significantly poorer performance for partial-thickness cuff tears [12]. CT arthrogram may be a good imaging alternative in patients with suspected intra-articular soft-tissue injury and contraindication to MRI.

CT

Noncontrast CT is unable to assess rotator cuff pathology in the acute setting.

US

In the post-traumatic setting, US has been shown to detect abnormalities, including rotator cuff tears [25]. In general, US can have high sensitivity and specificity for the detection of full-thickness rotator cuff tears [70-72]. There is conflicting evidence on the ability of US to diagnose partial-thickness rotator cuff tears [17,22,24,44,72]. Similarly, although interobserver agreement in detection of full-thickness rotator cuff tears can be high, it is much more variable for detection of partial-thickness tears [73,74].

FDG-PET/CT

FDG-PET/CT is not routinely used for describing rotator cuff tears. Indirect identification of symptomatic rotator cuff tears has been described on FDG-PET/CT by decreased radiotracer activity in the muscles of the torn tendons and increased activity of surrounding shoulder girdle muscles due to muscle recruitment [28,29]. However, FDG-PET/CT cannot describe the extent of rotator cuff tear or degree of rotator cuff atrophy, which are relevant for clinical management.

Bone Scan

Bone scintigraphy is not routinely used for describing rotator cuff tears. Increased radiotracer activity has been associated with symptomatic rotator cuff tears [33]. However, bone scintigraphy cannot describe the extent of rotator cuff tear or degree of rotator cuff atrophy, which are relevant for clinical management.

Variant 9: Traumatic shoulder pain. Radiographs already performed. Physical examination consistent with vascular compromise. Next imaging study.

The subclavian, axillary, and brachial arteries are uncommonly injured following fractures and dislocations about the shoulder; however, the consequences can be debilitating. Of these, the axillary artery is more likely to be injured in patients with proximal humeral fractures, and the risk increases in the presence of open fractures, shoulder dislocation, and fractures of the scapula and ribs [75]. No systematic or comparative data is available on detection of arterial injuries in the post-traumatic setting.

CT

Noncontrast CT may be able to demonstrate hematomas; however, it is not an adequate modality for evaluation of acute arterial compromise. Contrast-enhanced CT using intravenous (IV) contrast can identify some vascular injuries. However, contrast bolus timing and image reformatting using routine contrast-enhanced CT protocols is suboptimal for identifying and characterizing vascular injuries.

CTA

CT angiography (CTA) is a specialized protocol for contrast-enhanced CT in which image acquisition occurs during maximum arterial opacification by IV contrast. Thin-slice axial images of the region of interest is performed, which helps in detection of subtle vascular injuries. Maximum intensity projection (MIP) images in multiple planes are also commonly performed, allowing for long segments of vessels to be visualized on a single image. CTA is the preferred examination for evaluation of suspected arterial injury. It can delineate the extent of injury and has the added benefit of providing optimal assessment of osseous injuries [76,77].

MRI

Because of the length of time required for MRI, it is not the modality of choice for assessment of acute arterial injury. Both routine noncontrast and contrast-enhanced MRI protocols lack the spatial and temporal resolution as well as imaging plane orientation to identify and characterize most arterial injuries.

MRA

MR angiography (MRA) is MR imaging tailored to evaluate for arterial compromise using sequences such as time-of-flight, phase-contrast, and dynamic postcontrast imaging. MRA can produce 2D images or dynamic 3D images of the arteries that simulates arteriography. However, the special resolution of MRA is inferior to CTA and arteriography. MRA can be performed with or without IV contrast, although use of IV contrast is generally preferred. Because of the length of time required for MRA, it is not the modality of choice for assessment of acute arterial injury.

Arteriography
Catheter angiography can be performed when clinical suspicion of acute arterial injury is high and offers the possibility for concomitant repair or embolization.

US duplex Doppler
Bedside US can be used to assess the subclavian, axillary, and brachial arteries as permitted by patient condition.

FDG-PET/CT
There is no role for FDG-PET/CT in assessment of vascular compromise.

Bone Scan
Three-phase bone scintigraphy can demonstrate a lack of blood flow to an extremity, with blood pool and delayed images showing decreased or absent uptake in the affected area [78]. However, limited resolution precludes precise anatomic definition of the site of abnormality [78]. In addition, because of the length of time required for image acquisition, scintigraphy is not the modality of choice for assessing acute vascular compromise.

Variant 10: Traumatic shoulder pain. Radiographs already performed. Neuropathic syndrome (excluding plexopathy). Next imaging study.

Neuropathic pain is defined as pain caused by a lesion or disease of the somatosensory nervous system [79]. It is a clinical diagnosis that requires a demonstrable lesion or disease process, and can be classified as central or peripheral, depending on the level of the lesion. In the setting of trauma, neuropathic pain at the shoulder can be seen following injury to the brachial plexus (see the ACR Appropriateness Criteria® "Plexopathy" [80]) or the peripheral nerves (axillary, suprascapular, radial, ulnar, and median). Electrodiagnostic studies are considered the reference standard for diagnosis; however, imaging can be helpful in delineating the extent and level of injury. Although injury to specific nerves may be suspected on radiographs and CT based on knowledge of the expected course of nerves, high-resolution MR neurography can play an important role. The data on imaging of traumatic neuropathic pain at the shoulder not related to brachial plexopathy is sparse and consists of case reports and small series.

CT
CT without contrast may be obtained in the setting of trauma for detection or delineation of fracture and can suggest neural injury based on expected course of the nerves. However, CT is not the modality of choice for assessment of the nerves.

CT with contrast may be obtained in the setting of trauma for detection or delineation of arterial injury, and may suggest neural injury based on the expected course of the nerves. However, CT is not the modality of choice for assessment of the nerves.

There is no role for biphasic CT in the setting of suspected traumatic nerve injury.

CT Arthrography
There is no role for CT arthrography in the setting of suspected traumatic nerve injury.

MRI
Noncontrast MRI may demonstrate discontinuity of nerves, neuromas, or perineural musculofascial edema; however, the imaging planes and resolution of routine noncontrast MRI is not adequate for confident and complete assessment of the nerves that can be injured at the shoulder [81].

There are no systematic studies on MR neurography in assessment of the peripheral nerves about the shoulder in the post-traumatic setting; however, MR neurography is gaining acceptance in assessment of peripheral nerve injuries [82]. Use of 3T imaging allows for high resolution and excellent soft-tissue contrast and can delineate focal nerve discontinuities, neuromas, and musculofascial edema [83].

There is no role for addition of contrast to the standard shoulder MRI in assessment of peripheral nerve injury.

MR Arthrography
There is no role for MR arthrography in the setting of suspected traumatic nerve injury.

US
There is no role for US in the setting of suspected traumatic nerve injury.

FDG-PET/CT
There is no role for FDG-PET/CT in assessment of neuropathic syndrome.

Bone Scan
Bone scintigraphic abnormalities may be seen in patients with complex regional pain syndrome (CRPS), formerly known as reflex sympathetic dystrophy [84-86]. Bone scintigraphy may be helpful in assessing for CRPS in patients experiencing chronic post-traumatic pain without clear etiology. Meta-analyses have found only moderate concordance between bone scintigraphy and the presence or absence of CRPS [87] and low sensitivity for detection of CRPS when compared to clinical diagnostic criteria [88-90]. However, bone scintigraphy does have high specificity and can be used to rule out CRPS [90].

Summary of Recommendations

- Radiography of the shoulder is the most appropriate initial study for traumatic shoulder pain.
- In the setting of nonlocalized shoulder pain and negative radiographs, MRI of the shoulder without IV contrast is the most appropriate study.
- When radiographs show a fracture of the humeral head or neck, CT without IV contrast is the most appropriate study for characterizing the fracture planes, particularly in the case of nondisplaced fractures.
- When radiographs show a fracture of the scapula, CT without IV contrast is the most appropriate study for characterizing the fracture planes and documenting intra-articular extension of fracture and angulation and offset of fragments.
- In the setting of Bankart or Hill-Sachs lesions detected on radiographs, MRI shoulder without IV contrast or MR arthrography are both appropriate studies for assessing labroligamentous injuries.
- When physical examination and history suggest a prior dislocation event, or the presence of instability and radiographs are normal, MRI shoulder without IV contrast or MR arthrography are both appropriate studies.
- When physical examination is consistent with a labral tear and radiographs are normal, MR arthrography, CT arthrography, or MRI shoulder without IV contrast are appropriate studies.
- When physical examination is consistent with a rotator cuff tear and radiographs are normal, MRI without IV contrast, MR arthrography, or US are appropriate studies.
- When vascular compromise is suggested on physical examination and radiographs have been performed, CTA with IV contrast and conventional arteriography are both appropriate studies.
- In the setting of neuropathic symptoms (excluding brachial plexopathy, see the ACR Appropriateness Criteria® on "Plexopathy" [80]) following trauma to the shoulder and radiographs have been performed, MRI shoulder without IV contrast is the most appropriate study for delineating the extent and level of injury.

Summary of Evidence
Of the 90 references cited in the *ACR Appropriateness Criteria® Shoulder Pain-Traumatic* document, 9 are categorized as therapeutic references including 8 good-quality studies. Additionally, 76 references are categorized as diagnostic references including 20 good-quality studies, and 29 quality studies that may have design limitations. There are 28 references that may not be useful as primary evidence. There are 5 references that are meta-analysis studies.

The 90 references cited in the *ACR Appropriateness Criteria® Shoulder Pain-Traumatic* document were published from 1983 to 2017.

Although there are references that report on studies with design limitations, 28 good-quality studies provide good evidence.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [91].

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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