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Proximal Humerus Fracture

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Introduction

Proximal humerus fractures (PHF) account for 5-6% of all adult fractures[1]. There is increasing recognition given in regard to managing these fractures in the setting of elderly, low-energy falls as these events are contributing to the global impact of direct and indirect costs of osteoporosis and fragility fractures. Moreover, as the general population continues to age and an increasing percentage of these patients are being considered bone density compromised, the overall nonoperative and operative management of PHFs continue to receive considerable attention in the literature.

Etiology

PHFs classically fall under a bimodal distribution by age and energy level. This bimodal pattern is very common and clinicians should recognize the high-energy (e.g. Motor vehicle accident in young patients) versus low-energy (e.g. elderly patient status post ground level fall) paradigm in various groups and fracture patterns[2][3][2].

PHFs most commonly occur in patients over 65 years of age[4]. In the setting of osteoporosis[5][6][7][8][7] or osteopenia[9], a low-energy fall resulting in a PHF is, by definition, a fragility fracture. Thus, patients sustaining these injuries (even without an official diagnosis via DEXA scan) should be considered to already be on the osteoporotic spectrum. Younger patients often present with these injuries following high-energy trauma such as MVAs.

Epidemiology

PHFs most commonly occur in the elderly. The three most common osteoporotic (i.e. fragility) fractures include:

- vertebral compression fractures[2]
- distal radius fractures[10]
- proximal humerus fractures[11]

While high-energy mechanisms are more likely to result in associated soft tissue and/or neurovascular injuries, increasing age has been associated with more complex fracture types. The latter can include increasing degrees of comminution, displacement, and fracture/dislocation patterns. The overall incidence is reported at 4% to 6% with a 2:1 female to male ratio[12].

Pathophysiology

Anatomy

Proximal humeral anatomy includes four potential "parts". These parts were originally described by Neer[13] and have been incorporated into his traditional classification scheme for PHFs. Proximal humerus anatomy includes:[14]

- anatomic neck

- represents the old epiphyseal plate

- surgical neck
  - the anatomic region of the proximal humerus that is the weakest region of bone and located below the humeral head

- greater tuberosity
  - anatomic footprint and insertion site for three of the four rotator cuff muscles; working anterior to posterior these include: [15][16]
    - supraspinatus
    - infraspinatus
    - teres minor

- lesser tuberosity
  - the insertion site for the subscapularis

Other osseous elements that are relevant to proximal humeral anatomy include the bicipital groove/intertubercular sulcus, medial calcar, and insertion sites for the deltoid, pectoralis major, and latissimus dorsi muscles [17][18][17].

The humeral head articulates with shallow glenoid fossa of the scapula which allows for complex dynamic range of motion in many different planes. The anatomical neck can be identified as the fused epiphyseal plate which is obliquely directed and lies proximal to greater and lesser tubercles. The greater tuberosity is given additional management considerations given the concerns regarding even minimal (3- to 5-mm or greater) displacement as this can lead to a significant compromise in patient outcomes following injury via impingement and rotator cuff dysfunction.

The intertubercular sulcus or groove separates the two tuberosities. The tendon of the long head of biceps brachii runs through this groove[19][20]. Attached to the lips of the intertubercular sulcus are the tendons of the pectoralis major (lateral), latissimus dorsi (medial), and teres major (most medial/posterior). The most frequently fractured site of the humerus especially in elderly is the surgical neck which is an area of constriction distal to the tuberosities.

Deforming forces

The deforming forces relevant to PHFs include:

- pectoralis major: displaces humeral shaft anterior/medial
- supraspinatus, infraspinatus, teres minor: displace and lateral/externally rotate the greater tuberosity
- subscapularis: internally rotates the articular segment and/or lesser tuberosity

Neurovascular considerations

Several neurovascular structures are at risk of injury depending on the pattern of injury. The most commonly injured nerve in PHFs is the axillary nerve. Arterial injury occurs at about a 5% incidence rate and has a higher likelihood in elderly patients. Two common scenarios relative to arterial artery injury at presentation include:

- displaced/comminuted surgical neck fractures
- subcoracoid dislocation of the humeral head

The posterior humeral circumflex artery is the main blood supply to the humeral head[14]. The anterior humeral circumflex artery (AHCA) is known for its extensive arterial branching and anastomotic network it creates in the proximal humerus. Once traditionally thought of as the major blood supply to the proximal humerus, this theory has since been debunked[21]. The AHCA does give off two main branches via the anterolateral ascending branch and the arcuate artery, with the latter serving as the major blood supply to the greater tuberosity[14].

History and Physical

A comprehensive history and physical examination should be performed in any and all patients. The elderly (>65 years old) often present status post a low-energy fall with the arm outstretched in an attempt to brace the fall. Younger patients often present following an MVA.

Most cases present in the acute setting. Pertinent questions include:

- mechanism of injury
- description of pain intensity and quality
- presence of radiating pain or pain anywhere else about the ipsilateral limb
    - clinicians should note that other ipsilateral upper extremity injuries should be ruled out[3]
- any previous injuries to the shoulder girdle or ipsilateral limb
- any previous surgeries or current/previous implants to the ipsilateral limb
- hand dominance
- social/living situation
    - particularly pertinent in elderly patients living alone or at home with minimal if any support

Physical examination

Inspection is assessing for signs of open fracture, ecchymosis that may extend to the chest, arm, and forearm. Crepitus and pain are often present over the fracture site. Loss of deltoid contour suggests concomitant dislocation of shoulder suggesting a higher-energy mechanism. The examiner should determine if any associated neurovascular injury is present. A comprehensive neurovascular examination should also be performed. Examiners should maintain a heightened clinical suspicion for associated nerve injury (most commonly a transient neuropraxia to the axillary nerve) especially in the setting of a fracture-dislocation pattern. Arterial compromise is much less common and can occur even in the setting of intact distal pulses palpated on exam secondary to extensive collateral blood supply.

Evaluation

Radiographic imaging should be obtained in all patients. Recommended views include mandatory orthoganol imaging:

- True AP view ("Grashey")
- Scapular Y
- Axillary lateral
    - the velpeau view can be used in substitution depending on the patients ability to tolerate the axillary lateral radiographic position
    - the velpeau view is performed with the patient's arm held in internal rotation in a sling, and the film is taken superior to inferior with the patient leaning backward into the beam field

- the west point axillary view can also be considered
    - the technique for the West Point x-ray entails the patient being placed prone on the x-ray table. The affected shoulder is raised at the top of the table and cassette held against the superior aspect of the shoulder. The x-ray beam is centered at axilla. A tangential view of the anteroinferior rim of the glenoid rim is the resulting image of the shoulder.

CT scan aids in preoperative planning especially if the position of the humeral head or greater tuberosity is uncertain and intra-articular comminution. Furthermore, information obtained from the CT scan can help guide the ideal operative management when considering whether fixation versus reconstruction is most appropriate. MRI is rarely indicated however may be useful to identify associated rotator cuff injury

Classification Schemes

Neer's Classification is based on the anatomic relationship of four segments: greater tuberosity, lesser tuberosity, articular surface, and shaft.

One-Part Fracture

- Fracture lines involve one to four parts
- None of the parts are displaced (less than 1 cm and less than 45 degrees)

Two-Part Fracture

- Fracture lines involve two to four parts
- One-part is displaced (greater than 1 cm or greater than 45 degrees)

Three-Part Fracture

- Fracture lines involve three to four parts
- Two parts are displaced (greater than 1 cm or more than 45 degrees)

Four-Part Fracture

- Fracture lines involve more than four parts
- Three parts are displaced (greater than 1 cm or greater than 45 degrees) with respect to the four.

AO Classification arranges fractures into three main groups and additional subgroups based on fracture location, the status of the surgical neck, and the presence or absence of dislocation.

- Type-A fractures are extra-articular, unifocal fractures that include the greater tuberosity or surgical neck. These include A1, a unifocal extra-articular tuberosity, A2, a unifocal extra-articular impacted metaphyseal, and A3, a unifocal extra-articular non-impacted metaphyseal.
- Type-B fractures are bifocal fractures that include some unusual dislocations. These include B1, bifocal extra-articular with metaphyseal impaction, B2, bifocal extra-articular without metaphyseal impaction, and B3, bifocal extra-articular with glenohumeral dislocation.
- Type-C fractures are all intra-articular anatomic neck fractures, including dislocation and splitting of the humeral head. These are divided into C1, articular with slight displacement, C2, articular impacted by marked displacement, and C3, articular with dislocation.

Treatment / Management

Initial management includes immobilization and pain control in the acute setting. Goals of management can then be determined whether non-operative versus operative.

Nonoperative management

Sling immobilization followed by gentle progressive rehabilitation is advocated in minimally displaced surgical and anatomic neck fractures. The acceptable amount of displacement with respect to an isolated greater tuberosity fracture remains debated. Recent literature has advocated for earlier surgical management in these isolated, two-part fracture pattern injuries.

Progressive physical therapy and rehabilitation protocols include early, gentle, shoulder pendulum exercises starting as early as 10 to 14 days following injury as dictated by the patient's symptoms.

In general, nonoperative management alone has demonstrated an approximately 80% to 85% success rate when analyzing all types of PHFs. Nonoperative management is most successful in the following:

- minimally displaced surgical neck fractures (Neer’s one, two, and three-part)
- greater tuberosity fracture which is displaced less than 3-5 mm
- patients who are otherwise not ideal surgical candidates

Operative management

Operative management consists of several different options including closed reduction and percutaneous pinning (CRPP), open reduction and internal fixation (ORIF), intramedullary nailing (IMN), hemiarthroplasty and total shoulder arthroplasty (reverse TSA or standard/anatomic TSA).

CRPP

- indicated in two-part, three-part surgical neck fractures and valgus-impacted four-part fractures in patients with good bone quality, minimal metaphyseal comminution, and intact medial calcar

ORIF

- Indicated for:
    - greater tuberosity displaced greater than 3-5 mm
    - two-, three-, and four-part fractures in younger patients
    - head-splitting fractures in younger patients

IMN

- indicated in surgical neck fractures or three-part greater tuberosity fractures in younger patients, combined proximal humerus, and humeral shaft fractures

Shoulder reconstruction/arthroplasty

- general indications in the elderly may include anatomic neck fractures and other injuries comprised of significantly displaced/comminuted fracture patterns in any of the aforementioned injury types that are not amenable to nonoperative management. The latter also includes chronic malunions/nonunions with documented dysfunctional status and disability in patients managed nonoperatively.
- other indications that can, in general, be applicable to younger patients (i.e. patients 40 to 65 years of age) include:

- four-part fractures and fracture-dislocations (three-part if stable internal fixation unachievable)
- rotator cuff compromise
- head-splitting fracture patterns
- humeral head impression defects of greater than 40% of articular surface and detachment of articular blood supply (most three-part and four-part fractures)

- Total shoulder arthroplasty: Performed when the rotator cuff is intact with a compromised glenoid surface (arthritis, trauma).
- Reverse shoulder arthroplasty: Indicated in elderly individuals with non-reconstructible tuberosities or with prior evidence of rotator cuff compromise that can include varying degrees of rotator cuff tear arthropathy

Differential Diagnosis

The differential diagnosis for patients presenting with shoulder pain can include, but is not limited to, the following conditions:[22][23]

Trauma

- **Acute versus chronic fractures and/or associated complications**
  - detailed further assessed following a thorough history-taking in which prior injuries, fractures, and surgeries are documented
  - chronic conditions include malunion/nonunion with persistent disability, pain, and shoulder dysfunction

Impingement

- External/SIS
- Subcoracoid
- Calcific tendonitis
- Internal (including SLAP lesions, glenohumeral internal rotation deficit (GIRD), Little league shoulder, posterior labral tears)

RC pathology

- Partial- versus full-thickness tears (PTTs versus FTTs)
- RCA

Degenerative

- Advanced DJD, often associated with RCA
- Glenohumeral arthritis
- Adhesive capsulitis
- Avascular necrosis (AVN)
- Scapulothoracic crepitus

Proximal biceps

- Subluxation – often seen in association with SubSc injuries
- Tendonitis and tendinopathy

AC joint conditions

- AC separation
- Distal clavicle osteolysis
- AC arthritis

Instability

- Unidirectional instability – seen in association with an inciting event/dislocation (anterior, posterior, inferior)
- Multidirectional instability (MDI)
- Associated labral injuries/pathology

Neurovascular conditions

- Suprascapular neuropathy – can be associated with paralabral cyst at the spinoglenoid notch
- Scapular winging – medial or lateral
- Brachial neuritis
- Thoracic outlet syndrome (TOS)
- Quadrilateral space syndrome

Other conditions

- Scapulothoracic dyskinesia
- Os acromiale
- Muscle ruptures (pectoralis major, deltoid, latissimus dorsi)

Deterrence and Patient Education

All patients should be informed regarding the risks, benefits, and alternatives to all nonoperative and operative treatment options. While most patients improve and return to baseline function following either type of management pathway, persistent disability and loss of function remain common issues of concern. Each PHF should be treated on a case-by-case basis and should factor in the patient's age, hand dominance, functional status, social situation, medical comorbidities, and the overall goals and expectations during and after the recovery process.

Pearls and Other Issues

Isolated extremity trauma is the next potential target in specialty fields like orthopedic surgery as, in general, the diagnosis, treatment, and rehabilitation clinical care pathways are being given increasing attention in the literature as potential targets for alternative payment models, bundled payment care initiatives, and healthcare cost containment strategies. Thus, healthcare providers, clinicians, and institutions have been previously encouraged to implement a "big data versus little data" management mindset to apply notable trends, risk factors, and potential treatment variables that have been previously identified across large sample sizes and database literature reports and subsequently applying these potential "at-risk" variables in a customized fashion across all institutions. This ensures

that the healthcare systems worldwide mitigate the risk of falling into a "one size fits all" treatment strategy for patients in all areas of the world.

Enhancing Healthcare Team Outcomes

PHFs are commonly managed nonoperatively although referral to an orthopedic surgeon should be considered in all of these injuries given the wide variation in treatment strategies. Active and open communication should be considered standard of care as discussions between the nursing staff, therapists, physicians, and surgeons is required to ensure an ideal outcome for all patients being managed with these injuries. Finally, follow-up with a bone density specialist should be ensured when patients present with a PHF in the setting of a low-energy injury as these presentations are considered to be, by definition, an instant diagnosis of bone mineral density compromise.

Level of evidence: II-III

Questions

To access free multiple choice questions on this topic, click here.

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