

Intrathoracic Fracture-Dislocation of the Proximal Humerus Treated with Rib Fixation and Shoulder Arthroplasty

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Abstract

Proximal fractures of the humerus resulting in intrathoracic displacement of the humeral head are rare, but cause serious pain and can lead to pulmonary and glenohumeral complications. Many treatment options exist, but there is still no literature regarding mortality and morbidity associated with rib fixation in concordance with treatment of the proximal humerus.

This case describes a patient who was treated using a multi-team approach that involved shoulder arthroplasty with rib fixation, and which resulted in decreased pain and decreased narcotic use while improving the patient's pulmonary function.

Intrathoracic displacement of a humeral fracture is extremely rare. Because of the paucity of reported cases, a consensus on management of this injury remains unclear. Treatment options for the proximal humerus fracture with dislocation include: nonoperative, fragment removal, open reduction and internal fixation, shoulder arthroplasty, and shoulder arthrodesis. There is no discussion in the literature regarding rib fixation in concordance with treatment of the proximal humerus to decrease pain and improve pulmonary function following this injury. The patient provided written informed consent for print and electronic publication of this case report.

Case Report

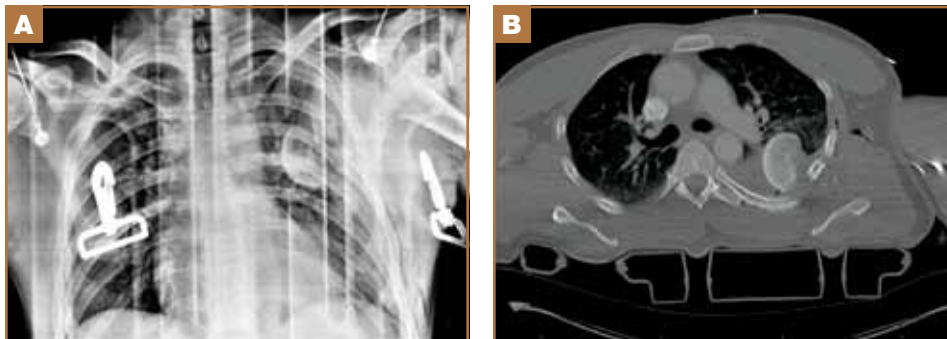
A 44-year-old, right-hand dominant man presented to a regional level one trauma center following an 18-foot fall down an elevator shaft. Upon presentation to the trauma bay, he was complaining of left shoulder pain, dyspnea, and pleuritic

chest pain. His Glasgow Coma Scale was 15; he answered all questions appropriately, and his vital signs remained stable. Examination of the left upper extremity exhibited gross instability of the shoulder without obvious deformity. Radial and ulnar pulses were strong, but sensation was decreased to the median and axillary nerve distributions. The skin was intact and there was no swelling or ecchymosis noted.

Radiographs and computed tomography (CT) scans revealed a 4-part fracture of the left proximal humerus, fractures of left third, fourth, and fifth ribs, a left hemothorax, extensive air within the shoulder and left flank, as well as a large retained fragment of the humeral head within the left hemithorax (Figures 1A, 1B).

After the patient was stabilized using the ATLS protocol, he was intubated due to respiratory distress and a thoracotomy tube was placed in the left hemithorax with 1.1 L of blood drained. The patient was taken to the operating room for an emergency posterolateral thoracotomy; upon exposure of the left chest wall, a flail segment was identified. Exposure of the left thoracic cavity was achieved using an opening in the fifth intercostal space. The humeral head was identified and recovered without complication, and after discussion with the orthopedic surgeon, was discarded due to being devascularized (Figure 2). On inspection of the left lower lobe, a moderate sized contusion was identified. The thoracic cavity was irrigated and suctioned with removal of several small com-

Figure 1. Presenting (A) radiograph and (B) CT scan showing the humeral head located in the posterior left hemithorax.



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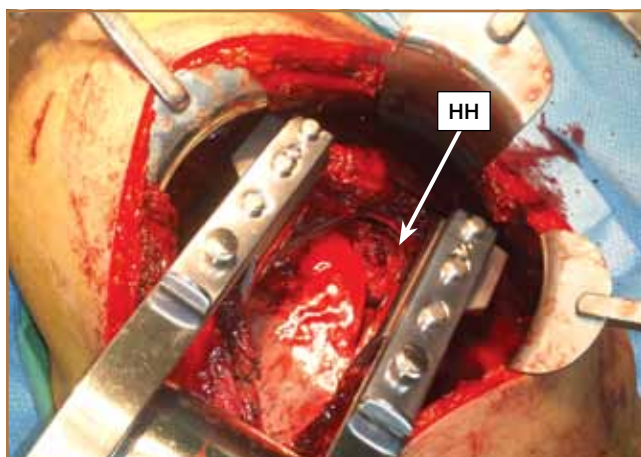


Figure 2. Intraoperative photograph showing the humeral head (HH) within the left thoracic cavity.

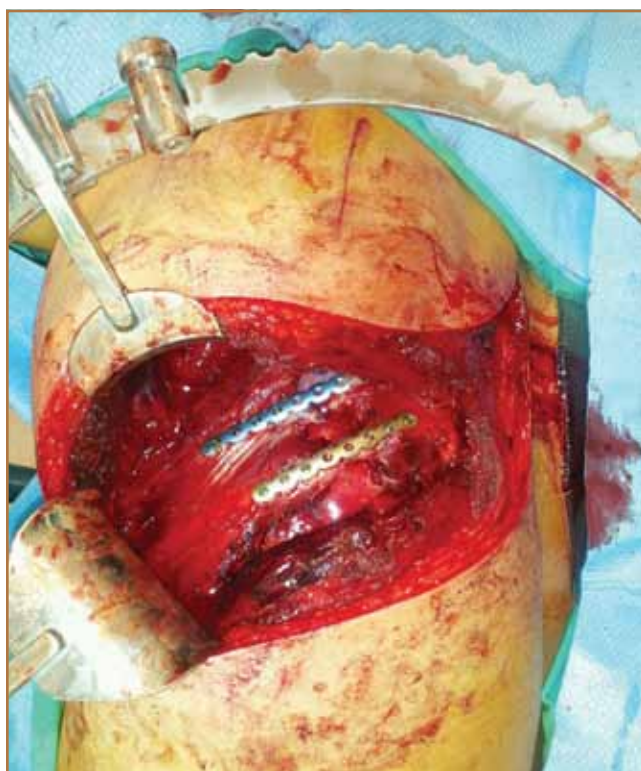


Figure 3. Intraoperative photograph showing rib fixation.

minuted pieces of bone. The fourth and fifth ribs were reduced and two 1.5 mm plates were applied and secured with thirteen 2.9 mm locking screws (**Figure 3**). The muscular layers and skin were closed leaving the chest tube in place.

On postoperative day 2, the patient was extubated after improved ventilation and chest radiographs. The patient began pulmonary toilet treatment soon after extubation and was able to use the incentive spirometer to 1250 ml. A postoperative chest film showed vast improvement in aeration of the left lung field.



Figure 4. Postoperative radiographs of the humeral hemiarthroplasty.

Five days after rib fixation the patient underwent hemiarthroplasty shoulder replacement by the orthopedic surgery team. Using a standard deltopectoral approach, dissection through the internervous plane revealed extensive capsular damage and multiple tuberosity fragments. The glenoid was intact with no incongruity in the labrum. The rotator cuff attachments were repaired to the humeral shaft, with good cortical contact and near anatomic alignment (**Figure 4**). A biceps tenodesis was performed. The left shoulder range of motion (ROM) had flexion to the top of his head and opposite shoulder, external rotation from neutral to 30°, and internal rotation to nearly 90°. The patient tolerated the surgery well and had complete neurologic recovery of the left upper extremity and resolution of his dyspnea and pleuritic pain by discharge. At 6-month follow-up, the patient's left shoulder active ROM was as follows: 120° forward flexion, 75° abduction, 35° external rotation, and 50° internal rotation.

Discussion

We found only 20 recorded cases of intrathoracic fracture dislocation in our literature search (**Table 1**). Diagnosis of this injury pattern may not be clear on initial examination and remains a difficult injury to treat.¹ The treatment choices depend heavily on the patient's injuries at the time of presentation. However, the necessity of humeral fragment removal and timing of the operation is still unknown.

The mechanism of injury in our case is a fall with the shoulder most likely held in abduction, with an initial internal or external rotatory force producing the dislocation. Like most cases of this type, our case did not require any reduction maneuvers. The patient did not recall his left upper extremity being abnormally positioned after the fall.

In only 4 cases, the humeral fragment or fragments were not removed.²⁻⁵ It has been suggested that removal of the humeral fragments is only indicated when cardiopulmonary complications arise.³ The youngest of these patients treated with obser-

Table I. Review and Summary of the Literature

Authors	Date	Proximal Humerus Fracture Classification	Pulmonary Complications	Head/Fragment Removed	Method of Fracture Treatment	Age	Mechanism of Injury
Patel et al. ⁴	1961	4-part	PTX	No	Immobilization	74	Fall (stairs)
Glessner ³⁰	1961	4-part	Lung abraded	Yes	RTC advancement	75	Unknown
Hardcastle et al. ⁹	1981	3-part	HTX	Yes	ORIF	18	Unknown
Kaar et al. ³	1995	4-part	HTX/PNA	No	Observation	79	Fall (stairs)
Brogdon et al. ²	1995	4-part	PTX	No	Hemiarthroplasty	80	Unknown
Simpson et al. ²⁹	1998	2-part	HTX	Yes with reduction	ORIF	14	PHBV
Abbott et al. ⁸	1998	4-part	Unknown	Yes – Thoracoscopy	Hemiarthroplasty	63	Fall 18 ft
al-Kaar et al. ²⁴	1998	4-part	B/L PTX	Yes	Hemiarthroplasty	63	Unknown
Ebersson et al. ⁷	2000	4-part	B/L PTX	Yes – Thoracoscopy	Hemiarthroplasty	64	Fall 15 ft
Harman et al. ¹	2004	4-part	PTX, HTX	Yes - Thoracotomy	Hemiarthroplasty	56	MVC
Wiesler et al. ³¹	2004	4-part	HTX	Yes	Hemiarthroplasty	49	Fall from horse
Anderson et al. ¹⁰	2005	4-part	PTX, HTX	Yes - Deltopectoral	ORIF	27	MCC
Daffner et al. ²⁸	2007	4-part	PTX, HTX	Yes - Thoracotomy	Hemiarthroplasty	68	Fall (ladder)
Griffin et al. ⁶	2007	4-part	HTX	Yes – Thoracoscopy	Observation/PT	78	Fall (standing)
Kocer et al. ²⁵	2007	4-part	HTX	Yes - Thoracotomy	Hemiarthroplasty	58	MVC
Liu et al. ¹¹	2007	4-part	HTX – contusion	Yes - Mini thoracotomy	Hemiarthroplasty	64	MCC
Boyer et al. ²⁷	2007	4-part	PTX, HTX, contusion	Yes – Thoracotomy	Hemiarthroplasty	77	Fall (stairs)
Maroney et al. ³²	2009	4-part	HTX	Yes - Thoracotomy	Reverse TSA	67	Fall (stairs)
Schoffl et al. ²⁶	2009	4-part	HTX	Yes - Thoracotomy	Hemiarthroplasty	63	Fall (bench)
Abellan et al. ⁵	2010	4-part	HTX	No	Hemiarthroplasty	70	PHBV

Abbreviations: B/L, bilateral; HTX, hemopneumothorax; MCC, motorcycle crash; MVC, motor vehicle crash; ORIF, open reduction and internal fixation; PHBV, pedestrian hit by vehicle; PNA, pneumonia; PT, physical therapy; PTX, pneumothorax; RTC, rotator cuff; THX, thorax; TSA, total shoulder arthroplasty.

vation of the humeral fragment was 70 years old, and none of these recorded cases reported long term cardiopulmonary complications from the retained fragments. However, there is a reported case of pneumonia among those treated with observation alone.³

We felt the patient would do better if the humeral fragment was excised. The high-energy nature of these injuries may produce severe lung injury that can be obscured by the underlying hemothoraces and lung contusions. The humeral head has even become imbedded within the lung parenchyma requiring an extensive resection.⁶ The humeral head in our case was highly mobile and in close proximity to the left pulmonary artery. Migration of the humeral head could have led to further lung or vascular injury and consequently required a more complicated dissection for excision.

The humeral fragment is a sterile entity; however, if the patient develops pneumonia, the bony fragment could act as a nidus for infection, which might further complicate the treatment course.³ A posterolateral thoracotomy provided excellent

exposure for humeral head removal and also provided suitable exposure for rib fixation. A major complaint of this approach is cosmesis. We chose this approach due to the amount of thoracic bony trauma seen on the 3-dimensional CT reconstructions, and to allow direct inspection of the lung for trauma (Figure 5). Thoracoscopy, extended delta-pectoral, and mini thoracotomy are other approaches used to treat this injury.⁶⁻¹¹

Recent studies of rib fixation have demonstrated encouraging results in treatment of a flail chest injury. Tanaka and colleagues¹² randomized 37 patients with severe flail chests into 2 groups. One group was treated with positive pressure mechanical ventilation and the other group was treated surgically with Judet struts. When compared with the nonoperative group, the surgically treated patients showed a significant improvement in ventilation days, intensive care unit (ICU) days, rates of pneumonia, and substantial increase in return to work by 6 months (Table 2). Another prospective study, by Granetzny and colleagues,¹³ demonstrated the subacute benefits of rib fixation. When 40 patients were randomized, the surgically treated patients had



Figure 5. 3-dimensional posterolateral rendition showing intrathoracic displacement of humeral head with rib fractures.

a less restrictive pattern on their pulmonary function test at 2 months postoperative.

Our case demonstrates the significant trauma sustained to the thoracic bony anatomy with humeral invasion, and another treatment choice for this injury. Locked rib fixation remains a clear treatment choice for flail chest.¹⁴ We propose that patients with a multilevel rib injury and who already require thoracotomy may benefit from rib fixation as adjunct therapy for a quicker recovery. Whether rib fixation decreases morbidity and mortality has been yet to be established; however rib fixation has been shown to decrease pain and reduce the need for opiates in patients with multiple rib fractures.¹⁵ Decreasing pain at the level of the ribs may lead to improved physical rehabilitation to the patient's other traumatic injuries, thus leading to improved outcomes for other injuries. The timing of the rib

fixation is variable and largely dependent on the clinician's intuition. We agree with de Moya and colleagues,¹⁵ and suspect that patients receive the most benefit from rib fixation if performed early. Pulmonary health remains an important factor for musculoskeletal recovery. However, the impact of early surgical intervention of flail chest and the possible benefits to orthopedic outcomes has yet to be established.

The treatment options for the 4-part proximal humerus fracture dislocation include nonoperative, surgical fixation, hemiarthroplasty, and reverse total shoulder arthroplasty. The type of arthroplasty chosen is multifactorial depending on the quality of the glenoid, the amount of soft-tissue attachment to the remaining fragments, patient age and function, presence of a rotator cuff tear, and surgeon preference. There is still much debate in the orthopedic literature as to which surgical option is the most appropriate.

In determining the type of surgery, a surgeon must take into account the risk of humeral head osteonecrosis, which increases from about 25% in a 3-part fracture to almost 60% in 4-part fractures.¹⁶ Critical factors in determining this risk include hinge disruption, initial displacement of the fracture fragments, and whether or not the initial varus angulation is greater than 20°.¹⁷

With anatomic reduction of amenable fracture patterns, the likelihood of revascularization of the humeral head increases.¹⁸ The advent of locking plates, as well as the use of intramedullary bone grafts, decreases the rates of nonunion in 3- and 4-part humeral fractures. This may account for the better shoulder outcome scores of patients who underwent surgical fixation with the locking plates, despite the increased complication rate, when compared to those who had hemiarthroplasty.^{17,19} The potential complications for surgical fixation include osteonecrosis, malunion, nonunion, hardware failure, and humeral head collapse with screw penetration.

While the majority of patients who undergo hemiarthroplasty for 3- and 4-part humeral fractures have little or no pain, they do present with varying limitations in function.²⁰ The literature supporting primary arthroplasty shows that a second surgery to replace the humeral head following osteosynthesis presents more difficulty and leads to worse functional outcomes.²¹

A successful hemiarthroplasty is dependent on obtaining proper implant position and optimal fixation of the tuberosities.^{22,23}

The majority of the cases of intrathoracic displaced humeral fractures have been treated with hemiarthroplasty of the glenohumeral joint with or without glenoid repair.^{1,4,6,10,15,24-28} There were 3 reported cases utilizing open reduction with internal fixation of the reclaimed humeral fragments.^{8,9,29} Even though these patients were younger, ranging from 14 to 28 years old, all but one eventually returned with avascular necrosis of the humeral head.⁹ Treatment of the humerus should be directed by the amount of hu-

Table II. Nonoperative Management versus Surgical Management of Rib Fractures^a

	Nonoperative Management (Positive Pressure Mechanical Ventilation)	Surgical Management
Days on ventilation	18.3	10.8
Days in ICU	26.8	16.5
Rate of pneumonia	90%	22%
Returned to work by 6 months	5%	61%
Cost of treatment	\$23,423	\$13,455

Abbreviation: ICU, intensive care unit.

^aData were derived from Tanaka and colleagues.¹²

meral head disruption and devascularization. The humeral head could act as a bolster, stabilizing the humeral-tuberosity repair. Although the humeral head may develop varying degrees of avascular necrosis due to the devascularization, this type of repair could prevent tuberosity nonunion and preserve rotator cuff function.

Intrathoracic proximal humeral fracture-dislocation requires a multi-disciplinary team approach. Optimally, the treating surgeons should collaborate and discuss operative timing, surgical plan, and postoperative care before the patient is taken to the operating room. Although important in all cases, a coordinated effort is required for the proper management of this fracture pattern. This collaboration between the trauma surgeon, orthopedic surgeon, and physical therapist will provide the best possible outcome. Surgical fixation of the ribs has been demonstrated to decrease pain, improve pulmonary function, and reduce narcotic use. In this case, the addition of rib fixation to the surgical management of the proximal humerus led to rapid improvement of pulmonary function and a good result to this complex injury.

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