9-2-2023

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Recommended Citation

Wright, Branden et al. A proximal humerus fracture with concomitant axillary artery occlusion and axillary nerve palsy treated with reverse total shoulder arthroplasty: a case report. JSES Reviews, Reports & Techniques, Volume 3, Issue 4, 529 - 533. DOI: 10.1016/j.xrrt.2023.08.003

JSES Reviews, Reports, and Techniques 3 (2023) 529–533

Contents lists available at ScienceDirect

JSES Reviews, Reports, and Techniques

journal homepage: www.jsesreviewsreportstech.org

A proximal humerus fracture with concomitant axillary artery occlusion and axillary nerve palsy treated with reverse total shoulder arthroplasty: a case report

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ARTICLE INFO

Keywords:
Proximal humerus fracture
Reverse total shoulder arthroplasty
Axillary artery occlusion
Brachial plexus
Axillary nerve palsy
Shoulder
Electromyographic study

Herein, we review the case of a 71-year-old man who sustained a Neer 4-part comminuted proximal humerus fracture (PHF) with concomitant axillary artery occlusion and axillary nerve injury treated with reverse total shoulder arthroplasty (RSA). PHFs are the third most common fracture and represent 5% of fractures overall.[6] The reported incidence of axillary nerve injury associated with PHF ranges from 6.2% to 67% using electromyography (EMG).[21] Axillary artery injury associated with PHF is rare, with an incidence of 0.09%.[8] However, it is important to understand that axillary artery and nerve injuries associated with PHFs often occur together, with concurrent incidence rates reported to be between 35 and 70%.[10] Even more striking, the odds ratio of a brachial plexus injury when there is a known axillary artery injury is 109.[10] Thus, concern for either vascular or nerve injury upon initial evaluation of a PHF should raise a high index of suspicion for the other.

Treatment of PHFs remains a controversial topic, with options including nonoperative, open reduction internal fixation, hemiarthroplasty (HA), and RSA.[14] For comminuted displaced 3-part and 4-part PHF fractures in the elderly, HA had previously been the treatment of choice.[2,16] Recently, RSA has emerged as the contemporary favorite treatment modality for displaced 3- and 4-part geriatric PHFs, demonstrating a 1841% increase in incidence from 2010 to 2019.[12] Current evidence supports this trend, as recent meta-analyses have shown RSA results in better clinical outcomes, better patient-reported outcomes, and fewer complications compared to HA.[15,18,20] Neurovascular injuries should also be taken into consideration when deciding on treatment. Previously, axillary nerve injury had been considered a relative contraindication for RSA due to the theoretical risk of dislocation, but recent literature has argued against this.[3,5] Recent systematic reviews have also shown slightly better outcomes for primary RSA for elderly PHF as compared to salvage after trying nonoperative treatment.[9] Based on current evidence and surgeon preference, RSA was chosen as the definitive treatment modality for this patient. The patient was informed that data concerning this case would be submitted for publication and provided consent.

Case report

A 71-year-old right-hand dominant man was evaluated at our institution after a fall on an outstretched right arm twelve days prior resulting in a right 4-part comminuted PHF (Fig. 1, *A* and *B*). The patient's relevant past medical history included acquired cystic kidney disease, carcinoma of the prostate, atherosclerotic heart disease, diabetes mellitus, and hyperlipidemia. The injury occurred in Florida where the patient was originally treated and told to follow-up in his home state for definitive fixation. Nine days following the injury, he was evaluated at an outside institution and sent to an outside hospital due to diminished pulses in the right arm upon examination. Computed tomography angiogram, wrist brachial index (WBI), and right upper extremity Doppler studies were performed at the outside hospital, and the patient was deemed to have distal right axillary artery occlusion with distally reconstituted blood supply due to collateral circulation (Fig. 2).

Institutional review board approval was not required for this case report.

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https://doi.org/10.1016/j.xrrt.2023.08.003

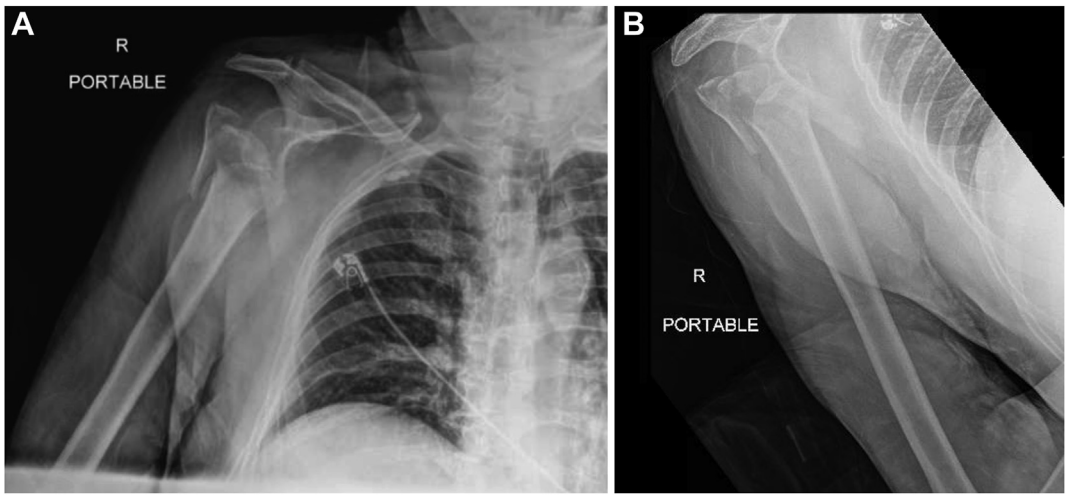

Figure 1 Preoperative x-rays. (**A**) An AP view of the right shoulder. (**B**) A lateral view of the right shoulder. *AP*, anterior posterior.

Figure 2 Preoperative computed tomography angiography (CTA) in the coronal view depicting right axillary artery occlusion.

The patient presented to our institution 3 days later. The physical exam revealed a warm and well-perfused right upper extremity. The patient had normal motor and sensory responses in the musculocutaneous, median, radial, and ulnar nerve distributions. The right radial pulse was palpable, however, decreased compared to the left. When testing the axillary nerve, the deltoid fired weakly, but sensation was intact to light touch over the deltoid. The initial American Shoulder and Elbow Surgeons (ASES) score was 18, and the Single Assessment Numeric Evaluation (SANE) score was 5%.

Vascular surgery at our institution was consulted to discuss potential concomitant bypass or revascularization. Repeat computed tomography angiogram confirmed right distal axillary artery occlusion in the proximal arm with a short segment of non-opacification followed by reconstitution. WBIs were 0.6 on the right side and 1.3 on the left. Vascular concluded that the right limb was not immediately threatened, did not warrant bypass for distal reperfusion, and recommended proceeding with orthopedic fixation.

RSA was selected as the method of fixation. Surgical exploration through a standard deltopectoral incision revealed significant posterior displacement of greater tuberosity pieces and a split humeral head that was partially flipped 180 degrees. Notably, the axillary nerve was identified as grossly intact. The fractured humeral head was excised and a standard RSA for fracture procedure was performed without complication (Fig. 3, *A* and *B*). Before closing, the axillary nerve was again palpated and proved to be intact. Postoperatively, the patient was instructed to wear a sling immobilizer for 4 weeks. The patient was permitted to start passive range of motion (PROM) immediately with assisted active range of motion and active range of motion (AROM) beginning at 4 weeks. Physical therapy began 2 weeks following the operation.

The patient reported no pain and small progress with PROM and strength at the 6-week follow-up. AROM for forward flexion and abduction measured 30° and 20°, respectively. PROM for forward flexion, abduction, and external rotation measured 80°, 80°, and 10°, respectively. Motor exam demonstrated weak anterior and lateral deltoid firing. Sensation over the deltoid was normal. Vascular follow-up confirmed sufficient collateral compensation for the axillary artery occlusion. The patient was instructed to continue with physical therapy to improve AROM.

At the 3-month appointment, the patient expressed frustration due to an inability to bring his arm above his head. AROM for forward flexion, abduction, and external rotation increased to 45°, 45°, and 30°, respectively. PROM for forward flexion, abduction, and external rotation increased to 120°, 90°, and 50°, respectively. The deltoid continued weak lateral and anterior firing, with intact sensation. ASES score was 63. The plan was to continue with physical therapy and schedule EMG to evaluate the extent of axillary nerve injury. EMG revealed markedly reduced amplitude of the right

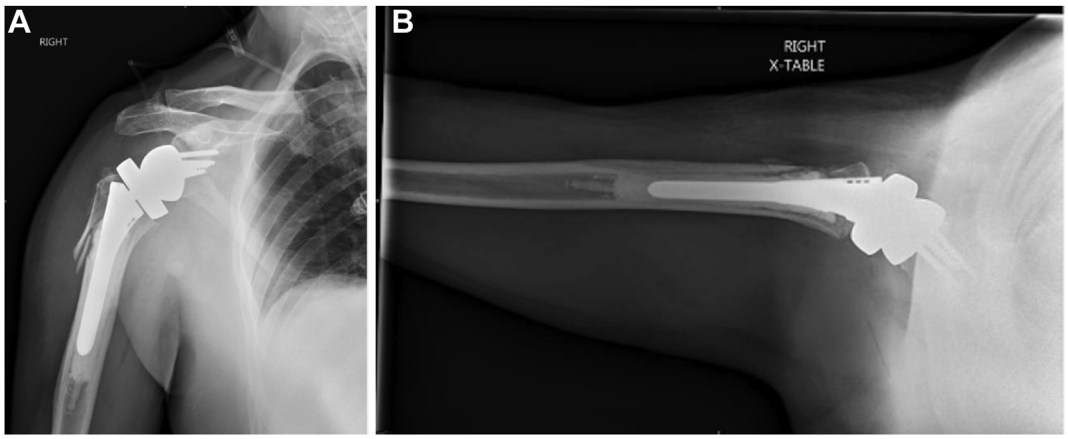

Figure 3 Postoperative x-rays following reverse shoulder arthroplasty procedure. (**A**) An AP view of the right shoulder. (**B**) An axial view of the right shoulder. *AP*, anterior posterior.

axillary motor nerve compared to the contralateral side as well as abnormal spontaneous activity in the right deltoid muscle (Fig. 4).

The patient was instructed to continue with physical therapy to continue to work on PROM and active assisted range of motion to prevent stiffness while we waited for nerve recovery. The therapists included range of motion, isometrics, supine punches, and electrical stimulation. No other formal intervention, medical or surgical, was done at this time. The patient continued with formal therapy for only four months after surgery at which point he self-discontinued formal therapy and proceeded only with a home exercise program.

At the 6-month follow-up, ASES function and index scores were 3.0 and 33.8, respectively. SANE score was 24.0%. AROM for forward flexion, abduction, and external rotation remained limited to 45°, 45°, and 30°, respectively. X-rays are depicted in Fig. 5, *A* and *B*. Lateral and anterior deltoid weakly firing persisted. After consulting with an upper extremity nerve specialist, the plan was to follow improvement over the next 2-3 months before considering radial to axillary nerve transfer. In a 1-year surgical outcome survey, the patient reported a VAS pain score of 5.05, ASES function and index scores of 3.0 and 29.75, respectively, and a SANE score of 25.0%.

The next follow-up appointment the patient attended in person was 22 months postop. At this point in time, the patient reported significant recovery of overhead motion, permitting the patient to resume playing golf. The patient acknowledged sustained difficulty with overhead weightlifting but affirmed he could perform his daily activities. On exam, there was improved AROM for forward flexion, abduction, and external rotation of 130°, 90°, and 30°, respectively. PROM for forward flexion, abduction, and external rotation was 150°, 90°, and 50°, respectively. Abduction strength remained weak with 3/5 measurement. The patient reported an ASES score of 58. Fig. 6, *A* and *B* depict x-rays demonstrating a stable RSA at this point in time.

Discussion

The exact etiology of our patient's persistent deltoid weakness is unclear and likely multifactorial. Factors potentially impacting the patient's outcome include severe, slow-resolving nerve palsy, an adverse effect from operative intervention, and potential ischemic influences on the nerve. First, the patient was noted to have deltoid weakness upon initial evaluation at our institution, leading us to believe there was some degree of nerve insult at presentation. The axillary nerve was grossly intact during surgery, ruling out a neurotmesis-type nerve injury.[13] The recovery course suggests an axonotmesis injury, as they typically resolve within 12-45 weeks.[19] Second, the incidence of axillary nerve injury as a complication of shoulder arthroplasty is low, with ranges of 1%-4% reported in the literature.[17] Great care was taken to identify and protect the axillary nerve during our patient's procedure, but an intraoperative complication cannot be definitively ruled out. Third, localized nerve ischemia secondary to the arterial occlusion may have contributed to the nerve palsy. Cases have been reported where prolonged ischemia to the axillary nerve secondary to occlusion, or prolonged compression due to hematoma or edema, have been attributed to axillary nerve palsies.[10,11] The patient's almost 2-week delay in care leaves us unsure of how long he was experiencing an axillary artery insult. The patient may have also had a poor baseline peripheral vascular status secondary to a history of diabetes. Unfortunately, there is no clear answer to our patient's axillary nerve outcome, and the etiology is likely multifactorial.

Conclusion

This case report details a PHF with an axillary artery occlusion and slow-resolving axillary nerve palsy that was treated with RSA. This patient's nerve palsy recovered between 6 months and 22 months following injury, which places this on the severe end of the spectrum of nerve palsies.[4,19] Previous case reports of PHFs with similar associated injuries treated with RSA have resulted in relatively good outcomes and influenced the decision on orthopedic fixation in this case.[1,5,7] This case should provide physicians with another piece of evidence for the utility of RSAs with this specific injury scenario given the patient's outcome at two years and restoration of functional status. However, physicians should also be cautious of the potential for an extended recovery course with an axillary nerve palsy and should counsel patients accordingly with these injuries.

Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: Catherine J. Fedorka, MD, is a paid consultant for Stryker Corporation but did not receive any financial payments or other benefits from any commercial entity related to the subject of this article. The other authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.
Patient consent: Obtained.

A

Side	Muscle	Nerve	Root	Ins Act	Fibs	Psw	Amp	Dur	Poly	Recrt	Int Pat	Comment
Right	Deltoid	Axillary	C5-6	Inc	3+	3+	Dec	Nml	Inc	Reduced	Disc Units	
Right	Biceps	Musculocut	C5-6	Nml	0	0	Nml	Nml	Nml	Nml	Comp	
Right	Triceps	Radial	C6-7-8	Nml	0	0	Nml	Nml	Nml	Nml	Comp	
Right	ExtCarRadLong	Radial	C6-7	Nml	0	0	Nml	Nml	Nml	Nml	Comp	
Right	FlexCarRad	Median	C6-7	Nml	0	0	Nml	Nml	Nml	Nml	Comp	
Right	1stDorInt	Ulnar	C8-T1	Nml	0	0	Nml	Nml	Nml	Nml	Comp	
Right	Supraspinatus	SupraScap	C5-6	Nml	0	0	Nml	Nml	Nml	Nml	Comp	

B

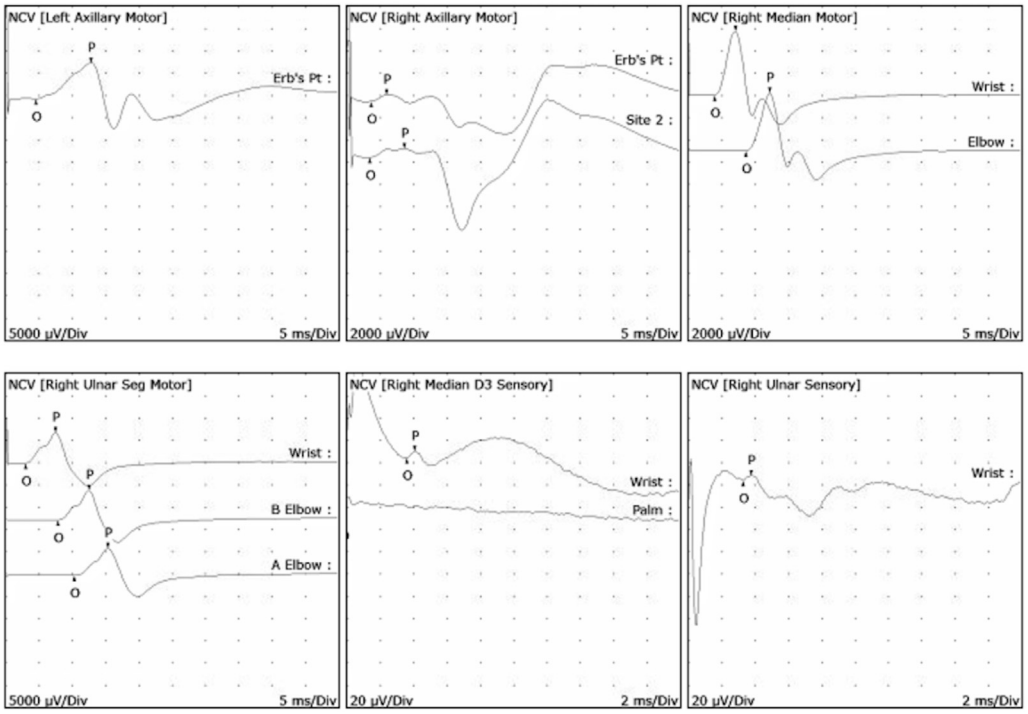

Figure 4 (**A**) The electromyographic (EMG) studies obtained after the 3-month follow-up. There is markedly reduced amplitude of the right axillary motor nerve compared to the contralateral side as well as the marked abnormal spontaneous activity noted in the right deltoid muscle. (**B**) The nerve conduction study which demonstrates decreased motor conduction velocities, prolonged sensory latencies, and decreased sensory amplitudes in the right upper extremity.

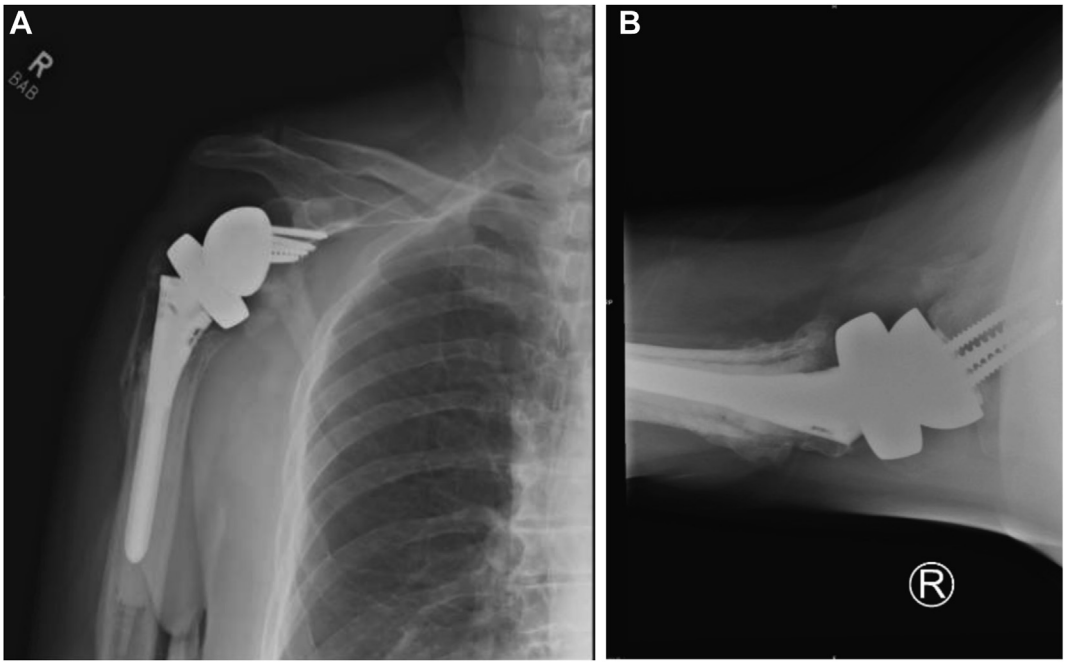

Figure 5 Postoperative x-rays at the 6-month follow-up. (**A**) An AP view of the right shoulder. (**B**) An axillary view of the right shoulder. *AP*, anterior posterior.

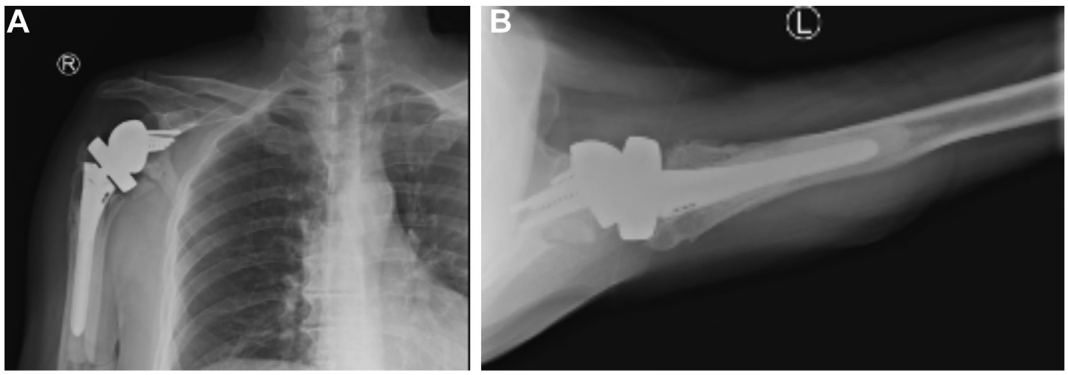

Figure 6 Postoperative x-rays at the 22-month follow-up. (**A**) An AP view of the right shoulder. (**B**) An axillary view of the right shoulder. *AP*, anterior posterior.

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