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Title

Functional deficits following brachial plexus injury in anterior shoulder dislocation: a case series

Abstract

The association between anterior shoulder dislocation and brachial plexus injuries remains relatively uncommon. Patients with a plexus injury due to anterior shoulder dislocation were monitored over a 2-year period. Muscle power according to the Medical Research Council scale and sensation were measured from presentation to discharge. In 28 patients, the power grade of proximal muscles supplied by nine injured nerves failed to improve over a median follow-up of 5 months. There was no statistically significant improvement in sensation over a median follow-up of 6 months. Poorer recovery in muscle power score was related to advancing age, whereby every decade increased the risk by approximately 30%. Anterior shoulder dislocation with a plexus injury carries a risk of permanent nerve injury. Patients should be referred for specialist nerve assessment leading to rehabilitation and timely early nerve reconstruction, if indicated.

Level of Evidence: IV

INTRODUCTION

Dislocations of the glenohumeral joint are common, with a reported incidence of 40.4 per 100,000 male person years and 15.5 per 100,000 female person years (Shah et al., 2017). The incidence is bimodal, affecting young males and older females (Avis and Power, 2018; Cutts et al., 2009; Krøner et al., 1989). A higher proportion of older females are reported to suffer dislocations after falling at home whereas males are more often involved in high-energy mechanisms, such as a road traffic accident or sports injuries (Avis and Power, 2018; Cutts et al., 2009; Krøner et al., 1989). However, even for low-energy injuries, a glenohumeral dislocation can substantially traumatise surrounding structures including the brachial plexus (Gutkowska et al., 2018b).

Neurological deficits as a result of shoulder dislocation has been reported to affect up to 14% of patients following reduction, and this is often associated with a rotator cuff tear or greater tuberosity fracture (Robinson et al., 2012). A prospective needle electromyographical (EMG) study concerning anterior shoulder dislocation reported abnormal findings in 48% of patients with low velocity trauma, with the axillary nerve most commonly injured (Visser et al., 1999). Although, in general, brachial plexus injuries (BPI) are purported to resolve less quickly in older patients (Kosiyatrakul et al., 2009), there is no longitudinal data to support this belief. Data demonstrating the typical neurological recovery in BPIs following shoulder dislocation is also limited.

This study was designed to observe the natural neurological recovery of patients with BPI associated with anterior shoulder dislocation. The main aim was to investigate the patterns of injury and recovery over time.

METHODS

Study Design & Setting

This retrospective consecutive case series investigated patients with BPI and shoulder dislocation (over 18 years of age) who were managed within a specialist nerve injury unit over a period of two years. Patients had a detailed clinical assessment to identify those in whom early nerve exploration was indicated, for example, high energy road traffic accidents (days to weeks). Patients were also sequentially monitored and in this group, patients who fail to demonstrate adequate recovery underwent nerve exploration and reconstruction within 3 months and no later than 6 months after the injury. Patient demographics and mechanism of injury were recorded and analysed.

Outcome measurements

Upper limb function (muscle power according to the Medical Research Counci (MRC) scale and sensation) was measured at baseline and at each clinic visit until discharge. Motor power was measured through palpable contraction. Proximal index muscles (PIM) were chosen for each nerve as these would be the first to be reinnervated in those with severe but in-continuity nerve lesion (Table 1). These assessments were performed in clinic according to the Medical Research Council's guidelines (Compston et al., 1942). Cutaneous sensation was recorded as the level of stimulus felt by the patient upon light touch and recorded as either absent, reduced or normal. Abnormal or absent sensation was recorded in 55 dermatomes. All assessments were undertaken by experienced physiotherapists with specialist interest in BPI.

Neurophysiology

The absolute values and clinician comments were extracted from nerve conduction and electromyography reports. Electromyography (EMG) reports were not standardised and contained different assessments and differing amounts of information that were presented in a case-to-case basis, and in various formats. This precluded any form of statistical analysis and a narrative summary of the findings was presented.

Statistical Methods

No prior information was available on which to base a sample size calculation. There was missing data for some patients, typically no documentation of objective assessments of some (assumed to be) uninjured nerves and repeated measurements. There was insufficient information for a meaningful assessment of the pattern of missingness and thus imputation. Therefore, the denominators of all assessments are provided, to show where data were missing. The MRC score was modelled using rank-based methods whereby scores are presented as medians (with interquartile ranges, IQR), paired scores are compared using the sign-rank test and the effect of age on change in MRC score was estimated using non-parametric regression. Further, the effect of age, side of injury, handedness and time from injury on motor recovery was modelled individually using Cox regression to estimate hazard ratios (HR). Sensory data is presented as frequencies (with percentages) paired scores and compared using the McNemar's test. Significance was set at 5% and 95% confidence intervals (CI) were generated.

RESULTS

28 individuals (12 females and 16 males) who sustained an anterior shoulder dislocation with traumatic infra-clavicular BPI were included. The mean age was 52 years (SD 14). Eight males (mean age 42 years) sustained high-energy injuries: two motorbike accidents, one bicycle accident and five falls from height. The two injured from motorbike accidents underwent exploration. One of these had a radial to axillary nerve transfer, and the other had an exploration only as the nerves were in continuity. The remaining 20 patients (13 females and seven males, mean age 56 years) sustained low-energy injuries after falling from standing height, and none of these underwent surgery. Patients who sustained a high-energy injury were 13 years younger (95% CI: 1 to 25; p=0.03). Concomitant injuries included a Hill-Sachs lesion, a greater tuberosity fracture and a fracture of right proximal humeral neck. The pattern of motor and sensory nerve deficit was similar in high and low-energy shoulder dislocations.

Motor Recovery

In 28 patients, 80 peripheral nerves were injured. In 58 (73%) injured nerves, the MRC grade of the proximal index muscle (PIM) improved by at least 1 MRC grade, with the median time to improvement of 5 months (IQR 1 to 9; range 1 to 22 months). Thirty-three improved within 1 to 6 months, 12 in 7 to 12 months, 9 in 13 to 18 months and 4 in 19 to 22 months. The PIM of 9 injured nerves failed to improve MRC grade during the follow up time. Table S2 shows the MRC ratings for each PIM representing a peripheral nerve at the time of injury and discharge, and their change over time. The PIMs of the axillary and radial nerves recovered function, whilst no recovery was seen in those innervated by the musculocutaneous, median and ulnar nerves.(Table 2)

The axillary nerve was most commonly injured 22/24 (92%), but the PIM (deltoid) improved by at least one MRC grade in 20 of the 22 cases, and two patients with an axillary nerve deficit failed to recover. The ulnar nerve was injured in 17/23 (74%) patients and six failed to improve. The radial and musculocutaneous nerves were injured in 15/23 (65%), and 14/22 (64%), respectively. One patient with a radial nerve injury failed to recover; this patient also had an axillary nerve deficit but was lost to follow-up after two months. Five patients with a musculocutaneous nerve injury failed to recover. The median nerve was injured least often 12/23 (52%) and the MRC grade of the PIM failed to improve in only one patient.

Advancing age increased the chance of no improvement in the PIM MRC score (HR 1.03 (95% CI: 1.0 to 1.1] ; p=0.01). Figure 1 suggests that for every decade of life beyond 20 years, the risk of no motor recovery (according to the MRC scale) increased by 30%.

The sex of the patient (p=0.464) and mechanism of injury (p=0.367) were not statistically associated with motor recovery.

Sensory Recovery

In all 28 patients, the sensation was reduced or absent at the time of injury in 55 spinal dermatomes. Overall, there was no statistically significant improvement in cutaneous sensation of any dermatomes over a median 6 months of follow-up (IQR 3 to 9; range 1 to 22 months; (Table 3). Of the 55 dermatomes with absent or reduced sensation at baseline, 16 showed improvement. Of the 16, nine recovered within 1 to 6 months; six in 7 to 12 months; and one in 18 months. The median time to recovery of cutaneous sensation was 3 months (IQR 1 to 8; range 1 to 22 months).

. The age (p=0.704), sex of the patient (p=0.659) and mechanism of injury (p=0.389) were not statistically associated with sensory recovery.

Neurophysiology

Of the 28 patients, 13 had clinical neurophysiology studies. The median time from injury to the first neurophysiological assessment was seven months (IQR 2 to 18; range 1 to 61). In six cases there was “evidence of reinnervation” or “significant reinnervation” on EMG but only five of these patients improved an MRC grade in the PIM (three deltoid, one flexor carpi ulnaris and one triceps). One patient with evidence of reinnervation on EMG at 28 months but no motor recovery, had medial and posterior cord injuries. No other conclusive information could be derived from the neurophysiology studies.

DISCUSSION

Our study demonstrates that motor recovery was, in general, better than sensory recovery in patients with BPI as a result of anterior shoulder dislocation. Injuries of the axillary and radial nerves improved significantly but not the other nerves in this case series and as expected, advancing age increased the risk of permanent injury. Furthermore, this study demonstrated that light touch sensory recovery is poor, at best, in most patients.

Several authors have found that the axillary nerve is most vulnerable to injury following anterior dislocation (Gutkowska et al., 2018a, 2018b; Krøner et al., 1989; McManus et al., 1976). The anatomical position of the axillary nerve around the surgical neck of the humerus puts it at significant risk during dislocation when the humeral head typically moves in an anterior and inferior direction (Apaydin et al., 2010). BPI are more likely to occur when a shoulder is dislocated with the arm fully extended and abducted, as this subjects the plexus to the most amount of stretch (Hems and Mahmood, 2012). Our study is in agreement with this finding as axillary motor nerve deficit was most frequently observed.

A number of publications have reported demographic associations between gender, age and mechanism of injury (Cutts et al., 2009; Gutkowska et al., 2018b, 2018a; Sakellariou et al., 2014) but amongst our cohort, only age was observed to be a significant factor relating to motor recovery. Gutkowska et al., (2018b) reviewed the literature and reported that most neurological deficits recovered spontaneously, however, the rate of recovery decreased with age (Gutkowska et al., 2018b). Increasing age (above 50 years) was also found to contribute to neurological complications (Gutkowska et al., 2018b). Perlmutter et al., (1999) described a wide range of outcomes from a return to normal function, to life-long pain, paralysis and paraesthesia. Koysiyatrakul et al., (2009) described better recovery in the intrinsic muscles of the hand in patients less than 50 years (Kosiyatrakul et al., 2009). Furthermore, Visser et al., (1999) reported that the risk of nerve injury increased by a factor of 1.3 for every increasing decade.

Chronic pain affects 95% of patients with a BPI (Park et al., 2017). Sensory impairment in the hand causes functional impairment and poor motor learning which may explain the 20% risk of re-injury (Emamhadi and Andalib, 2019; Park et al., 2017). Few studies have reported the recovery of cutaneous sensation following anterior shoulder dislocation. Travlos et al., (1990) reported sensation to always precede motor recovery and to be a potentially good indicator for motor recovery; however, this was not observed in our study. Considering the ratio of sensory to motor nerves in the brachial plexus to be at least 9:1 (Gesslbauer et al., 2017) future research should focus on the impact of afferent neuronal pathways on pain and functional disability.

Patients with BPI following anterior shoulder dislocation require specialist assessment to determine appropriate management. Some patients have better functional recovery when managed non-operatively (Sakellariou et al., 2014). Even when managed conservatively, these patients are closely monitored and supported by experienced physiotherapy and occupational practitioners and within this context, patients can be educated about their injury and the rehabilitation process. Passive range of motion exercises can be taught to mitigate contractures and focus on zones of denervation. As muscles are re-innervated, the rehabilitation can be tailored to strengthen reanimating muscle groups. Until better evidence is obtained, therapy for BPI should be delivered in academic institutions such that research can be undertaken on how best to improve limb function and quality of life.

There were several limitations in this study. The review was conducted within a small cohort of patients referred to a tertiary brachial plexus injury service and therefore may not represent the population of patients with nerve injuries following shoulder dislocation. The small sample size reduces statistical power and may increase the risk of type 2 error. Patient notes were reviewed retrospectively with variable observation periods and number of times each MRC and sensory innervation was tested. There were missing data for some outcomes and thus, we provide the denominator for clarity. A prospective study could potentially capture more complete data with set observation intervals. Assessment of power and sensation was performed by different clinicians, and there can be slight variations in the way these were measured. Further research could focus on improving the homogeneity of these assessments. Furthermore, we acknowledge that using the proximal index muscle does not include intrinsic muscle assessment in the hand, but MRC assessment of these small muscles can be challenging when there is associated joint stiffness and swelling from prolonged denervation. Electrodiagnostic tests can influence the decision-making process, in particular, in those with delayed recovery (Lawrence et al., 2000). In our study, 13 of 28 cases had electrical evaluation precluding meaningful analysis so we recommend that clinicians routinely acquire repeated neurophysiological assessments at fixed timepoints to better understand the utility of this test. At the time of dislocation, the rotator cuff is at risk of both musculotendinous and neurological insult. We have not assessed the rotator cuff in this patient cohort, rather, we have focused on the infraclavicular plexus and motor deficit from nerve injury alone; future studies might consider performing routine sonographic assessment of the cuff as soon as possible in all patients. Testing of sensation remains challenging. There were only three categories for sensation grading and therefore small improvements to sensory recovery may not be captured. More objective measures (such as 2-point-discrimination or mono filament threshold testing) recorded at set intervals in a prospective study would be a better approach. Similarly, there was no definition of high- and low-energy mechanisms of injury which may undermine our analysis. The median follow-up of 6-months is relatively short, and this is likely to be downwardly biased by the patients that were only minimally disabled at presentation (e.g. MRC 4/5 in the deltoid) and who recovered rapidly, within a few months. Equally, for those who were more disabled, our surveillance period may be insufficient to appreciate the fullness of their recovery.

Patients with brachial plexus injuries from anterior shoulder dislocation are at risk of long-term functional deficit; this risk is most pronounced in the elderly. From our study, the axillary nerve is the most commonly affected nerve and ulnar nerve innervation showed the lowest rate of recovery. Such patients should be immediately referred to a specialist brachial plexus service for assessment, physiotherapy and the option of surgery if indicated.

References

Apaydin N, Tubbs RS, Loukas M, Duparc F. Review of the surgical anatomy of the axillary nerve and the anatomic basis of its iatrogenic and traumatic injury. Surg Radiol Anat. 2010;32(3):193-201. doi:10.1007/s00276-009-0594-8.

Avis D, Power D. Axillary nerve injury associated with glenohumeral dislocation: : A review and algorithm for management. *EFORT Open Rev*. 2018;3(3):70-77. Published 2018 Mar 26. doi:10.1302/2058-5241.3.170003.

Compston A. Aids to the investigation of peripheral nerve injuries. Medical Research Council: Nerve Injuries Research Committee. His Majesty's Stationery Office: 1942; pp. 48 (iii) and 74 figures and 7 diagrams; with aids to the examination of the peripheral nervous system. By Michael O'Brien for the Guarantors of Brain. Saunders Elsevier: 2010; pp. [8] 64 and 94 Figures. *Brain*. 2010;133(10):2838-2844. doi:10.1093/brain/awq270.

Cutts S, Prempeh M, Drew S. Anterior shoulder dislocation. Ann R Coll Surg Engl. 2009 ;91(1):2-7. doi:10.1308/003588409X359123.

Emamhadi M, Andalib S. Successful recovery of sensation loss in upper brachial plexus injuries. Acta Neurochir (Wien). 2018;160(10):2019-2023. doi:10.1007/s00701-018-3648-z.

Gesslbauer B, Hruby LA, Roche AD, Farina D, Blumer R, Aszmann OC. Axonal components of nerves innervating the human arm. Ann Neurol. 2017; 82(3): 396–408. doi:10.1002/ana.25018.

Gutkowska O, Martynkiewicz J, Stępniewski M, Gosk J. Analysis of Patient-Dependent and Trauma-Dependent Risk Factors for Persistent Brachial Plexus Injury after Shoulder Dislocation. Biomed Res Int. 2018; 2018:4512137. Published 2018 Jan 10. doi:10.1155/2018/4512137.

Gutkowska O, Martynkiewicz J, Urban M, Gosk J. Brachial plexus injury after shoulder dislocation: a literature review. Neurosurg Rev. 2018;43(2):407-423. doi:10.1007/s10143-018-1001-x.

Hems TEJ, Mahmood F. Injuries of the terminal branches of the infraclavicular brachial plexus: Patterns of injury, management and outcome. J Bone Joint Surg Br. 2012 ;94(6):799-804. doi:10.1302/0301-620X.94B6.28286.

Kosiyatrakul A, Jitprapaikulsarn S, Durand S, Oberlin C. Recovery of brachial plexus injury after shoulder dislocation. Injury. 2009;40(12):1327-1329. doi:10.1016/j.injury.2009.05.015.

Krøner K, Lind T, Jensen J. The epidemiology of shoulder dislocations. Arch Orthop Trauma Surg. 1989;108(5):288-290. doi:10.1007/BF00932317.

Lawrence R. Robinson MD. Traumatic injury to peripheral nerves. Muscle Nerve. 2000; 23(6):863-73.

McManus F. Brachial plexus lesions complicating anterior fracture-dislocation of the shoulder joint. Injury. 1976;8(1): 63–6. doi:10.1016/0020-1383(76)90013-9.

Mills KR. The basics of electromyography. J Neurol Neurosurg Psychiatry. 2005; 76 Suppl 2(Suppl 2): ii32-ii35. doi:10.1136/jnnp.2005.069211.

Park HR, Lee GS, Kim IS, Chang JC. Brachial plexus injury in adults. Oper Nerve Repair Reconstr. 2017, 2: 1285–301.

Perlmutter GS. Axillary Nerve Injury. *Clin Orthop Relat Res*. 1999; (368): 28–36.

Robinson CM, Shur N, Sharpe T, Ray A, Murray IR. Injuries Associated with Traumatic Anterior Glenohumeral Dislocations. J Bone Joint Surgery-Am. 2012; 94(1): 18–26. doi:10.2106/JBJS.J.01795.

Sakellariou VI, Badilas NK, Stavropoulos NA, et al. Treatment Options for Brachial Plexus Injuries. ISRN Orthop. 2014;2014:314137. Published 2014 Apr 14. doi:10.1155/2014/314137.

Shah A, Judge A, Delmestri A, et al. Incidence of shoulder dislocations in the UK, 1995-2015: A population-based cohort study. BMJ Open. 2017; 7(11):e016112. Published 2017 Nov 14. doi:10.1136/bmjopen-2017-016112.

Travlos J, Goldberg I, Boome RS. Brachial plexus lesions associated with dislocated shoulders. J Bone Joint Surg Br. 1990;72(1):68-71.

Visser CPJ, Coene LN, Brand R, Tavy DL. The incidence of nerve injury in anterior dislocation of the shoulder and its influence on functional recovery. A prospective clinical and EMG study. J Bone Joint Surg Br. 1999;81 (4):679-685. doi:10.1302/0301-620x.81b4.9005.

von Elm E, Altman DG, Egger M, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ*. 2007;335(7624):806-808. doi:10.1136/bmj.39335.541782.AD.

Figure 1. A scatter plot of age against motor recover according to the MRC scale. The line of fit (and 95% CI) are derived from non-parametric regression and show that younger patients have better motor recovery.