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Injuries associated with serious brachial plexus involvement in polytrauma among patients requiring surgical repair

Radek Kaiser, Libor Mencl, Pavel Haninec *

3rd Faculty of Medicine, Charles University, Department of Neurosurgery, Faculty Hospital Kralovske Vinohrady, Srobarova 50, 100 34 Prague, Czech Republic

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ABSTRACT

Background: Brachial plexus injury occurs in up to 5% of polytrauma cases involving motorcycle crashes and in approximately 4% of severe winter sports injuries. One of the conditions for the success of operative therapy is early detection, ideally within three months of injury. The aim of this study was to evaluate associated injuries in patients with severe brachial plexus injury and determine whether there is a characteristic concomitant injury (or injuries), the presence of which, in the polytrauma, could act as a marker for nerve structures involvement and whether there are differences in severity of polytrauma accompanying specific types of brachial plexus injury.

Methods: We evaluated retrospectively 84 surgical patients from our department, from 2008 to 2011, that had undergone brachial plexus reconstruction. For all, an injury severity scale (ISS) score and all major associated injuries were determined.

Results: 72% of patients had an upper, 26% had a complete and only 2% had a lower brachial plexus palsy. The main cause was motorcycle crashes (60%) followed by car crashes (15%). The average ISS was 35.2 (SD = 23.3), although, values were significantly higher in cases involving a coma (59.3, SD = 11.0). The lower and complete plexus injuries were significantly associated with coma and fractures of the shoulder girdle and injuries of lower limbs, thoracic organs and head. Upper plexus injuries were associated with somewhat less severe injuries of the upper and lower extremities and less severe injuries of the spine.

Conclusion: Serious brachial plexus injury is usually accompanied by other severe injuries. It occurs in high-energy trauma and it can be stated that patients involved in motorcycle and car crashes with multiple fractures of the shoulder girdle are at high risk of nerve trauma. This is especially true for patients in a primary coma. Lower and complete brachial plexus injuries are associated with higher injury severity scale.

Introduction

Brachial plexus injury (BPI) is a very mutilating lesion which typically affects young men of productive age. Therefore BPI has a serious socio-economic impact.[1,2] There are two major mechanisms and types of BPI. One is a traction injury, which results in the avulsion or rupture of one or more cervical roots and the other is direct injury to the trunks, cords and nerves of the brachial plexus. BPI occurs in approximately 5% of polytrauma patients involved in motorcycle crashes and in 3–4.8% of patients who experience a serious winter sports injury. While motorcycle collisions are the most common cause of BPI in adults,[1] car crashes and pedestrian accidents predominate in children.[3]

BPI is typically a closed lesion and more than 50% of patients need operative reconstruction of affected brachial plexus elements.[4] The rupture or avulsion of upper roots (C5–6 ± C7) is the most common type of BPI (upper brachial plexus palsy, weakness of the shoulder girdle and elbow flection). A complete lesion with avulsion of all roots is less common. The avulsion of lower roots only (C8–T1, lower BPI, weakness of the hand movements) is very rare since it is usually accompanied by a rupture of the upper roots as well. Upper roots are more fixated in intervertebral foramina which results in a greater tendency to rupture.[5] Better resuscitation techniques, which have led to increased survival of patients after polytrauma, has increased the total number of BPIs.[4,6] Patients with supraclavicular lesions usually have more coincident severe injuries than patients with infraclavicular lesions.[7]

A detailed examination is often not possible due to coma or multiple fractures. Moreover, many injuries initially appear as complete lesions because of neurapraxia (functional block). Neurological impairment is often detected after the patient comes out of a coma or after primary treatment (surgical treatment of

* Corresponding author. Tel.: +420 267 168 540; fax: +420 272 738 490.
E-mail addresses: kaiser@fnkv.cz (R. Kaiser), mencl.libor@gmail.com (L. Mencl), haninec@fnkv.cz, pavel.haninec@fnkv.cz (P. Haninec).

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fractures or vascular injuries). Horner's syndrome is, however, an early sign of lower cervical roots avulsion.[6,8] The aim of this study was to evaluate associated injuries in patients with serious brachial plexus involvement and determine whether there is a characteristic concomitant injury (or injuries), the presence of which, in polytrauma, could act as a marker for nerve structures involvement and whether there are differences in severity of polytrauma accompanying specific types of brachial plexus injury.

Material and methods

We retrospectively evaluated 84 surgical patients (of the senior author) from 2008 to 2011. All patients had a closed BPI. The group consisted of 78 men and 6 women (male–female ratio 13:1) with an average age of 31.3 years (SD = 9.3, range = 14–65 years). The average latency between injury and surgery was 6.4 months (SD = 1.9, range = 3–13 months).

Preoperative examination

All patients sent to our department had no clinical or electrodiagnostic evidence of recovery within 3 months. The injury was assumed to be severe and the patient was deemed a candidate for surgery. Generally, we operate on all such patients, i.e. with severe BPI who have good prognosis relative to participation in subsequent rehabilitation.

Preoperative neurological status was assessed in each patient. The Medical Research Council (MRC, British system) scale for grading of muscle strength has been used. Each clinical assessment was augmented by electrophysiological evaluation. All the patients underwent preoperative EMG examination by a needle concentric electrode and nerve conduction studies. CT myelography was performed to evaluate the cervical root avulsion. We did not include MR into the preoperative evaluation because of lower sensitivity for the diagnosis of avulsion.[6,8]

Operative technique

The combined supra- and infraclavicular approach was used in all cases in which the condition of the cervical nerve roots was uncertain and preoperative clinical and electrophysiological data showed high probability of a lesion above and below the level of the clavicle. The infraclavicular approach was used in cases in which clear avulsion of the nerve roots was demonstrated by computed tomography myelography and the finding was consistent with both clinical and electrophysiological data. In these cases, a nerve transfer was performed from the infraclavicular approach. In cases of denervation of suprascapular nerve, its neurotisation by using spinal accessory nerve was performed via supraclavicular approach. A supraclavicular approach alone was used in cases in which clinical and electrophysiological data suggested the lesion was limited to the level of anterior rami of the spinal nerves and trunks.

The standard technique of nerve grafting was used to repair injured anterior rami of spinal nerves. Intraoperative decisions during direct repair (grafting) procedures were guided by electrophysiological methods. The most common type of operation performed was nerve transfer (neurotisation). Donors of motor fibres for nerve transfer were assessed preoperatively by EMG examination as well as during the operation procedure by direct bipolar electrical stimulation and visual evaluation of the muscle contraction.[8]

Postoperative examination

All patients were hospitalised for one week with the upper extremity fixated in shoulder adduction and elbow flexion. The extremity was fixated for three weeks and after that the every day rehabilitation with electrostimulation of denervated muscles were recommended. The patients were examined with EMG and clinically with using MRC muscle grade score every half year. Minimum time of follow-up is two years. Our long-term results were previously published in 2007.[8]

Associated injuries

Data came from discharge summaries of the hospital where the patient received primary treatment after the crash and reports from patients' general practitioners. Patients with cutting, stabbing or iatrogenic injuries or patients with a single nerve injury caused by a shoulder dislocation or fracture of the humerus (axillary or radialis nerve) were not included in the study.

The following data were obtained for all patients: mechanism of injury, initial coma, severe brain (intra- or extracerebral haematoma) or cranial injury requiring surgery, spinal injuries, fractures of ribs, scapula, clavicle, pelvis, and skeleton of upper and lower limbs and injuries of parenchymal organs and large vessels. An Injury Severity Scale (ISS) value was calculated according to the severity of individual injuries.

The results were analyzed using the Pearson's Chi-squared test (χ^2) with Yates' correction for continuity (for categorical data) and *t*-test (for continuous data). Analyses were done using Statistica 9.0 software (StatSoft Inc., Tulsa, Oklahoma, USA). Significance was assumed at $p < 0.05$.

Results

Twenty-two from 84 (22/84) cases (26%) of BPIs were affected by rupture of one to three upper roots (without avulsion). An avulsion of one to three of these roots was present in 39/84 cases (46%). Upper brachial plexus palsy was found in 61/84 cases (72%). Five of seven patients with at least one avulsion of the lower roots, also had a rupture involving the upper roots. Nineteen patients had an avulsion of all roots C6–8 ± C5 ± Th1. A clinical picture linked to complete palsy was expressed in 24/84 (26%) patients. A lower plexus palsy was only seen in 2/84 patients (2%).

The dominant cause of BPI was motorcycle collision (60%, 50 cases). This was followed by car collision, falls, bicycle crashes or injuries during winter sports. Other causes were rare. The results are summarised in Table 1.

Table 1
Causes of brachial plexus palsies. Rupture: rupture of one to three cervical root(s) C5–7, Upper avulsion: avulsion of one to three cervical root(s) C5–7, Lower avulsion: avulsion of one to three root(s) C7–Th1, Complete avulsion: avulsion C6–8 ± C5 ± Th1. Water flow: shoulder injury caused by a water shot from a fire hose. Values are reported as number of cases from a specific group of BPI types/(%).

Type of BPI	Motorcycle	Car	Falls	Winter sports	Bicycle	Fall of the object onto shoulder	Water flow
Rupture	8 (36%)	4 (18%)	2 (8%)	4 (18%)		3 (17%)	1 (3%)
Upper avulsion	27 (69%)	2 (6%)	3 (8%)	2 (6%)	5 (11%)		
Lower avulsion	6 (86%)	1 (14%)					
Complete avulsion	9 (47%)	5 (31%)	1 (6%)	1 (6%)			
All cases	50 (60%)	12 (14%)	6 (7%)	7 (8%)	5 (6%)	3 (4%)	1 (1%)