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BRACHIAL PLEXUS INJURY. ASSESSMENT AND TREATMENT

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SUMMARY

Brachial plexus injury can lead to sever upper extremity impairment. Appropriate clinical evaluation of newborn or adult has to be done to assess the current status and a possible regeneration phenomenon. In case of no improvement, the surgical treatment should be undertaken approximately 3–6 months after injury. Surgery can involve in-situ repair of the plexus or nerve transfers outside. In case of late presentation or poor neurosurgical results, secondary procedures including the tendon transfers, joint fusions or osteotomies can be proposed to improve function of upper extremity. The aim of this report was to describe methods of evaluation and treatment of brachial plexus injuries with a literature review on this topic.

Keywords: brachial plexus injury, brachial plexus palsy, surgical nerve reconstruction, surgical nerve transfers

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USZKODZENIE SPLOTU RAMIENNEGO. DIAGNOSTYKA I LECZENIE

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STRESZCZENIE

Uszkodzenie splotu ramiennego może doprowadzić do znaczącej utraty funkcji kończyny górnej. Zarówno w przydatku uszkodzeń splotu u noworodków jak i osób dorosłych, powinna zostać przeprowadzona odpowiednia ocena kliniczna, aby ocenić aktualny stan uszkodzenia oraz ewentualnego procesu regeneracji samoistnej w nerwach. W przypadku braku poprawy klinicznej, leczenie operacyjne powinno być podjęte około 3–6 miesięcy po urazie. Operacja może obejmować naprawę in situ nerwów splotu lub transfery nieanatomiczne nerwów. W przypadku braku poprawy w trakcie leczenia lub efektów rekonstrukcji nerwów, należy rozważyć wtórne zabiegi rekonstrukcyjne: przeniesienia ścięgien, artrodezy lub osteotomie w celu poprawy funkcji kończyny górnej. Celem tego doniesienia było przedstawienie metod oceny i leczenia urazów splotu ramiennego, łącznie przeglądem literatury w tym zakresie.

Słowa kluczowe: uszkodzenie splotu ramiennego, porażenie splotu ramiennego, chirurgiczna rekonstrukcja nerwu, chirurgiczne przeniesienie nerwu

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Introduction and aim

Brachial plexus injury can result in severe impairment, which can be persistent in up to 23% of cases (Chauhan *et al.* 2014). Besides shoulder dislocation in older patients and direct acute injuries, two groups of patients are usually met: new-borns with birth palsy and young adults. First is an injury during childbirth, mostly in cases with shoulder dystocia or when force is used (vacuum or clams) with the prevalence of 1.3 per 1000 births, but a decrease in time is observed (Chauhan *et al.* 2014). Second are patients injured in motorbike accidents which is a result of specific mechanism during falling down from motorbike and having brachial plexus stretching with a significant force (Sinha *et al.* 2015). Although most of these nerve injuries can spontaneously regenerate, approximately 27% are severe because of root avulsion from spinal cord or rupture of plexus trunk which can make them hard to repair (Chantaraseno *et al.* 2014). In this report, it was aimed to expose methods of their evaluation and treatment by the own experience as well as the review of relevant literature on these topics.

Material and methods

Examples of patients with brachial plexus injury, whose clinical status was evaluated with routine examination methods as well as neuroimaging and neurophysiological tests. Surgical and conservative procedures of treatment in different cases are presented.

Results

Patients have to be carefully clinically evaluated because other imaging and tests can only support the diagnosis and rarely decide about the treatment. Especially examination in children can be tricky and needs the experience. The level of the injury (supra-, sub- or infra- clavicular, pre- or post-ganglionic) and possible pattern should be assessed (Sinha *et al.* 2015). Mostly three main patterns can be described: complete involvement of all roots (75%–80% of traumatic brachial plexus injuries – BPIs), C5 and C6 upper trunk (Erb's palsy at 20–25%), C8, T1 or lower (Klumpke's palsy ranging at 0.6–3.0% of traumatic BPIs).

Clinical evaluation

Routinely like in cases of nerve lesions, sensory, motor and autonomic function of plexus branches have to be evaluated. Muscle testing and map of sensory perception is created to help in assessment of injured nerves. Tinel's sign can be found several weeks after injury and its presence can be a proof for rupture of trunk and neuroma formation rather than the root avulsion. Horner's sign (drooping of the left eyelid, pupillary constriction, anhidrosis) suggests C8 and Th1 root avulsion (Sinha *et al.* 2015). Specific test as "cookie test" in new-borns is used to evaluate the elbow flexion (Sinha *et al.* 2015). In late cases with the shoulder external rotation deficit, hornblower's sign can be observed (Figure 1a and b). Several scores (The Mallet's scale, Active Movement Scale (AMS), Toronto Test) are used separately to summary the patient's status and evaluate results (Greenhill *et al.* 2015).

Imaging

Imaging has supportive but limited role in diagnosing of mentioned above injuries. It is mostly because of complicated pattern and structure of brachial plexus, hard to be evaluated and interpreted by radiologist. MRI is used for assessment of possible root avulsion and evaluation of plexus itself mostly with use of short TI inversion-recovery (STIR) but some special views like IDEAL or FIESTA are needed to improve quality and selectivity of images (Tomura *et al.* 2015; Upadhyaya *et al.* 2015).

Ultrasonography has been recently employed for evaluation of plexus injury but the need of high technical skills and experience with subjectivity of the method itself makes this option rarely possible and

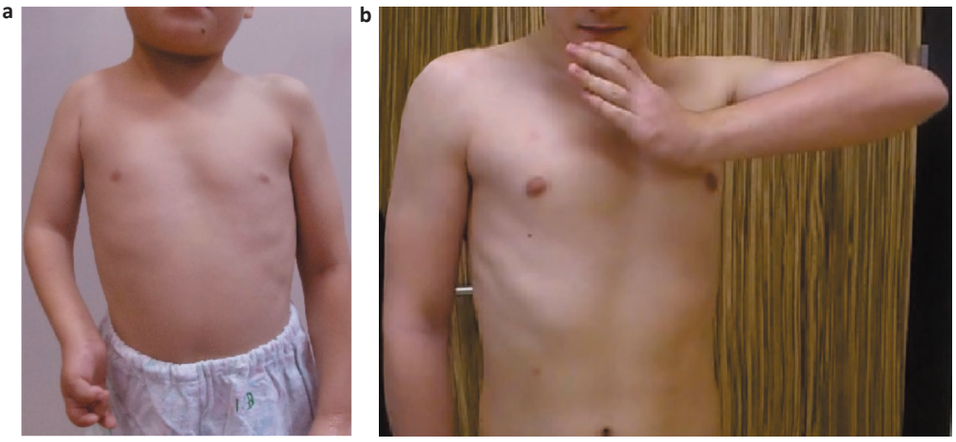

Figure 1. (a) Typical presentation of a child with the brachial plexus palsy. (b) Hornblower's sign.

less accurate than MRI (Smith *et al.* 2015; Somashekar *et al.* 2015).

Nerve conduction studies

Transmission of nerve impulses in nerve fibers can be evaluated to access the severity and level of injury. Mostly it is hard to distinguish the exact type of injury (root avulsion or rupture), but in cases of patients with evaluation of nerve regeneration, series of tests in different period can help to evaluate the indication for surgery or necessity to wait for regeneration. Intraoperative nerve stimulation is of the greater importance to evaluate neuroma in continuity and nerve status to decide if the resection and grafting are mandatory (Bahm *et al.* 2007).

Non-operative treatment

In most of the brachial plexus injuries it is expected the spontaneous regeneration in both new born and adult groups of patients. In case of unsatisfactory recovery in the period of early observation (3 to 6 months after the injury), the surgical treatment is indicated (Bahm *et al.* 2007; Mencl *et al.* 2015). Non-operative treatment mainly includes the rehabilitation protocol including passive and active mobilisation, electrostimulation and additional procedures as botox injections in some specific cases of muscle spasticity or contracture (mostly to subscapularis muscle).

Surgical treatment

If no signs of regeneration are observed or in cases of the confirmed open brachial plexus injury, the surgery is recommended to provide the best possible results. The nerves reconstructions or their transfers (in early treatment) should be undertaken around 4–6 months after closed injury but some possibilities up to 2 years after injury have been reported (Bahm *et al.* 2007). In cases of late presentation (after one year) or failed nerve reconstructive procedures still there are possibilities to improve limb function with surgery.

Early treatment

The nerve reconstruction procedures include primary brachial plexus repair with end to end adaptation (rare possibility, mostly in open injury or some specific cases) or grafting. Many strategies are described and used to recover the substantial function of shoulder, elbow and hand. Mostly, the choice is based on possible donors (healthy roots) which are used to cover the distal deficiency (Mencl *et al.* 2015). Best results are described in birth palsy due to the higher regeneration potential in newborns (Mencl *et al.* 2015). Supraclavicular approach is used with exposition of plexus roots and trunks for evaluation, if cases of sub- or infraclavicular injury, wider approach with clavicle osteotomy is used (Figure 2). Preoperative planning based on

clinical and imaging studies is mandatory to prepare several options adequate to situation found during surgery.

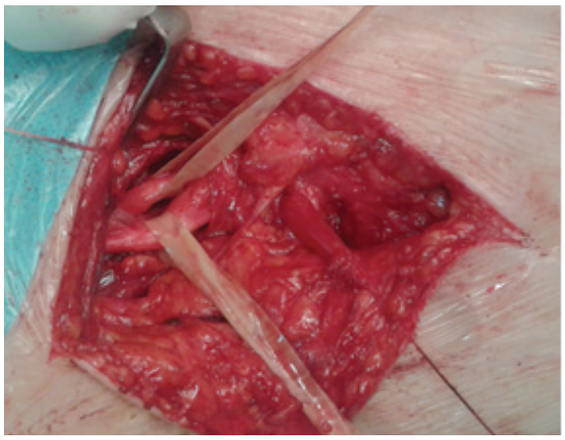

Figure 2. Supraclavicular exposition of brachial plexus trunks.

The second possibility, gaining popularity last years is the nerve transferring (Bahm *et al.* 2011; Bhandari and Maurya 2014). Donor nerves or branches are used to reconstruct motor branches of injured brachial plexus areas. They are mostly used in partial plexus injuries (possible uninjured donors) or as the support for plexus reconstruction to reanimate the shoulder and elbow function. They have several disadvantages like no need for plexus exploration, low morbidity, specific targeting of motor branches and short distance and time to achieve the regeneration and a final effect. The standards are accessory nerve to suprascapular nerve and branch of radial nerve to axillary nerve for shoulder recovery (Somsak procedure) and a branch from median, ulnar or both to biceps and/or brachialis branch of musculocutaneous nerve for the elbow flexion recovery (Oberlin transfer). (Figueiredo *et al.* 2016). These procedures provide reliable results in most of the cases with clinical effects starting approximately 4 months after procedure (Figueiredo *et al.* 2016) (Figure 3).

Late treatment, secondary procedures

In late or unsuccessful cases, some secondary procedures can be used to recover the functional impairment. They include joint fusions (in shoulder or wrist), many possibilities of tendon transfers, rotational osteotomy (humerus – shoulder, radius – forearm pronation), free functional muscle transfers (towards recovery of elbow flexion and finger movements) (Zhang *et al.* 2014; Hultgren *et al.* 2014).

Shoulder and wrist fusion provide stability of the joint and in a case of lack active movement of shoulder by use of scapular motion up to 90 degrees of flexion and abduction. These procedures are possible at any stage of treatment and give reliable everlasting results (Figure 4).

Tendon transfers are proposed in all the areas of upper extremity, mostly to support the shoulder abduction and external rotation by transfer of Latissimus dorsi in children (Figure 5). Pectoralis major or proximal flexors transfer can be solution for the elbow flexion improvement. Transfers in hand are based on possible donors. Donor tendons and muscle must be in a good condition and strength about 5 in Lovett's scale to have enough force after transfer and result in satisfactory joint motion recovery (Socolovsky *et al.* 2015).

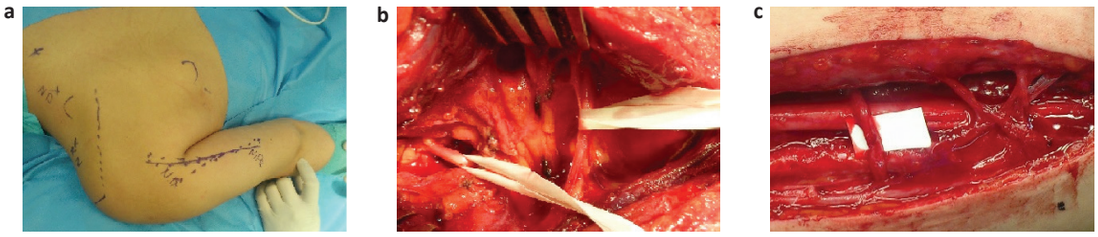

Figure 3. (a) Dorsal approach for transfers of shoulder recovery, (b) exposition of accessory and supraclavicular nerves, (c) ulnar nerve branch transferred to musculocutaneous branch for brachialis reconstruction.

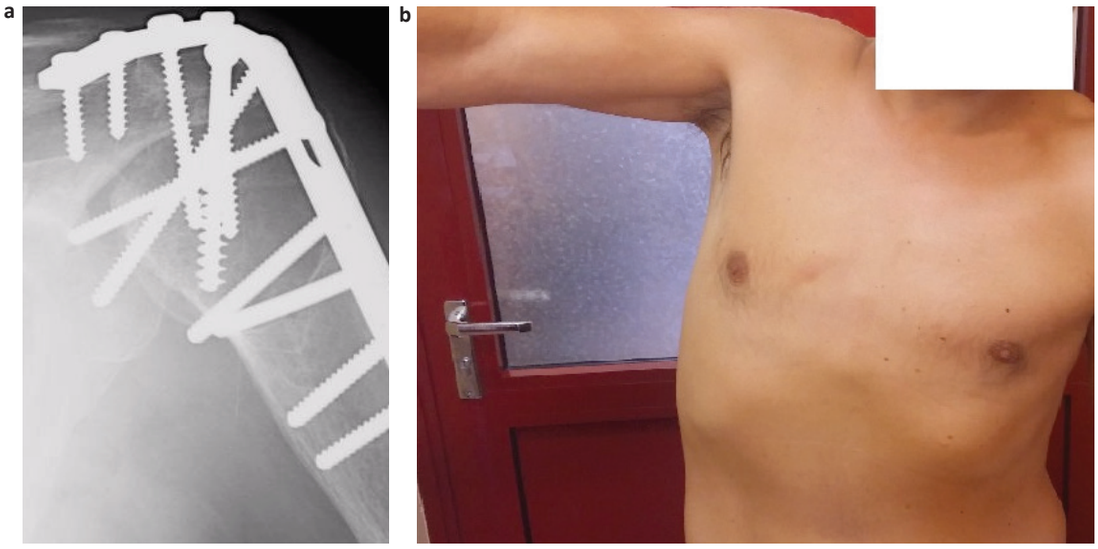

Figure 4. (a) Shoulder fusion, postoperative X-ray, (b) result 1 year after surgery for active shoulder abduction.

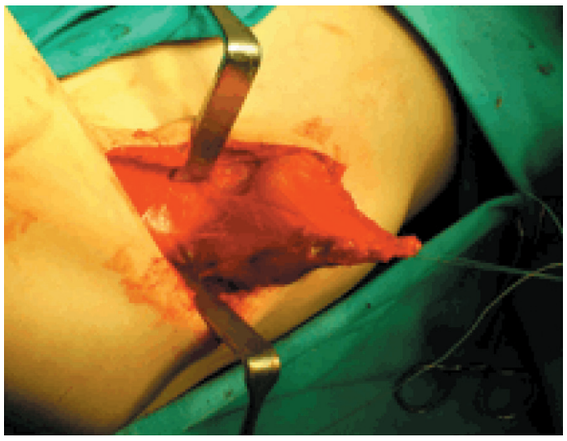

Figure 5. Latissimus dorsi muscle prepared for transfer to improve the abduction and external rotation.

Conclusions

Brachial plexus injury leads to severe impairment. Adequate treatment strategy based on clinical and imaging findings is mandatory to minimalize this severity both in young and adults patients.

REFERENCES

Bahm J., El Kazzi W., Schuind F. *Nerve transfers*. Revue Médicale de Bruxelles 2011; 32: S54–57.

Bahm J., Ocampo-Pavez C., Noaman H. *Microsurgical technique in obstetric brachial plexus repair: a personal experience in 200 cases over 10 years*. Journal of Brachial Plexus and Peripheral Nerve Injury 2007; 2, 1.

Bhandari P.S., Maurya S. *Recent advances in the management of brachial plexus injuries*. Indian Journal of Plastic Surgery 2014; 47: 191–198.

Chantaraseno N., Precha V., Supichyangur K., Cholpranee K. *Brachial plexus birth palsy: the natural history, outcome of microsurgical repair and operative reconstruction*. Journal of the Medical Association of Thailand 2014; 97 Suppl 11: S96–101.

Chauhan S.P., Blackwell S.B., Ananth C.V. *Neonatal brachial plexus palsy: incidence, prevalence, and temporal trends*. Seminars in Perinatology 2014; 38: 210–218.

Figueiredo R.M., Grechi G., Gepp R.A. *Oberlin's procedure in children with obstetric brachial plexus palsy*. Child's Nervous System 2016 Jan 13. (Epub ahead of print)

Greenhill D.A., Lukavsky R., Tomlinson-Hansen S., Kozin S.H., Zlotolow D.A. *Relationships Between 3 Classification Systems in Brachial Plexus Birth Palsy*. Journal of Pediatric Orthopaedics 2015 Dec 2. (Epub ahead of print)

Hultgren T., Jönsson K., Roos F., Järnbert-Pettersson H., Hammarberg H. *Surgical correction of shoulder rotation deformity in brachial plexus birth palsy: long-term results in 118 patients*. The Bone & Joint Journal 2014; 96-B: 1411–1418.

Mencl L., Waldauf P., Haninec P. *Results of nerve reconstructions in treatment of obstetrical brachial plexus injuries*. Acta Neurochirurgica 2015; 157: 673–680.

Sinha S., Pemmaiah D., Midha R. *Management of brachial plexus injuries in adults: Clinical evaluation and diagnosis*. Neurology India 2015; 63: 918–925.

Smith E.C., Xixis K.I., Grant G.A., Grant S.A. *Assessment of Obstetric Brachial Plexus Injury with Pre-Operative Ultrasound*. Muscle and Nerve 2015 Nov 13. doi: 10.1002/mus.24975. (Epub ahead of print)

Socolovsky M., Costales J.R., Paez M.D., Nizzo G., Valbuena S., Varone E. *Obstetric brachial plexus palsy: reviewing the literature comparing the results of primary versus secondary surgery*. Child's Nervous System 2015 Nov 28. (Epub ahead of print)

Somashekar D.K., Di Pietro M.A., Joseph J.R., Yang L.J.-S., Parmar H.A. *Utility of ultrasound in noninvasive preoperative workup of neonatal brachial plexus palsy*. Pediatric Radiolog 2015 Dec 30. (Epub ahead of print)

Tomura N., Saginoya T., Kokubun M., Tsuchiya M., Yamamoto T. *T2-weighted IDEAL fast spin echo imaging of the brachial plexus: comparison with STIR*. Acta Radiologica 2015; 56, 10: 1242–1247.

Upadhyaya V., Upadhyaya D.N., Kumar A., Pandey A.K., Gujral R., Singh A.K. *Magnetic resonance neurography of the brachial plexus*. Indian Journal of Plastic Surgery 2015; 48: 129–137.

Zhang C.-G., Dong Z., Gu Y.-D. *Restoration of hand function in C7-T1 brachial plexus palsies using a staged approach with nerve and tendon transfer*. Journal of Neurosurgery 2014; 121: 1264–1270.

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