Obstetric brachial plexus injuries and treatment between 0-2 years of age

Aydin Yuceturk

ABSTRACT

Obstetrical brachial plexus injury treatment was debatable before 1980. In the last three decades, however, treatment options and techniques are progressed. With successful results increasing the overall success rate, today, treatment of these patients is routinely performed in many countries, including Turkey, since 1993. Surgical treatment of brachial plexus injuries is still progressing in correlation with nerve injury treatments, but there are still obstacles related to treatment of multiple root avulsions and restoring hand function. In general, when treating an injury is difficult, it is always better to take care to prevent it. This may be possible with education of the population, patients, doctors and the government. In this article, differential diagnosis, radiological examination and conservative and surgical treatment of obstetrical brachial plexus injuries in the first two years of the age are discussed.

Key words: Obstetric brachial plexus injury, treatment

Introduction

Obstetrical brachial plexus injuries must be diagnosed and treated as early as possible. There is limited time for treatment, especially when the patient requires nerve repair. Early nerve repair using microsurgical techniques provides satisfactory results. Today, there is not much controversy surrounding wait time for surgery and the indications for its use. Expert surgeons and those experienced on the subject have shown that suitable patient knowledge with the correct surgical indication is now a routine of treatment in obstetrical birth palsy [1-3]. All patients, even those healed without nerve repair, must be followed up till skeletal maturity and secondary surgeries must be performed if there is need and an indication.

History

Obstetric brachial plexus injuries have been mixed with other congenital anomalies for centuries. Smellie, in 1768, first mentioned that it is an obstetrical trauma-related problem [1]. Danya, in 1851, showed lesions in a newborn autopsy [1]. This was followed by Duchenne, in 1861 and 1872, published a case of four patients with proximal root avulsions. The first publication in English was by Erb in 1874, his name becoming synonymous with upper root lesions. Klumpke, in 1885, showed isolated involvement of C8-T1, while slightly earlier, Seeligmueller (1877) described the total plexus injury [1-4]. Over the last 25 years, the development of microsurgical techniques in traumatic brachial plexus injuries, along with the overall surgical treat-
ment of obstetric patients, has made significant strides [2-4]. Gilbert and Tassin (180 patients), in 1984, and Gilbert (241 patients), in 1990, published the results of surgical treatment of obstetrical brachial plexus. [1,2,5-7]. In Turkey, the first obstetrical brachial plexus surgery was performed in 1993 by the author [8].

**Clinical Anatomy**

Brachial plexus injuries are common, but diagnosis is difficult because of the complex anatomy and the degree of injury. Between the roots and axilla of the cervical plexus, there are fascial attachments that increase the risk of injury, so the plexus is strongly affected by tension force [4]. For diagnosis, physical examination, treatment, follow-up and rehabilitation, supraclavicular and infraclavicular brachial plexus anatomy and the variations must be known extensively.

**Clinical Features**

**Epidemiology**

The incidence of obstetric brachial plexus is between 0.3-4/1000 and 0.38-2.6/1000 in United States [1,9]. In 1996, the authors screened 47,000 children all over Turkey in a project for pediatric disorders and found that obstetrical birth palsy incidence was 0.9/1000 [10]. This means that every year, nearly 1250 babies are born with obstetrical birth palsy.

Gilbert analysed 241 patients and 39.8% were C-5 and C-6, 33.6% were C-5, C-6 and C-7, and 26.6% were had total involvement [11]. In Laurent’s series of 75 patients, 73% were C-5, C-6 and C-7, 20% were C-5,C-6,C-7, C-8 and T-1, 2% were C-7, C-8 and T-1 and 4% bilateral [12]. The main risk factors for obstetrical brachial plexus injuries are high birth weight (over 4000 gr), prolonged labor time, shoulder dystocia and breech birth [1,13-15].

**History**

Patient history, maternal age, pregnancy number, duration of pregnancy, difficulty of birth (ie. normal or not), forceps or vacuum use, caesarean section, birth occurring at a hospital or elsewhere and whether birth was performed by a doctor or another medical professional are all essential details to collect from the patient. As well, the baby’s Apgar score, presence of perinatal asphyxia, and delivery weight must be inquired about. Further, the mother’s previous number of births and weight of the other children are also important to know [1,14-16].

**Physical Examination**

Within the first 48 hours of obstetric brachial plexus, injury should be looked into. The affected extremity is usually motionless and the Moro reflex has typically disappeared. Horner’s syndrome can be also seen (Figure 1). All physical findings must be recorded [17]. Based on nerve root avulsion from the spinal cord, developing hematoma can cause spastic paralysis of the extremities. As a result of prolonged and difficult birth, cerebral palsy may be found. Facial paralysis and sefal hematoma may be accompanied by cervical vertebra, clavicle and humerus fractures, seen isolated or in combination with brachial plexus injury. The presence of hematoma, pupil inequality, diaphragma involvement, spinal cord injury, and encephalopathy [1,7,9,11,12,14-16,18]. In Erb-Duchenne-type paralysis, the shoulder is in adduction and internal rotation while wrist and hand function is normal. Deltoid, supraspinatus, infraspinatus, teres minor, biceps brachii, supinator and brachioradialis muscle functions are corrupted (Figure 2) [1,9,15-17]. In Klumpke-type paralysis, there is loss of function of wrist flexors, finger flexors and intrinsic muscles of the hand. Horner’s sign on the same side can be seen when the cervical sympathetic fibers are also affected. In the mixed type, the entirety of the upper extremities are totally involved and loss of sensation is common. With this, motor and sensory examination and evaluation in infants is difficult. Arm, forearm, and palm-comparative atrophy measurements and acromi-
Obstetric brachial plexus injuries and treatment

Figure 2. A: Right side (newborn) B: Left-side brachial plexus palsy.

Figure 3. Radiological examination and differential diagnosis of obstetrical brachial plexus palsy A: humerus fracture; B: Neonatal septic arthritis and humerus osteomyelitis; C: Congenital high scapula, vertebral and rib anomalies (Klippel-Feil Syndrome).
on-olecranon and olecranon-ulnar styloid length measurements can be made but they are only valuable in the sequelae period [1,16]. An active and passive range of motions of the joints are evaluated. Muscle power assessment must be performed while the baby is crying. Examinations must be repeated every month, and the parents and the physicians should note any improvement [1].

**Radiological evaluation**

During initial consultation, cervical spine, chest, arm, shoulder and the chest x-rays should be taken. Radiographs of the cervical spine are reviewing for subluxation, fracture, and congenital anomaly (Figure 3). The diaphragm on a chest radiograph is evaluated - if there is elevation of diaphragm, this is a sign of C4 root or phrenic nerve injury [1].

Shoulder x-rays are conducted to evaluate clavicle fracture, shoulder dislocation, and humeral epiphysial or proximal fractures at the sequelae period glenoid and humeral head deformities along with coracoid elongations are examined [1,7]. If there are arm or forearm deformities, arm and forearm x-rays are taken for fractures or congenital abnormalities [14].

For root avulsion, 20 years ago, evaluations consisted of myelography and myelography with computerized tomography. However, today, MRI is the best diagnostic test available. [1] In the author’s experience, obstetrical plexus injuries are different than traumatic brachial plexus injuries when there is C8T1 pseudomeningocells present in the MRI, where adult hand function is severely injured. Yet, in obstetrical cases, rarely can the patient have totally normal hand functioning as depicted in Figure 4, so physical examination is always important.

**Electrophysiological evaluation**

Clinical examination in infants is the most impor-
Differential Diagnosis

In the differential diagnosis of neonatal tetraplegia, perinatal cerebrovascular problems, cervical vertebral problems, arthrogryposis multiplex congenita, cerebral palsy, clavicle fracture, humerus fracture or epiphyseal separation, or septic arthritis of the shoulder, osteomyelitis of the humerus should be considered.  

Treatment


The obstetrical brachial plexus injury follow-up treatment algorithm is shown in Table 1.
Table 1. Obstetrical brachial plexus injury follow-up and treatment algorithm.
Obstetric brachial plexus injuries and treatment

vide proper conditions for spontaneous nerve healing. In the first 10 days, the shoulder must be kept in adduction and internal rotation over the trunk [1].

Shoulder exercises should be avoided for the first three weeks, though after this period, shoulder and other joint exercises should be initiated. Family members should be instructed to make gentle movements of the joints, while traction and immobilization devices should be avoided. Immobilization devices cause pressure on the articulating surfaces, and subluxation or dislocation of the shoulder and external rotation contracture can be seen. External rotation and abduction devices must not be used and are contraindicated for the treatment of obstetrical plexus brachial injuries [21,22]. Excessive treatment, like forcing the shoulder posteriorly and forced shoulder abduction and external rotation, should be avoided and the limb must be protected [22]. Application of electrotherapy in the infant is not tolerable and remains controversial. For these reasons, it is rarely used. During monthly physical examinations, it is important to note developments by family members and by the physician.

According to a number of authors, 90-95% of obstetrical brachial plexus-injured patients heal in the first 3-6 months, physical therapy being sufficient. In Laurent’s series of 250 patients, not enough improvement was seen in 33% of patients in the first 4-6 months [12]. The prognosis is poor with total plexus involvement, in the Klumpke-type, in the presence of Horner’s syndrome, in associated phrenic nerve lesions, and in the patients with periscapular muscle involvement [1,11].

Palliative surgery during conservative treatment

In a baby’s development, there are two stages for palliative surgery. In the first stage, during the healing period, external rotator and internal rotator muscles cannot resist the adductor and internal rotator muscles. This means that the internal rotator and adductor subscapularis, teres major and latissimus dorsi muscles innervate before being injured than the external rotator infraspinatus and teres minor muscles, so this will result with internal rotation and adduction contracture of the shoulder joint [23,24].

Adduction-internal rotation contracture surgery

Initial findings begin when the baby is 5-months-old. Based on the subscapularis and teres major muscle contractures, humeroscapular motions are restricted. Shoulder subluxation or dislocation may occur. The author’s youngest patient with shoulder dislocation was 5 months of age and operated on. Diagnosis of shoulder subluxation and dislocation can be performed easily by axial plane views of the shoulder MRI. The only disadvantage of this technique is that the patient needs sedation with general anesthesia. Shoulder ultrasonography is also helpful but is not as sensitive as MRI. It is difficult to diagnose shoulder dislocations by conventional x-ray, though computerized tomography is helpful but has radiation over dosage problem (Figure 5) [1,23,24]. If there is excessive internal rotation contracture of the patient and the patient has shoulder subluxation or dislocation, early surgery is indicated. Surgical approach is anterior subscapularis release or sometimes subscapularis lengthening. If the shoulder is unstable, latissimus dorsi +/- teres major transfer to rotator cuff posteriorly is recommended. Body cast or orthosis immobilization for 6-8 weeks follows. At the end of the immobilization period, long-term physical therapy is advised [1,25].

Brachial plexus nerve repair

Surgical treatment timing

The most important indications for surgical treatment are the surgeon’s knowledge, skills, experience, and equipment. Obviously, the surgeon should aim not to harm the patient. Prior to surgery, the evaluation of the patient must be done perfectly, and the surgeon must know as best possible the brachial plexus anatomy and the methods of repair that can be used during surgery. The surgeon and their team must have skills and experience in microsurgery, dissection, and arterial and nerve repair. During surgery, a magnification loop and a microscope should be utilized. Operating room personnel and necessary materials must be sufficient [1,8,9,11-13,15,25,26].

The patient’s family must be informed about the risks of the surgery, recovery time, and expected results and success [1].

As previously mentioned, active elbow flexion in infants that does not begin within 3-5 months is an indication for surgical treatment. Generally, the author
waits 3 months for total palsy and 5 months for Erb’s palsy in injuries with elbow flexion. When elbow flexion does not begin in 3 months, Gilbert has suggested surgery, though Clarke waits until 9 months for elbow flexion. [1,9,11,25,26].

In total brachial plexus palsies, only 20% have all five root avulsions so, even in total palsies, one can find one root to repair the brachial plexus. That being said, there are many donor intraplexial and extraplexial nerves to repair brachial plexus injuries, but there is still the great problem of distant innervations, especially with intrinsic muscles. There is always better surgical results in obstetrical injuries than with traumatic adult patients [9,11,25-28]. There seems to be no significant complications arising from surgery when performed by an experienced surgeon [28].

Surgical technique

Surgery is conducted in the supine position, the affected shoulder and interscapular area being elevated and the head turned to the unaffected side. The neck, shoulder, arm and hand is prepared. Both legs for total palsy are and one leg for Erb’s palsy lesions is prepared for sural nerve graft harvesting, and the author does not use a tourniquet. Supraclavicular exposure is sometimes enough for C5-6-7 lesions but clavicula can be osteotomised for robust exposure in total palsy [1].

Muscle relaxants must be avoided after intubation for nerve stimulation during surgery till such point that nerve stimulation is not required any further [1,15]. Sural nerve grafts are taken through long incision by the author. A number of surgeons use mini-incisions and others try to utilize the assistance of endoscopic instruments [1]. The author does not use a urethral catheter, intraarterial moniterization, or intraoperative nerve conduction studies during the operation. In addition, it is rare that blood transfusion is needed [1]. 3 to 4 weeks of Velpeau immobilization is employed after the surgery for nerve healing.

The aim of brachial plexus surgery

The main aim of brachial plexus surgery is to restore all the upper extremity functioning, though this is not always possible, especially in total palsies.

The priorities are: 1. For elbow flexion, biceps/brachialis muscle reinnervation; 2. Stabilization of the shoulder, for abduction and external rotation suprascapular nerve reinnervation; 3. Adduction of the arm to the chest (brachiothoracic pinch) and pectoralis major muscle reinnervation; 4. Lateral cord innervation for the below elbow C-6, C-7 for dermatome sensation; 5. Lateral and posterior cord reinnervation for wrist extension and finger flexion [1].

Techniques of nerve repair

Neurolysis

This is a controversial technique and a number of authors believe in it but most authors do not accept it. The current author does feel this technique can be
used if intraoperative monitorization and nerve conduction studies can be performed during the surgery \[1,7,9,12,15\].

*Nerve grafting*

As a consequence of the the property of traction injuries or depending on the size of the neuroma, excised nerve endings cannot be repaired end-to-end. In this case, one needs a nerve graft for nerve repair. The most frequently used graft is the sural nerve graft. Moreover, the forearm medial and lateral antebrachial nerves can be used. A variety of surgeons prefer the ulnar nerve as a graft in C-8 and T-1 root avulsions. However, this latter method is used in traumatic injuries and, in infants, is not recommended as the success rate of short nerve grafts is higher. There is no difference between the results of repairing the nerve with a graft using suture or fibrin glue. Nerve grafting in obstetrical brachial plexus repair is still the most popular technique (Figure 6). \[1,8,9,11-14,17,26,28,29\].

*Nerve transfer (neurotization)*

Injured nerves are repaired by healthy motor and sensory nerves, nerve branches or axons. Nerve transfer principles are as follows: 1. The recipient anastomosis should be conducted nearest site to the muscle; 2. Anastomosis should be executed shortly after injury. However, El-Gammal et al. claims that it can be performed until the 50th month, nearly 4 years later; \[1,30\] 3. Nerve transfer must be through end-to-end anastomosis and a graft should not be preferred; 4. The best results are directly proportional to the patient’s age; 5. Before nerve transfer, the nerves must be stimulated and verified; 6. Donor nerves usually contain less axons than recipient nerves; 7. The optimal number of required axons for reinnervation is not known \[1,31\].

The nerves used for nerve transfer are the spinal accessory nerve, intercostal nerves, ulnar nerve axon(s), median nerve axon(s), phrenic nerve, medial pectoral nerve, lateral pectoral nerve, anterior interosseous nerve, radial nerve motor branch to long head of biceps, radial motor nerve branches to wrist extensors, long thoracic nerve, thoracodorsal nerve, and sensory branches of the radial and median nerves at the wrist and hand are some examples \[1,31-33\].

**Root coaptations**

In rare cases of obstetrical brachial plexus injury, especially when the ipsilateral C7 root is intact, it can be used for unreparable C5-6 and directly sutured to Erb’s point nerves. As well, an intact C7 can be sutured to C8-T1 directly when the patient has C8-T1 total root avulsion \[9,34\].

**Contralateral C7 transfer (CC7)**

This technique was first used by Gu and the results published in 1992. CC7 was initially utilized in traumatic brachial plexus injuries and also for obstetrical cases by quite a lot of authors. The present author first made use of CC7 in an obstetrical case in 1996. The use of CC7 in obstetrical case indication is considered when the patient has total plexus palsy and there is no root that can be employed during surgery. Further, this was mentioned before – only 20% of total palsy patients do not have even one healthy root (Figure 7) \[35,36\].

**Conclusion**

In Turkey, the incidence of obstetrical birth palsy is 1/1000 deliveries. This means that every year, 1250 babies are born with this injury and nearly 150-200 of them require nerve repair. Surgery for obstetrical brachial plexus can be done at the right time but needs the right indication. 80-90% of patients improve through spontaneous recovery in the first 3 months. Generally, total palsies are operated on at 3 months of age and Erb palsies can be delayed till 5-6 months. The ideal time for surgery is in the first 6 months. The plexus nerve repair success rate decreases after the age of 1 year. Brachial plexus surgery requires specialized training and experienced hands.

**Conflict of interest statement**

The authors have no conflicts of interest to declare.

**References**

3. Kawai H. Historical reiew of the brachial plexus palsy. In: Kawai and Kawabata (eds.) Brachial plex-


