Obstetrical brachial plexus palsy: an analysis of 105 cases

Gürsel Leblebicioğlu[1], Dilek Leblebicioğlu-Könü[2], Nazan Tugay[3]
Ö. Ahmet Atay[1], Talat Göğüş[1],

[1]Department of Orthopedic Surgery and Traumatology, Faculty of Medicine, [2]Department of Neurosurgery, University Hospital of Zürich, Zürich, Switzerland, and [3]School of Physical Therapy and Rehabilitation, Hacettepe University, Ankara, Turkey

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Obstetrical brachial plexus palsy (OBPP) remains a dramatic consequence after complicated childbirth. An increasing number of methods are being developed for the physical therapy and the early repair of the nerve lesions in OBPP, including neuroma excision and nerve grafting, neurolysis and neurotization. Secondary deformities of the shoulder, forearm, and hand can be reconstructed using soft tissue and skeletal procedures. In this article we analyze our approach to 105 patients to obtain optimal functional outcome in patients with OBPP.

Key words: obstetrical brachial plexus palsy, Horner's sign, C7 lesion, tendon transfer.

The brachial plexus, which originates from C5 to T1 spinal segments, is formed by the exchange of motor and sensory nerve fascicles between the spinal cord and the nerves innervating the shoulder girdle and the upper extremity. Autonomic innervation of the head and neck is also partly supplied by the cervical sympathetic nervous system.

Obstetrical brachial plexus palsy (OBPP) is described as partial or total severance of the brachial plexus during delivery, and it is a dramatic disability, particularly following a difficult labor. The traction applied to the baby's arm has been known as the causative factor since Smillie's treatise in 1764. Duchenne[1], Klumpke, Sever[2], Lauwers[3] and later Erb[4] have expounded further on this condition. It has a higher incidence in comparison to clavicular and humeral fractures and fetal death[5].

Enthusiasm over surgical repair in the early period of this century diminished as a result of serious complications, but there were expectations for decades that a better cure would be found[6]. Until the 1970s, the dogma that nerve repair was futile remained unquestioned. The studies of Gjorup[7], Narakas[8], Tassin[9], and Gilbert[10,11] led to a remarkable growth of interest among peripheral nerve surgeons in the clinical evaluation of and optimal treatment options in OBPP. Marked improvements in microsurgical reconstruction techniques, progress in late rehabilitative surgery techniques, recent developments in physical therapy renewed interest in obstetrical brachial plexus surgery. Gilbert and Tassin[12] concluded that if biceps and deltoid contraction had not started by three months of age, ultimate function was likely to be poor, although that was later debated by several authors[13-15]. Valid indications for early primary surgical intervention remain a controversial issue.

In this study we review the physical treatment, surgical indications, and results of these treatment modalities.

Material and Methods

During the period between May 1995 and December 1998, 136 patients with OBPP were seen at the outpatient clinics. A detailed physical examination was performed by the surgeon (GL) and by the physiotherapist (NT). Observations of shoulder, elbow, and hand functions were recorded. Clinical examinations were repeated at four weekly intervals. Seventy-seven of these patients were treated solely with a guided home exercise program. Twenty-eight patients were treated surgically: 17 patients had

primary brachial plexus exploration and microneural reconstruction, and 11 patients had secondary reconstructive procedures including tendon transfers, arthrolyses, and humeral external rotation osteotomies. In 11 of the patients who later had brachial plexus surgery, a home therapy program was applied for a short period, and six patients were elected for surgical intervention at the first consultation. These patients were included in Group II. Thirteen infants are currently undergoing a home physiotherapy program. Seven patients aged between five and 24 months, who were previously treated conservatively elsewhere for OBPP, are candidates for secondary reconstructive procedures. Eleven patients were lost to follow-up. The patients who were lost to follow-up, were currently having their home physical therapy program, and were candidates for secondary reconstruction were excluded from this study, and 105 patients were analyzed.

Clinical Evaluation

The babies were examined as soon as possible after birth. Any problems during the course of the pregnancy were ascertained. Medical records of the delivery were obtained for babies born in hospital. The number and the problems of previous pregnancies and birth weights of the infants were recorded. General examination of the musculoskeletal system, specifically physical examination of the hip joint, the spine, the clavicles, and the extremities was an essential first step in our clinical examination. Further investigations were performed if any pathologic finding was observed.

The babies were first examined by having the parents hold the baby upright, with deltoid and supraspinatus function looked at and palpated. In a prone position on a specific examination table, serratus anterior, trapezius, and rhomboidei activity was examined. In a supine position muscle activity in the shoulder girdle was looked for. Distal functions, including thumb movements in three planes, finger flexion and extension, wrist flexion and extension, and biceps and triceps function provoked by several stroking and movement maneuvers were recorded. When turning the baby from supine to lateral decubitus position, the arm was kept in a neutral or extension position on the normal side by the activities of the posterior part of the deltoid and triceps, which are affected in proximal brachial plexus lesions. The appearance of the skin, the existence of perspiration and nail growth in the involved extremity were noted. Horner's sign was searched for and photographed using a Sigma 1/150 mm objective from a standard distance of 50 cm under a standard illumination. The babies with Horner's sign were examined preoperatively and postoperatively at the Outpatient Clinic of the Department of Ophthalmology. This examination included exophthalmometric measurements, phenylephrine test, and assessment of the function of the Müller muscle.

Home Physiotherapy Program

All the parents were instructed by our senior physiotherapist (NT). A physiotherapy program essentially consisting of the method described by Clarke and Curtis[16] with slight modifications was employed. During the first three weeks, the shoulder, arm, forearm, and hand were kept in neutral position. Passive range of motion exercises were started with stretching four weeks after birth. The parents were shown how to abduct and externally rotate the involved shoulder by stabilizing the contralateral shoulder. Elbow and wrist ROM exercises were also demonstrated. Special emphasis was given to external shoulder rotation and forearm supination. Active-assisted and active exercises were begun if there was enough muscle power. Natural play activities were specifically helpful in planning home therapy. The parents were also educated regarding tricky movements during washing, skin care, and carrying. The patients and their parents were seen regularly at monthly intervals during the first 12 months. Although the regular outpatient controls were done only up to the age of 12 months, the parents were advised to continue those exercises as long as possible.

Decision Making

It is essential that the same surgeon perform serial and careful clinical examinations. Discussion of the clinical findings with the parents was the most important aspect in guiding the surgeon in the decision-making process. We do not routinely employ electromyography (EMG) studies due to the unnecessary technical difficulties encountered during electrodiagnostic examinations. Preoperative computerized tomography (CT) myelograms were performed only in two cases, mainly for medico-legal concern. Magnetic resonance imaging (MRI)

investigations were performed in severe cases, and in all cases in whom an operative intervention was scheduled.

The main indication for surgery was the absence of deltoid and/or biceps function by the end of the 4th month. Acceptance by the parents of the fact that no further progress in shoulder and elbow function was expected was the essential prerequisite for surgery; none of the patients in this series was operated without the parents', observation that no further improvement was taking place.

The aims of surgery were clearly explained to the parents, and a written consent, including permission for the possible harvesting of the sural nerve(s), was obtained.

Surgical Technique

Group II

Following the induction of general anesthesia using halothane (0.7-1%), N_2O, and a short-acting neuromuscular blocking agent (succinylcholine 1.5-2 mg/kg), no further neuromuscular blocking agents were used until the completion of brachial plexus exploration, since electrical stimulation is used in intraoperative monitoring. Legs were prepared and draped following tourniquet application for sural nerve autograft harvesting. A small silastic rubber cushion under the upper thorax, and a slight beach chair position made the exposure easier. The head was turned gently to the contralateral side. A full brachial plexus exposure was obtained if necessary using the classic incision following the sternocleidomastoid, the clavicle, the coracoid and the deltopectoral groove. The supraclavicular fibrofatty tissue was moved superolaterally, and the omohyoid muscle was sutured medially and laterally and divided. Superficial and deep cervical vessels were coagulated and very carefully divided. The phrenic and spinal accessory nerves were identified and protected. The elements of the brachial plexus were identified, including the roots, divisions, trunks, cords, and the dorsal scapular, suprascapular, axillary, musculocutaneous, median, ulnar, and the lateral and medial pectoral nerves. During this exposure division of the clavicle was frequently necessary. If all the roots could be observed up to the levels of the foramens, electrical stimulation was applied. If a good motor response was provoked, and the appearance of the root was satisfactory, an external neurolysis was performed. If there was minimal or no motor response, and the appearance of the root was not satisfactory, extensile extra and intraneural neurolyses were performed. If there was extensive fibrotic changes and neuroma formation, it was apparent that grafting was indicated. A sural nerve was harvested from the contralateral side using "neural strippers" and/or open techniques. In routing the "Axonal donors", priority was given to the lower trunk. The musculocutaneous and the axillary nerves were grafted next. The most frequently performed procedure in this study group was the C5-C6 to upper cord grafting. In severe cases with limited proximal supply, 3rd, 4th, 5th, and 6th intercostal nerves were used. In cases with internal rotation contracture of the shoulder, subscapularis release was also applied in addition to the brachial plexus surgery. Following microreconstruction, the clavicle was reduced and fixed with 1/0 vicryl sutures passing through the bone. The subcutaneous tissue and the skin were closed with interrupted sutures. The upper extremity was immobilized over the thorax with an elastic bandage. The sutures were removed without removing the elastic, and immobilization was continued for four weeks postoperatively. Following this period the regular physical therapy protocol was adhered. No splint of any kind was used. Exercises and play provoking awareness of the involved limb were encouraged. The patients were seen at monthly intervals after the operation.

Group III

Significant internal rotation contractures of two cases (ZT, MMA) were treated with combined latissimus dorsi and teres major transfer defined by Richards[17], provided the latissimus dorsi had full strength. Humeral derotation osteotomy[18] was performed for patients with an internal rotational contracture and glenohumeral deformity. In patients with persistent internal rotation contracture despite the physical therapy, subscapularis release was performed. Tendon transfers in forearm and hand were performed as imposed by the deformity and functional loss. For optimal positioning and stabilization in patients with severe wrist involvement, arthrodesis was applied with standard plates using the technique described by Weiss and Hastings[19].

Findings and Results

Associated Anomalies and Injuries

Three of the cases were found to have acetabular dysplasia and were treated with abduction

splints. In one case, brought to us at the age of 37 months, there was a right unilateral facet dislocation with a rotatory subluxation of C4 over C5. Posterior spinal fusion for spinal instability was performed, and a secondary reconstructive procedure for shoulder internal rotation contracture is planned in this child. In another case there was a severe spinal stenosis due to bilateral facet dislocation and C5-C6 subluxation leading to paraparesis in addition to right-sided OBPP. This baby had a laminoplasty recently. In one case there was right mild OBPP, in addition to fractures of the occiput, the right clavicle, and the right humerus. All these injuries were treated conservatively with a satisfactory outcome. In one baby there was a supracondylar humerus fracture which was treated conservatively. In three cases isolated clavicular fractures were found and treated conservatively. In a patient in Group III wrist arthrodesis was performed because of instability. The result of the operation was satisfactory in terms of wrist stabilization, but an increase in fingertip ulcerations was observed. The child has a habit of biting his fingertips for which psychiatric examination/treatment were arranged.

In one patient in Group II (EK), a transient contralateral upper brachial plexus lesion developed postoperatively, and resolved spontaneously. This was probably related to improper "hand up" positioning for fluid transfusion and noninvasive monitoring[20]. This was the only case in this series with bilateral brachial plexus findings.

Group I: Home Physiotherapy Group

The mean age of the 77 infants who completed a planned physical therapy program with satisfactory clinical results was 3.2 months at the time of the first clinical visit. There were 47 (61%) males and 30 (39%) females in this group. In 43 cases the left side, and in 34 the right side was affected. The mean birth weight was 4,117 g. There were 65 vertex, 7 breech presentations, and 5 cesarean sections. Twenty-three of these children were the first, 33 were the second, 15 were the third, 5 were the fourth, and 1 was the fifth living child in their families. Maternal diabetes was diagnosed in two of the cases. In 35 patients (45%) there was upper plexus involvement, and in 42 patients (55%) there was total plexus involvement. There were no cases of isolated lower plexus paralysis. In three cases a transient ptosis at the affected side was observed. The mean age of this group at the time of the completion of the conservative treatment was 17 months, and the mean follow-up was 14.3 months. At the end of the follow-up period, no functional impairment was recognizable by the parents, and no motor, reflex or sensory abnormalities were detectable in any of the patients examined.

Brachial plexus lesions in three infants delivered by caserean section were of intermediate type with paresis of the latissimus dorsi and triceps and paralysis of the wrist and finger extensors. Shoulder abduction, elbow flexion, and forearm supination were not affected in these infants, and the typical waiter's tip position was not observed. In all infants, the neural dysfunctions were noticed by the pediatricians during routine postnatal controls. All of these infants recovered within six weeks.

Group II: Brachial Plexus Exploration and Microneural Reconstruction Group

The mean age of the 17 infants who had brachial plexus exploration and microneural reconstruction was 17 months. There were 11 males and six females in this group. There were one (6%) left-sided and 16 (94%) right-sided lesions. There were 13 vertex and four breech presentations. The mean birth weight of this group was 4,150 g. The birth weights of the infants in Group I and in Group II were not different statistically. The mean age at the time of surgery was 17.3 months. If the four cases that were operated over the age of 35 months were excluded, the corrected mean age in the primary surgery group was 10.3 months. The mean postoperative follow-up of this group was 21 months. The mean age of this group at the time of the last outpatient visit was 38 months. The findings and surgical procedures performed in this group are listed in Table I. The mean operative blood loss was 30 cc, and no transfusions were needed. No infection or clavicular healing problems were seen. Shoulder function was assessed using modified Mallet classification[21]. Impairment of elbow and hand functions was assessed using Gilbert's criteria[22,23].

Group III: Late Reconstruction Group

The mean age of the 11 patients in whom secondary reconstructive procedures were performed, such as humeral rotational osteotomies and tendon transfers, was 10.9 years

at the time of the first outpatient visit. There were nine males and two females in this group. Two (18%) of the lesions were left-sided and nine (82%) were right-sided. The mean follow-up was 14.7 months. The surgical procedures performed in this group are listed in Table II.

Table I. Surgical Procedures in Group II

Patient	Age (m)	Surgical procedure	Results
MÖ (male, L)	7	Neurolysis (C5-C6, C7, upper trunk)	Shoulder: Mallet V; Elbow: Gilbert 3/2/0 Hand: Gilbert V
NK (female, R)	41	Neuroloysis (C5-C6, C7, C8-T1; 2, 3, 4 intercostal routing to axillaris and lateral cord)	Shoulder: Mallet II Elbow: Gilbert 2/1/-1 Hand: Gilbert III
ÖB (male, R)	19	Neurolysis (C5-C6; C7; nerve grafting to the lateral cord)	Shoulder: Mallet IV Elbow: Gilbert 2/2/0; Hand: Gilbert V
Ek (female, R)	38	Neurolysis (C5-C6, C7, C8-T1; 2, 3, 4 intercostal routing to axillaris; C6 to musculocutaneous grafting)	Shoulder Mallet II Elbow: Gilbert 2/1/-1 Hand: Gilbert IV
HB (female, R)	35	Neurolysis (C5-C6, C7, C8-T1; C5 and C6 to uper trunk grafting)	Shoulder: Mallet IV Elbow: Gilbert 3/2/0; Hand: Gilbert IV
BY (male, R)	8	Neurolysis (C5-C6, C7, C8-T1)	Shoulder: Mallet IV; Elbow: Gilbert 3/1/0 Hand: Gilbert III still recovering
OK (male, R)	6	Neurolysis (C5-C6, C7, C8-T1)	Shoulder: Mallet IV; Elbow: Gilbert 3/1/0 Hand: Gilbert III still recovering
MG (female, R)	6	Neurolysis (C5-C6, C7)	Shoulder: Mallet II; Elbow: Gilbert 1/0-2 Hand: Gilbert IV
EB (male, R)	11	Neurolysis (C5-C6, C7, C8-T1)	Shoulder: Mallet IV; Elbow: Gilbert 3/2/0 Hand: Gilbert III still recovering 14 months postoperative
TK (female, R)	38	Neurolysis (C5-C6, C7, C8-T1; C5 to axillaris, C6 to lateral cord grafting)	Shoulder: Mallet III Elbow: Gilbert 2/1/-1; Hand: Gilbert IV
MK (male, R)	8	Neurolysis (C5-C6, C7)	Shoulder: Mallett III; Elbow: 3/1/-1 Hand: Gilbert III still recovering 12 months postoperative
SG (female, R)	21	Neurolysis (C5-C6, C7, C8-T1)	Shoulder: Mallet II; Elbow: Gilbert 2/1/-1 Hand: Gilbert V
NK (male, R)	13	Neurolysis (C5-C6, C7, C8-T1)	Shoulder: Mallet IV; Elbow: Gilbert 3/2/0 Hand: Gilbert V
CE (male, R)	8	Neurolysis (C5-C6, C7; C5-C6 to lateral cord grafting)	Shoulder: Mallet V Elbow: Gilbert 2/1/0; Hand: Gilbert III still recovering 10 months postoperative
AÜ (male, R)	11	Neurolysis (C5-C6, C7, C8-T1; C5-C6 to upper trunk, C7 to posterior cord grafting)	Shoulder: Mallet II Elbow: Gilbert 2/1/0 Hand: Gilbert III still recovering 6 months postoperative
SE (male, R)	7	Neurolysis (C5-C6, C7)	Shoulder: Mallet V; Elbow: Gilbert 2/2/0 Hand: Gilbert III han began to improve 4 months postoperative
GCS (male, R)	9	Neurolysis (C5-C6, C7)	Shoulder: Mallet V; Elbow: Gilbert 3/2/0 Hand: Gilbert V

Table II. Surgical Procedures in Group III

Patient	Age (y)	Procedure	Results
Eİ (male, R)	10	Humeral external rotation osteotomy, subscapularis release	Significant improvement in shoulder function
AT (female, R)	16	Pronator quadratus release, pronator teres rerouting, revision of radial head excision	Significant improvement in forearm prosupination
ZT (female, R)	11	Humeral external rotation osteotomy, subscapularis release, latissimus dorsi transfer	Satisfactory improvement in shoulder abduction and external rotation
AA (male, R)	11	Wrist arthrodesis	Satisfactory wrist stabilization
NS (male, R)	16	Humeral external rotation osteotomy, subscapularis release	Significant improvement in shoulder function
HG (male, L)	15	Humeral external rotation osteotomy, subscapularis release	Significant improvement in shoulder function
BA (male, R)	11	Wrist arthrodesis	Fair result, increased fingertip ulcerations
AÖ (male, R)	13	Wrist arthrodesis	Satisfactory wrist stabilization
AT (male, R)	9	FCR-ECRL, PL-EPL transfers pronator rerouting	Significant improvement in hand function
HRK (male, L)	9	ECU-AbPL, FCR-EDC transfer, ulnar dorsal capsulectomy, biceps rerouting	Significant improvement in hand function, improvement in forearm supination
MMA (male, R)	9	Latissimus dorsi transfer, trapezius transfer, pectoralis major PL-EPL transfer, AbPL tenodesis	Significant improvement in hand function and shoulder function

Discussion

Many infants with OBPP recover with minor or no residual functional deficits[24]. In our series 94 patients were first seen during their early childhood. Eleven of the patients who later had brachial plexus surgery, first underwent a home therapy program for a short period, and six patients were elected for surgical intervention at the first consultation. Seventy-seven (82%) of these 94 patients were treated only with a physical therapy program, and recovered completely.

The mean birth weight in Group I was 4,117 g, and in Group II 4,150 g. There was no statistical difference between these measurements, which were below the values stated in the literature. Although this might be related to constitutional factors, frequently stated risk factors may not be associated with OBPP[25].

In six cases (BY, OK, EB, SG, NK, AÜ) in Group II, preoperative ptosis partially (EB, SG) or totally (BY, OK, NK, AÜ) disappeared postoperatively. The alteration is usually manifested by the end of the third postoperative week, and continues for months. The mean age of these patients was 11 months and two of the cases were older than one year. Total or partial disappearance of ptosis after that age was probably related to the surgical procedure. The surgical procedure itself may disrupt a neural mechanism, which causes ptosis. In all these six cases, C8 and T1 roots were neurolysed to the level of the intervertebral foramina. This may decompress the preganglionic fibers to stellate ganglion and increase sympathetic input to the postganglionic neurones.

In three infants delivered by cesarean section paresis of the latissimus dorsi and triceps and paralysis of the wrist and finger extensors were present. Shoulder abduction, elbow flexion, and forearm supination were not affected in these infants, and the typical waiter's tip position was not present. This clinical picture was evaluated as intermediate lesion. As stated by Al. Qattan[26] this is a rare condition, although the incidence was slightly higher (~ 3%) in our series. Clinical findings suggesting relatively isolated C7 injury in three infants delivered by cesarean

section were probably due to the lateral traction maneuver applied to the arm of the infants[27]. These lesions were typically noticed by the pediatrician and resolved within six weeks.

There are more questions than answers in the field of obstetrical brachial plexus palsy. Indications and timing are the most debatable aspects[28]. It is clear that earlier surgical reconstruction leads to better clinical result, but there is a group of infants recovering even after 12 months, with poor deltoid and biceps function at the 4th month. Although criteria for timing of microsurgical intervention have been established, it may not be ethical to operate on all infants with no demonstrable deltoid or biceps function by the end of the 4th month. Six patients in Group I with no biceps contraction at the end of the 3rd month had improved significantly by 12 months, and no primary plexus surgery was needed. This finding clearly implies that there is a certain percentage of error in deciding early primary operation during the first months of life. The difficulty of predicting the outcome at the 4th month, and the possibilty of obtaining a better outcome with primary surgery may justify acceptance of a high margin of error. Parents and specifically mothers are very careful observers, and their impressions are very important in the formulation of the treatment. In addition, after the surgical repair, the infants spend most of their time with their mothers. Parent's motivation and cooperation is a key factor in the management of OBPP, not only during the first months of life, but also postoperatively, and during the later periods of life. For this reason we always await the mother's acceptance of the disability caused by OBPP. Early intervention carries the advantage of supplementing spontaneous improvement with the improvement gained solely by surgery. Late intervention, on the other hand, has the disadvantage of delayed nerve reconstruction. The optimal condition and timing for microneural reconstruction can probably be determined by very close cooperation of the parents, the surgeon, and the physiotherapist specified for the management of OBPP.

Another aspect of timing of treatment is brachial plexus surgery after the age of 24 months[29]. The mean age at the time of surgery in Group II was 17.3 months. If the four cases that were operated over the age of 35 months were excluded, the corrected mean age in the primary surgery group was 10.3 months. There were four cases in this series with neglected OBPP treated surgically over the age of 24 months. One child (NK) aged 41 months was referred to us at the age of 40 months because of flail arm. Severe fibrosis involving C5, C6, C7, C8 roots, upper trunk, and middle trunk was released. T2, T3, T4 intercostal nerves were routed to the axillary nerve and to the lateral cord. During the postoperative two years limited improvements in shoulder, elbow, and hand function were noted. Shoulder abduction was 30° and biceps was 3. Finger and wrist flexion and extension were present. The thumb obtained an opposition position, and intrinsic balance developed. Although sensation was not assessed properly before the operation, protective and deep sensations were elicited at the postoperative follow-up. Another neglected case with a flail upper extremity (EK) was operated at the age of 38 months. C5 root was partially avulsed, and there was only one fascicular structure transmitting electric impulse and provoking muscle contraction. C6 was fibrotic but transmitting impulses. All roots were neurolysed. T2, T3, T4 intercostal nerves were routed to axillary nerve, and C6 was grafted to the lateral cord. At the follow-up, shoulder was abducting to 30°, biceps was 3, and a good hand function (Gilbert IV) returned. Another case (HB) was referred to us at the age of 32 months. Her arm was flail and hand was completely insensitive to painful stimulation. During surgery severe fibrosis involving C5, C6, C7, and C8 roots was found. Most of the upper trunk was excised and C5 and C6 were grafted to the distal stump of the lateral cord. The clinical improvement was very satisfactory with a shoulder abduction of 90°, and satisfactory elbow (Gilbert 3/2/1) and hand (Gilbert IV) functions. In the fourth case (TK), C5 and C6 were severely fibrotic and avulsed. C5 root was grafted to axillary nerve, and C6 root was grafted to the lateral cord. At the follow-up, shoulder abduction was possible to 80°, biceps was 3, and satisfactory hand function was gained. In neglected cases with OBPP, shoulder and elbow functions may be reconstructed with several procedures, but satisfactory hand function, specifically hand sensation and fine intrinsic movements, are impossible to reconstruct with secondary reconstructive procedures. Even in patients above the age of three years with OBPP, there may be an indication for brachial plexus reconstruction,

as possible return of hand function may warrant the secondary surgical interventions for shoulder and elbow functions. Furthermore, brachial plexus reconstruction may increase the possibility of secondary tendon transfers for hand functions.

Computerized tomography CT, MRI, and EMG examinations are very widely used in the determination of neural damage in OBPP. We believe that careful serial clinical examinations performed at regular intervals including the sensibility, skin texture, and motor examinations of all muscle groups of the shoulder girdle and upper extremity are more important than any investigation in the decision-making process. EMG was found helpful in the determination of spontaneous healing potential during the conservative treatment and postoperative follow-up. CT and/or MRI are helpful in documentation for medicolegal purposes, and in the discussion of patient prognosis with parents.

Decision making during the first months of life is a very critical aspect of the treatment of OBPP. As a minimally invasive method, endoscopic visualization of the damaged brachial plexus can be very helpful in the planning and possibly in the execution of the treatment at very early phases. In patients with upper plexus involvement, endoscopy of the lower components may prevent unnecessary exposure and increased morbidity.

Conclusion

A multidisciplinary team consisting of the pediatric neurologist, physical therapist, and specialized orthopedic surgeon, and close cooperation with parents are of crucial importance in the early diagnosis and optimal treatment of OBPP. As stated by Algimantas Narakas in 1978, "What we need is some other type of advance, porbably connected with the physiology of nervous tissue"[30]. This statement is still valid today, but improvements in surgical techniques and developments in biologic and pharmacological manipulation to support nerve regeneration and differentiation will increase our potential to deal with this problem.

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