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Obstetric Lesion of the Brachial Plexus: The Fundamental Role of Rehabilitation

Sara A[1]*, Bernardo M[2], Margarida R[1], Rosa A[1] and Lurdes P[1]

[1]Physical Medicine and Rehabilitation Service - Porto University Hospital Centre (Centro Hospitalar Universit rio do Porto), Portugal

[2]Physical Medicine and Rehabilitation Service, Senhora da Oliveira Hospital (Hospital Senhora da Oliveira), Guimar es, Portugal

Abstract

Obstetric paralysis is defined as an injury to the brachial plexus at birth. The injury is caused by the stretching of the nerve trunks or root avulsion. Risk factors may be related to childbirth, the mother or the fetus. It is currently the most common form of peripheral neuropathy in pediatrics.

Diagnosis is essential for clinical examination. Auxiliary diagnostic tests are important for the location and extent of lesions, helping to clarify cases with surgical indication.

Its prognosis depends on the type and severity of the injury, with 20-30% presenting functional sequelae. This integrative literature review was carried out with the aim of analyzing the scientific literature in order to identify and describe the existing rehabilitation treatments/therapies for the Obstetric Brachial Plexus Injury (OBPI).

Keywords: Obstetric brachial plexus injury; Peripheral neuropathy; Rehabilitation

Introduction

The Obstetric Brachial Plexus Injury (OBPI) is defined as the flaccid paralysis of an upper limb after birth due to brachial plexus injury, with the passive range of motion greater than the active range of motion. It is a lesion due to the distension of the nervous structures of the brachial plexus in the newborn (NB), which usually occurs during childbirth.

The first clinical case of OBPI was described in 1764 by Smellie. In the late 1800s, Duchenne and Erb described cases of upper trunk injury (C5 and C6) and Klumpke described the injury involving the lower trunk (C8 and T1).

It is the most common form of peripheral neuropathy, with an incidence rate of 0.5 to 2 cases per 1,000 newborns in developed countries.

Clinical diagnosis is essential for your diagnosis. Regarding auxiliary diagnostic tests, these can clarify the location and extent of lesions in cases with surgical indication.

Methods

A selective review of the literature was carried out between 2009 and 2019, searching the MEDLINE/PubMed and SciELO databases, using the descriptors “congenital brachial palsy”, “congenital brachial injury”, “obstetrical brachial plexus lesion” and “obstetric brachial plexus palsy”. Clinical trials and systematic reviews were evaluated, as well as well-conducted observational studies, classic works and chapters from expert books on the subject. Fourteen articles were included in this integrative literature review, based on a bibliographic search covering the title, abstract and full text, and considering the inclusion criteria. In this review, we analyzed and combined the collected data, for a more in-depth understanding of the object of study: state-of-the-art treatments for the rehabilitation of children with obstetric brachial plexus injury.

Anatomy

The roots of C5 and C6 come together to form the upper trunk, C7 corresponds to the middle trunk, C8-D1 forms the lower trunk. Each trunk is divided into anterior and posterior to form the cords (lateral, medial and posterior), which are subdivided into branches.

Etiopathology

Its etiopathology is not fully understood for all cases. It is often traumatic, due to traction or

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*Correspondence:
Sara Filipa Tenreiro Amaral, Physical Medicine and Rehabilitation Service-Porto University Hospital Centre (Centro Hospitalar Universitário do Porto), Portugal.
Tel: 964915395
E-mail: sarafilipaamaral86@gmail.com
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forced stretching of the plexus during labor maneuvers. Usually, it is due to a combined movement of cervical lateral flexion in relation to the shoulder, during the obstetric exit procedure.

Abnormal intrauterine pressures, due to abnormalities of the uterus during pregnancy, and endogenous propulsive/expulsive forces, during labor, related to uterine contractions, are also associated with OBPI. It is more common in instrumented deliveries, although it has also been described in caesarean sections (2%). It should also be noted its prevalence in males (59%). In 2-4% there is bilateral injury.

Risk factors

Risk factors can be divided into neonatal (macrosomia greater than 4 Kg, cephalopelvic disproportion and fetal hypotonia), maternal (primiparity, multiparity, diabetes, excessive weight gain during pregnancy, uterine abnormalities and a history of brachial plexus paralysis) and delivery (dystocia of the shoulders in cephalic presentation, instrumentation, prolonged delivery, untimely maneuvers and breech presentation). Shoulder dystocia is reported in about 50% of cases of OBPI. Despite these risk factors, OBPI is not a strictly predictable situation in the prepartum period [1].

We should highlight situations of very high risk: macrosomic newborns with cephalic presentation and shoulder dystocia (94-97%) and premature newborns with pelvic delivery, suffering and/or fetal hypoxia (1-2%).

The presence of other simultaneous injuries, namely, fracture of the clavicle (10-15%), fracture/dislocation of the shoulder, diaphragmatic paralysis and Horner's syndrome, should be discarded [1].

Classification

Various classifications are described taking into account the location and type of injury found: Depending on the location:

Upper OBPI or Erb-Duchenne - roots of C5 and C6.

Lower or Klumpke OBPI - roots from C8 to T1.

Complete OBPI - roots of C5, C6, C7, C8 and T1.

According to functionality and evolution (Narakas scale), Table 1:

This classification does not include Dejerine-Klumpke's palsy in which there is inferior injury, from C8 to T1 and which is manifested by elbow flexion, forearm supination and hand paralysis with the absence of the hand grip reflex, being referred to as “good shoulder, bad hand”. It is a very rare situation (<5%), doubting some authors of its real existence, as they consider it to be a sequel to complete paralysis.

We can also classify according to the severity of the nervous injury (Seddon - Table 2).

Prognosis

It depends on the type and severity of the injury. The percentage of spontaneous recovery is very variable, with 20-30% presenting functional sequelae.

Narakas divides into 3 Groups according to the evolution:

Start of recovery during the first 3 weeks: complete recovery.

Start of recovery after 3 weeks: progressive recovery.

Start of recovery after the second month of life: poor spontaneous evolution.

Factors of bad prognosis

Among the factors of bad prognosis, the following should be highlighted: affectation of C7; absence of biceps recovery at 6-9 months; high birth weight; complete paralysis; Horner's syndrome (ptosis, miosis, enophthalmos, anhidrosis); paralysis of the para-scapular musculature (injury of the long thoracic nerve and the dorsal scapular nerve); phrenic nerve palsy; sympathetic involvement and facial nerve palsy [2].

Diagnosis

The diagnosis is clinical, and auxiliary diagnostic tests may help to clarify the location and extent of the lesions, especially in cases with surgical indication. They provide less information regarding the prognosis than a sequenced clinical evaluation [3].

It is extremely important, to exclude a fracture of the clavicle, to request radiography of the shoulder.

EMG gives information about the neuroanatomical location (pre- or post-ganglionic), severity of the injury, evolutionary chronology (prognosis) and distinction between birth injury or intrauterine injury. As negative points, mention the difficulties of interpretation at this age, the fact that it involves pain and does not objectively alter the therapeutic intervention in OBPI. Signs of EMG re-innervation appear 2 months before clinical signs. The first EMG study is usually carried out between the first 3-6 weeks of life), and signs of denervation can be seen in moderate and severe injuries [4]. There is no consensus among the authors regarding the prognostic information of the electromyography performed at three months. However, in a prospective study of forty-eight newborns with elbow flexion paralysis, it was found that the absence of motor unit action potentials in the deltoid and biceps at month of age on needle electromyography had a high sensitivity in the prediction of elbow absence flexion at three months [4]. Sensory nerve conduction studies are useful in distinguishing the rupture of the trunk distal to the dorsal sensory ganglion in which there is an absence of sensory and motor potentials. In addition, in avulsion, the injury is generally very proximal to the dorsal root ganglion where sensory conduction studies are normal and there is an absence of potential engines. The absence of re-innervation at 3 months is indicative of avulsion. Electromyography results have a high probability of false negatives in the NB and false positives in the first months [4-6]. Van Dijk et al., justify, as a cause of the discrepancy between clinical and electromyographic findings, the fact that the small size of the newborn's axons reduces the time necessary to complete the denervation process and begin re-innervation compared to the adult. Anomalous re-innervation and inadequate motor control are pointed out as other potential causes.

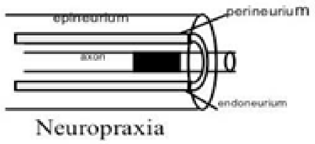
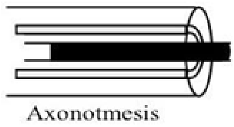
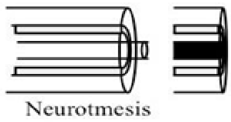
As for the CT myelography, it only assesses pre-ganglionic lesions [5]. It is an invasive test that requires intrathecal administration of contrast and uses ionizing radiation.

With regard to MRI, it is used to identify pre- and post-ganglionic lesions. It allows visualization of neuromas, avulsions and continuity solutions within the plexus. It is indicated for children with bad evolution. The timing of the imaging evaluation will be that of the eventual surgical approach (after 3-6 months without recovery or limited recovery).

Table 1: Classification according to Narakas.

Group	Group I	Group II	Group III	Group IV	Group V
Type of injury	C5 and C6 injury	C5 to C7 injury	C5 to T1 injury	C5 T1+Horner injury	Avulsion + Horner
Characteristics	-They correspond to Erb-Duchenne's palsy. -It is the most frequent (80-90%). -It is characterized by the characteristic “waiter’s tip” posture, in which the arm is in adduction and internal rotation, the elbow in extension, the forearm in pronation and the wrist slightly flexed with preserved hand grip.		-They correspond to complete paralysis of the upper limb, with total injury. -The hand has a “claw” configuration, due to the flexion of the interphalangeal joints and corresponds to 6.5 to 18% of the cases.		-They correspond to the complete avulsion of the entire plexus (pullout). -It is a more serious injury.

Table 2: Classification according to the severity of the nervous injury.

NEUROPRAXIA	AXONOTEMESIS	NEUROTMESIS
Temporary blocking of local conduction Maintained axonal Integrity Spontaneous and rapid recovery (2 weeks to 3 months)	Axonal injury with sheath integrity of perineurial and endonerial tubes Recovery possible with good direction or not Loss of continuity of a peripheral nerve	Pre-ganglion avulsion Spontaneous recovery impossible Nerve repair surgery to restore neuronal continuity.
		

Clinical examination

The first clinical evaluation must take place within the first 48h. A complete medical history that includes family, maternal and perinatal history is essential.

Clinical evaluation of the newborn: A comprehensive inspection of the newborn should be carried out, including postural attitude of the upper limb, muscle atrophy and dysmetria of the upper limbs. Particular attention should be paid to signs of respiratory distress/ asymmetries in chest expansion (which may correspond to phrenic nerve injury), Claude Bernard Horner syndrome, signs that suggest injury to other nerves (e.g. facial N), cervical postural asymmetries (torticollis) and spontaneous mobility of the 4 limbs.

The assessment of motor function is difficult given the lack of collaboration by the newborn, based essentially on spontaneous movements and research on primitive reflexes and postural reactions. Therefore, in the examination of the newborn with suspected OBPI the position of the affected limb at rest, spontaneous movements, which give an indication of the extent of the injury, muscle deficit and the presence of pain, osteotendinous reflexes and primitive reflexes.

In the NB with total plexus injury (C5-T1), the affected upper limb is flaccid, close to the body, without spontaneous movements, the osteotendinous reflexes are absent (bicipital C5, brachioradial C6, tricipital C7), the primitive reflex of Moro is asymmetrical.

In total plexus injury, there may also be injury to the phrenic nerve (C3-C5) and consequently diaphragm paralysis, with possible respiratory failure, abdominal asymmetry in respiratory movements, elevation of the sub-diaphragmatic domes, which is a sign of poor prognosis. In this situation, the presence of Horner's syndrome, due to injury to the sympathetic fibers of D1, manifesting with miosis, ptosis and anhidrosis of the affected side, should be investigated [4].

In injuries to the upper trunk, the upper limb presents adduction and internal rotation of the shoulder, elbow extension, pronated forearm, flexed wrist and extended fingers, poor spontaneous movements, decreased osteotendinous reflexes and asymmetry of the Moro reflex.

In the lower lesions (C8-T1), there is a “claw” hand posture associated with pronation of the forearm and also with changes in spontaneous movements and the presence of Moro's reflex.

Palpation of the clavicle and humerus is extremely important for the exclusion of pseudo-paralysis (not excluding the diagnosis of OBPI).

Regarding muscle assessment, it must be performed through spontaneous mobility and skin stimulation. The Active Movement Scale (AMS) is the scale used to assess motor function in newborns. The AMS is used to objectively observe the activation of muscle groups and can be used from the neonatal period to adolescence. The AMS scores observed in the fifteen joints of the upper limb are scored from 0 to 7 based on the percentage of active movement performed. The active movement made with the eliminated gravity is scored from 0 to 4 and the movement made against gravity is scored from 5 to 7.

Sensitivity is difficult to research in this age group. The behavioral response - flight, frowning - to tactile stimulation or mobilization in the respective dermatomes can provide information on sensitivity. The Narakas scale is one of the few existing scales to classify sensitivity in this population. The FLACC scale (Face, Legs, Activity, Cry, Consolability) is used to objectively classify pain on a scale of 0 to 10, by visualizing the reactions of five items [7].

Clinical assessment of children at preschool age: At a later stage, it is important to assess the integration of the upper limb in the body scheme, the manipulative activities, namely bimanual, and the gait pattern.

Motor assessment can also be performed by AMS, but, according to the collaborative capacity, the Medical Research Council scale can be used with muscle strength assessment from 0 to 5 [8].

For functional evaluation, mention some scales used, namely: Modified Mallet/Mallet scale (for children under 3 years old, evaluates shoulder function from the global movement of the MS, uses 5 items: abduction, external rotation, hand to the neck, hand to the spine and hand to the mouth), Gilbert scale (shoulder), Gilbert and Raimondi scale (elbow), Raimondi scale (hand).

As for the PEDI - Pediatric Evaluation of Disability Inventory: it evaluates the functional capacities and the typical performance in children (6 m-7.5 a) regardless of the disease; AHA - Assisting Hand

Assessment: it assesses the effectiveness of using the upper limb in bimanual activities in children (18 m-12 a) with unilateral disability. It can apply from eighteen months to twelve years. In this assessment, games are used as an observational basis. With a duration of fifteen minutes, the session is recorded and the score is achieved later, at the time of watching the video. Twenty-two items are listed, describing the use of the upper limb - overall use of the arm and hand, grabbing and releasing a toy, coordination, speed and fine forceps - on a scale of 1 to 4 (1-does not, 2-ineffective, 3-partially effective, 4-effective). The Assisting Hand Assessment is the only grip assessment validated for application in the NBPP [5].

In the objective examination, joint integrity must be assessed by measuring joint amplitudes, length and perimeter of the upper limb using goniometry. In a survey of parents, the difference in length and perimeter of the limb was considered important by about 37% [9].

In the clinical evaluation of children of preschool age, possible motor sequelae are evaluated. Synkinesias result from the simultaneous contraction of agonist and antagonist muscles and are related to anomalous re-innervation. The co-contraction of the shoulder abductors and the elbow flexors gives rise to the horn signal, and the biceps/triceps co-contraction makes it difficult to flex the elbow.

Differential diagnosis

As for the differential diagnosis of OBPI, pseudoparalysis due to pain caused by fracture of the clavicle and/or fracture of the humerus, osteomyelitis/septic arthritis of the shoulder, brain injury, cervical spinal cord injury, cervical rib, vertebral malformation, neoplasm should be excluded and congenital amyoplasia (arthrogryposis).

Sequelae/complications

With regard to sequelae, we should refer to muscle contractions, contractures, deformities (shortening of the MS), sub-luxation of the humeral head, winged pseudo-scapula, elbow flexion, sub-luxation of the radial head), pain/sensory changes (self-mutilation due to severe changes in sensitivity), change in laterality, scoliotic attitude, loss of balance during walking/running and shoulder arthropathy and psychological repercussions.

Stiffness in internal rotation of the shoulder is the most frequent sequela, being responsible for glenohumeral growth disorders, leading to progressive glenoid retroversion and sub-luxation of the humeral head [7].

Rehabilitation

The revised studies present, regarding the rehabilitation program, some general indications, which are cited: it must be continuous in the first 6 months and adapt itself according to the evolution, and there must be a minimum follow-up until 3-5 years. In neuropraxia, it is important to know the average recovery times: Scapula: 0-3 months; Fingers: flexion/extension: 0-3 months; Wrist: flexion/extension: 0-3 months; Shoulder: flexion/abduction 45-90º: 0-4 months; 90-160º 4-8 months; Elbow - forearm: initially flexion with forearm in pronation - 0-4 months, extension: 0-5 months and supination: 10-15 months.

The rehabilitation program is divided into 3 phases, taking into account that each clinical situation is unique. Phase I corresponds to the first 3 weeks. Studies present some controversies as to what is recommended for this phase, that is, some studies, although less and less, recommend keeping the extremity at rest, immobilized in adduction and internal rotation, others recommend simple passive mobilization techniques. What is in common agreement is the importance of teaching parents about dressing, hygiene and feeding techniques, avoiding the suspended upper limb. The upper limb must be positioned in adduction: promoting ER and supination. It is important to observe the newborn's head and keep it in the midline.

In phase II, that is, between the 3rd week and the 3rd month, it is recommended to perform a superficial centripetal massage, as it normalizes the tone and contractures, prevents atrophies and muscle retractions. It is suggested the stimulation of the preserved musculature, the accomplishment of smooth muscular stretches. Teaching parents how to dress (start on the affected side), undress (start on the unaffected side), bath (keep the armpit very clean) and feed (always put the upper limb in flexion on the trunk, feed the child from both sides) their children, is an integral and fundamental part of this rehabilitation process.

Passive kinesi therapy must be initiated, maintaining the arch and joint congruence (of the paretic - deltoid muscles, external rotators, biceps, supinators). As for gentle shoulder mobilization, this should avoid 90º anteversion - always with scapular fixation. Thus, the shoulder movements must be combined with the shoulder in abduction and external rotation (subscapular lengthening) and retropulsion (to lengthen the pectoralis major), maintaining the scapular fixation. Elbow mobilization is also suggested: flexion, extension, prone supination, insisting on supination, as well as wrist and hand mobilization. We should not forget that active mobilization and muscle strengthening are facilitated by carrying out activities appropriate to the different stages of development, initially eliminating gravity and later against gravity.

In this second phase, sensory stimulation and proprioceptive training also play an important role. Postural kinesi therapy begins to play a fundamental role in order to avoid vicious attitudes.

As for electrotherapy (NMES), it still does not have scientific evidence, so its use is quite limited and controversial. There are no published studies with a significant number of children using NMES, not clarifying its effect on reinnervation [10].

Finally, in phase III (from 3-4 months), everything that is carried out in phase II, the start of stimulation of the integration of the affected limb in the body scheme, and the encouragement of bimanual activities are indicated, preventing neglection of the

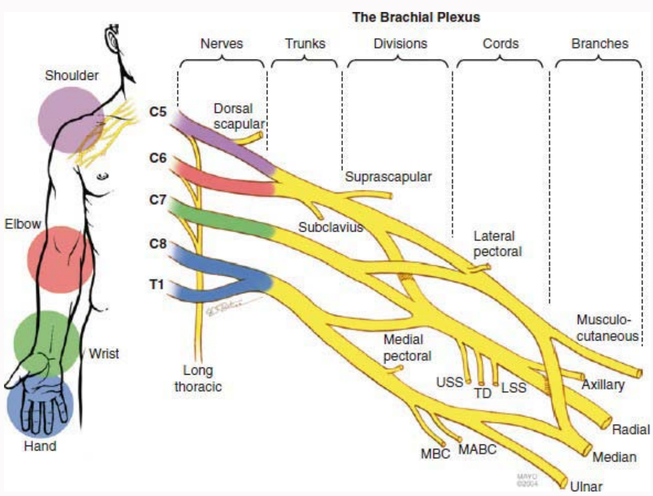


Figure 1: Representative scheme of the brachial plexus.

affected limb. In order to avoid neglection of the affected limb, a technique called Constraint-Induced Movement Therapy (CIMT) was developed [11]. The purpose of this technique is to increase motor activity in the affected limb, limiting the use of the unaffected upper limb through the use of a "glove" and intensely stimulating the affected limb [11]. The modified CIMT was proposed to increase the tolerance and compliance with this technique, especially in children, changing the type of restriction used and the frequency and intensity of the intervention [12].

Balance training in seating, crawl training and gait training are also recommended. The importance of integrating the affected upper limb into the midline should not be overlooked.

In relation to Botulinum toxin, it is indicated for muscle contractions (ex: triceps- biceps), triceps "hypertonia" and dynamic contracture in internal rotation of the shoulder.

Hydrotherapy, in turn, facilitates the child's collaboration, being well tolerated. Improves the range of motion (proximal) and stimulates muscle strength.

The use of orthoses (static/serial) is indicated for the reduction of contractures, prevention of deformities and can be useful in the postoperative period. Static orthoses stabilize the hand and wrist (wrist and finger extension), while serial ones are useful for elbow flexion. Both are beneficial in association with botulinum toxin [13,14]. Careful selection of the orthosis and adequate time of use (essential to allow motor and sensory stimulation) is extremely important.

Microsurgery

In complete paralysis, Terzis advocates an early microsurgical intervention, at 2 months. In turn, Gilbert advocates assessment at 3 months, and if at 3 months there are already flexion movements of the fingers and wrist as well as finger extension, a new reassessment should be performed at 6 months.

As for upper paralysis, if flexion/extension movements of the fingers and wrist extension are progressing favorably, we should choose to assess elbow flexion at 6 months, with surgery being suggested up to 12 months.

Soft tissue surgery

These are second-time treatments, recommended for children with residual sequelae. They frequently present contractures in internal rotation of the shoulder, leading to flattening of the humeral head and formation of biconvex glenoid. The progressive loss of passive external rotation is related to the retroversion of the glenoid and posterior sub-luxation of the humeral head.

Soft tissue release and tendon transfer surgeries are useful to prevent the installation of structural changes in the joint, and should be performed when the joint is still congruent. If the joint is no longer congruent, bone procedures are necessary.

Gilbert described that the stretching of the sub-scapularis alone is capable of improving the shoulder joint balance by 50%, given that this muscle is considered the main responsible for the contracture in internal rotation of the shoulder.

With regard to tendon transfers, they are isolated procedures for patients with incomplete recovery after injury to the plexus, and should be performed after primary microsurgical procedure to improve function.

They are usually directed at the shoulder region in order to improve external rotation and abduction, as well as to correct contractures in internal rotation (which occur due to the imbalance between internal and external rotators).

Transfers of the latissimus dorsi and teres major muscles are useful for improving shoulder function but do not improve glenohumeral dysplasia, if it is already established.

It is essential to establish function at the midline before making any tendon transfers. Simultaneous transfer of the latissimus dorsi and teres major muscles in children with C5-C7 injury can result in loss of function of the midline, and should therefore be performed with great caution, so it assumes a role only as a third-time treatment.

Still as third-time treatments, refer to tendon transfers to improve abduction, namely, the lateral transposition of the clavicular part of the pectoralis major together with the transfer of the teres major to the infraspinatus. They have an average gain of 77º in abduction.

As for osteotomies, we highlight the osteotomies of the humerus and the glenoid anteversion osteotomies. Humeral desrotation osteotomies are recommended for older children when glenohumeral dysplasia is already established, as well as restriction in external rotation and abduction. They place the limb in a more functional position, but do not improve the range of motion. They allow the child to flex the elbow, bringing the hand to the mouth without moving the arm away from the trunk (trumpet signal). As for glenoid anteversion osteotomies, they have been recommended in conjunction with tendon transfers, as an option for cases of severe glenohumeral dysplasia already established. Osteotomy of the glenoid neck and soft tissue rebalancing surgery are performed, showing improvement in Mallet scores for global external rotation and hand-neck movements, as well as good functional and radiological imaging results.

Final Considerations

Conservative treatment for OBPI involves early diagnosis and follow-up, soon after the child's birth, if possible.

There is a consensus that early conservative treatment is the main treatment option for the rehabilitation of neonatal brachial plexus paralysis. Whatever the type of injury, it is generally expected that clinical development/recovery will progressively assist in the definition of the diagnosis, facilitating the decision to maintain only conservative treatment or opt for surgical treatment, restarting intensive conservative treatment after surgery. Conservative treatment includes multidisciplinary team work with a physiatrist, physiotherapist and occupational therapists. These professionals use rehabilitation techniques and resources in a complementary way. It is important that professionals and family members work together.

The rehabilitation program should include teaching parents, maintaining complete joint mobility, avoiding secondary musculoskeletal and osteoarticular deformities, stimulating contraction of paretic muscles, stimulating normally innervated muscles, improving sensitivity, maintaining adequate cortical patterns, integrating the upper limb in the scheme, preventing/ decreasing secondary disability and facilitating the child's activity and participation (school, professional context).

Surgical treatment includes primary surgeries, indicated for children who do not have any type of spontaneous rehabilitation in the first three months of life; and secondary surgeries, recommended in children who, after primary surgery, have some limitation in the function of the injured limb, or in children who have had some spontaneous recovery, but still have significant functional deficits.

Despite the important conclusions that this integrative literature review allowed us to identify in relation to the options for rehabilitating treatment for OBPI, we also note that there is no current scientific evidence on some means/techniques of rehabilitation used in conservative treatments, such as, for example, in relation to limb positioning, such as external rotation of the shoulder and forearm to prevent contractures and deformities (glenohumeral dysplasia); the use of kinesiological tapes; the use of weight displacement on the injured limb (at key stages of the child's development) and hydrotherapy. Due to this multiplicity, we identified the need for further research on these types of media/techniques.

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