DIGEST AND REVIEWS

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Birth injury, Duchenne-Erb's obstetric palsy. Diagnosis and treatment (literature review)

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Obstetric practice dates back thousands of years, providing assistance to women in labor is often complicated by the rapid course of labor, pelvic presentation of the fetus, shoulder dystocia with a possible clavicle fracture. Damage to C_V–C_{VI} roots, classic Duchenne–Erb palsy, accounts for 46 % of the total number of obstetric palsies. Objective. To analyze the scientific and medical literature in order to identify historical scientific and practical information about the study of childbirth injuries, and, in particular, Duchenne–Erb's obstetric palsy. Methods. To study and analyze sources of scientific and medical information, publications from Google search engines, electronic databases PubMed, Google Scholar, archival medical journals. Results. The first data on obstetric paralysis were provided by Duchesne in 1872, highlighting thorough reports on upper extremity muscle damage. Subsequently, in 1874, Erb performed electrical stimulation of the affected muscles, finding out the zone of neurological damage. The history of the development and formation of this scientific issue is quite ambiguous, because it borders on two medical fields: neurosurgery and orthopedics. According to literary sources, it is obvious that the pathohistology and pathophysiology of the direct injury zone (roots C_V–C_{VI}), delayed changes in the function of the upper limb, and the latest diagnostic technologies simplify the understanding of the presentation. The existing methods of operative interventions allow physicians to improve the child's life. However, the question remains open regarding the use of certain operative interventions in relation to the child's age and further rehabilitation. Conclusions. Despite a significant stratum of scientific and practical research on Duchenne–Erb's obstetric palsy, there are still a number of questions regarding the diagnosis and treatment of children with this abnormality. The search for improving the functional state of the upper limb in children should continue.

Акушерська практика налічує тисячі років надання допомоги породіллям. Цей процес ускладнюється стрімким плином пологової діяльності, тазовим передлежанням плода, дистоцією плечиків із можливим переломом ключиці. Ушкодження корінців C_V–C_{VI} (класичний парез Дюшена–Ерба) складає 46 % від загальної кількості акушерських паралічів. Мета. Проаналізувати науково-медичну літературу, виявити історичну науково-практичну інформацію про дослідження пологового травматизму, зокрема, акушерського паралічу Дюшена–Ерба. Матеріал і методи. Вивчити й проаналізувати джерела науково-медичної інформації за допомогою пошукових систем Google, електронних баз PubMed, Google Scholar, архівів медичних журналів. Результати. Першу інформацію про акушерський параліч у 1872 році надав Дюшен, висвітливши ґрунтовні звіти щодо ураження м'язів верхньої кінцівки. Згодом, у 1874 році Ерб виконав електростимуляцію уражених м'язів, з'ясувавши зону неврологічного ураження. Історія розвитку та становлення цього наукового питання є досить неоднозначною, адже проблема знаходиться на межі двох медичних галузей: нейрохірургії й ортопедії. За літературними джерелами очевидно, що вивчено патогістологію та патофізіологію зони безпосередньої травми (корінці C_V–C_{VI}), відтерміновані зміни функції верхньої кінцівки та те, що новітні діагностичні технології спрощують розуміння клінічної картини. Існуючі методики оперативних втручань дозволяють покращити життєдіяльність дитини. Проте залишається питання стосовно застосування тих чи інших хірургічних утручань щодо віку дитини та її подальшої реабілітації. Висновки. Незважаючи на значний пласт науково-практичних досліджень акушерського паралічу Дюшена–Ерба, на сьогодні питання діагностики та лікування пацієнтів із цією патологією залишається актуальним. Наразі триває пошук покращення функціонального стану верхньої кінцівки в дітей. Ключові слова. Акушерський параліч, плечове сплетення, сухожилково-м'язові транспозиції, остеотомія, ботулотоксин.

Key words. Obstetric palsy, brachial plexus, tendon-muscle transpositions, osteotomy, botulinum toxin

Introduction

Duchenne–Erb obstetric paralysis is currently considered to be an orthopedic and neurological disease. In the absence of timely diagnosis and treatment, it leads to permanent loss of function of the upper limb and disability of the child in general. According to statistics, obstetric paralysis occurs in 0.38–5.1 cases per 1,000 newborns in European countries and from 0.4 to 4.6 cases per 1,000 babies in the United States [1].

Taking into account the topographical anatomy of the brachial plexus, C_V–C_{VI} roots are damaged most often due to their superficial location. For the most part (according to M. Shah), neurological disorders are transient in nature with full recovery of the function of the upper limb during the first year of life. However, in 10–27 % of people, irreversible changes occur at the level of the damaged roots of the brachial plexus with the formation of functional limitations that remain for life and are caused by muscle weakness, muscle imbalance, contractures [2]. There are quite a large number of different methods of surgical correction of this abnormality: interventions directly on nerve structures and active tendon-muscle transpositions, and various options for osteotomies.

Purpose: to analyze the scientific literature in order to identify key scientific and practical achievements that have influenced the stages of development of surgery for obstetric Duchenne–Erb paralysis in pediatric patients.

Material and methods

The selection of scientific information for analysis was carried out in the search engines PubMed, Google Scholar, archives of scientific and medical journals, according to the keywords: obstetric paralysis, brachial plexus, tendon-muscle transpositions, osteotomy.

Results and their discussion

Obstetric monoparesis is a nerve plexus injury during childbirth [3]. Factors leading to this abnormality are high fetal weight, prolonged childbirth, use of fetal extraction methods, fracture of the clavicle and proximal part of the humerus [4]. The most common (up to 97 %) complication of childbirth, which causes damage to the brachial plexus, is dystocia of the fetal shoulders [5–10]. The risk of trauma to the roots of the brachial plexus is much higher in the case of pelvic presentation and may be bilateral [11–13]. Trauma also occurs during cesarean section, but much less often.

Brachial plexus is a complex structure of the peripheral part of the nervous system. According to the topographical anatomy, it innervates the entire upper extremity, so the consequences of the injury are much larger than local organic damage. Coming from the spinal cord, C_V–T_I roots form five spinal roots, which unite and later form trunks. In particular, C_V–C_{VI} roots form the upper trunk, located rather superficially, which causes its traumatization.

A thorough study of the pathophysiological mechanisms of obstetric paralysis helps to better understand the location of the peripheral nervous structure. Individual motoneurons start from the cell body of the anterior horn of the spinal cord and are directed by an elongated axon to the muscles that they directly innervate. Nerve fibers along the length of the nerve are united into nerve bundles, which are additionally located in the connective tissue — the perineurium. Perineural tissue provides nerves with a greater ability to stretch and, above all, protects nerve structures and vessels that feed them from excessive traumatization [14]. Thus, the trunks of the brachial plexus consist of 55 % of perineural connective tissue [15]. Motoneurons carry an electrical signal along the length of the axon to the neuromuscular synapses, where the neurotransmitter acetylcholine is released under its action. The resulting injury causes partial or complete damage to the nerve and impaired axonal conduction. This significantly impairs the connection between the nerve cell and the distally located muscles of the upper limb. This can trigger Wallerian degeneration, which is an active process of changes

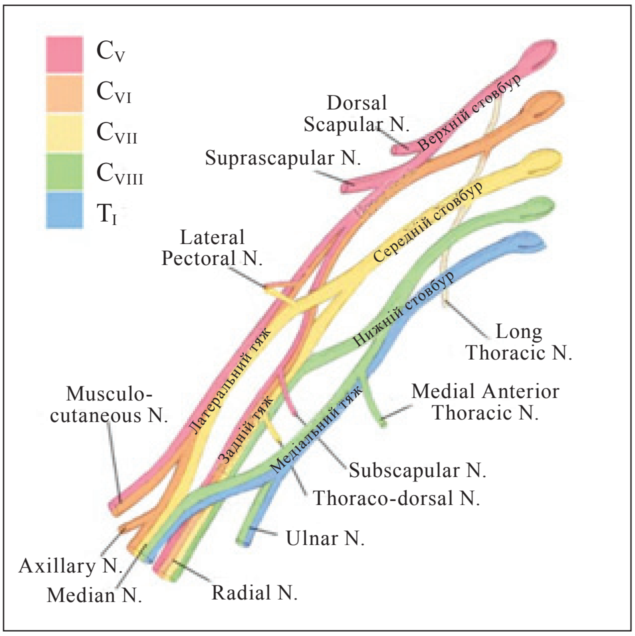

Figure. Anatomy of the brachial plexus due to partial damage or complete cut of the nerve and part of the axons located distally [16]. The degree of nerve injury is classified and described by H. Seddon, S. Sunderland, and S. Mackinnon [17–21] and presented in Table 1.

Neuropraxia according to Sunders is the easiest form of injury, however, like neurotmesis — a complete separation of a nerve — can lead to permanent disability of the child [22, 23].

In view of the above, it becomes obvious that childbirth trauma results in violated innervation of certain groups of muscles, Table 2.

The shoulder joint is constantly under the influence of dynamic stabilizing forces. Injury to C_V–C_{VI} roots of the brachial plexus starts a chain of destabilizing processes that lead to secondary (soft tissue and bone) deformations.

A detailed and timely examination of the patient gives an idea of the injured structures. According to the clinical observations of A. Narakas et al., the injured upper extremity is classified into four groups [24]:

– I (classic Duchenne–Erb paresis) — level of C_V–C_{VI} damage, which is characterized by a violation of shoulder abduction, lack of external rotation, flexion in the elbow joint, and supination of the forearm. Patients of this group make up 46 % of the total number and have a good prognosis for recovery of function;

– II — level of C_V–C_{VII} damage is 30 % of the total number. Clinical manifestations are characteristic,

Table 1

Degrees of nerve injury according to Seddon, Sunderland

Impairment	Sunderland	Seddon	Trauma interpretation	Restoration period
Mild	I	Neuproxia	Nerve blockade, the nerve is intact. There is no Wallerian degeneration	less than 3 months
	II	Axonotmesis	Axons and their myelin sheath are injured. Motor and sensory functions distal to the site of injury are lost	2.5 cm per month
	III	Cicatrization	During healing, excessive scarring of the endoneurium occurs, which interferes with axon regeneration	2.5 cm per month, but slowed by scar tissue. It is determined by the degree of scarring and the involvement of nerve bundles. Interventions to restore neural transduction
	IV	Degeneration	The nerve is continuous, its regeneration is blocked by an increase in scarring	
Severe	V	Neurotmesis	Nerve rupture	recovery during surgery

Table 2

Muscles of the upper limb and their innervation

Muscle of the upper limb	Brachial plexus root	Innervation	Movement
Deltoid	C_V–C_{VI}	Axillary nerve	Flexion/extension of the arm, abduction of the humerus
Subscapular	C_V–C_{VI}	Upper and lower axillary nerves	Internal rotation, abduction, flexion of the raised arm, stabilization of the front part of the shoulder joint
Supraspinatus	C_V–C_{VI}	Supraspinatus nerve	Helps the deltoid muscle during shoulder abduction, stabilizes from above
Infraspinatus	C_V–C_{VI}	Supraspinatus nerve	Rotates the head of the humerus outward
Teres minor	C_V	Axillary nerve	External rotation, shoulder adduction
Teres major	C_V–C_{VI}	Lower subscapular	Rotates the shoulder inward, extends and adducts the arm
Latissimus dorsi	C_{VI}–C_{VII}–C_{VIII}	Long subscapular (thoracodorsal)	Adducts, extends and pronates the shoulder
Biceps brachii	C_V	Cutaneous-muscular	Flexes the shoulder and forearm
Brachialis	C_V (C_{VI}–C_{VII}–C_{VIII})	Cutaneous-muscular (sometimes radial)	Bends the forearm

as well as for lesions of C_V–C_{VI}, in particular, there are weak active movements to extend the elbow joint. The prognosis for recovery of function is worse compared to group I;

– III — total plexopathy («whip hand»). About 20 % of the total number of patients;

– IV — total plexopathy in combination with Horner's symptom [25].

Obstetric injury quite rare (< 1) affects only the lower roots of the plexus (Klumpke's palsy, so it was not included in the Narakas system classification) [26].

As indicated in the literature, in 10–40 % of patients with damage to C_V–C_{VI} roots, despite complex conservative therapy, there is a risk of developing shoulder joint dysplasia against the background of paresis of certain muscle groups and the gradual formation of intra-rotational contracture of the shoulder joint, dislocation of the shoulder [27]. It is in this group of patients that complete restoration of abduction in the shoulder was recorded, however, its internal rotation is associated with deformation of the scapula, which is due to the weakness of the rhomboid muscle resulting from damage to the posterior scapular nerve.

Under the conditions of a minor injury, the function is fully restored within 2-3 months. In the case of medium severity, the recovery process takes longer and, unfortunately, is not always complete. Taking into account the peculiarities of the anatomical structure of the brachial plexus, the degree of severity of the injury and the period of recovery of the nerve fiber, the clinical manifestations of obstetric monoparesis are very variable. In severe cases, a complete lack of function in the shoulder joint is typical, in particular, elevation and rotation of the scapula compared to the healthy side [28]. The joint deformity is secondary to the primary muscle imbalance. According to literature sources [29], contractures of the shoulder joint occur in 1/3 of children with obstetric paralysis, which require a long time to recover, and in 2/3 of patients, peripheral nerve conduction remains incomplete.

J. L'Episcopo reported a change in the components of the shoulder joint, in particular, the articular cavity of the scapula due to hypoplasia of the posterior edge of the articular cavity of the scapula and the intra-rotational position of the humeral head. A number of other researchers have referred to the possible epiphysiolysis that occurs during childbirth. E. Zancolli indicated the formation of posterior subluxation of the humeral head, caused not only by muscle imbalance, but also by damage to the joint components. That is, the development of deformation of the articular surface is possible simultaneously with the formation of soft tissue contractures.

Observation of this group of patients is recommended during the first three months. During which it is possible to fully determine the type of injury to the brachial plexus and to make a decision regarding treatment tactics (conservative with the use of manual therapy or performing neuroplastic reconstruction of the brachial plexus), as well as control of muscle imbalance and timely prevention of the development of persistent contractures of the shoulder joint with the possible use of other botulinum toxin injection [30].

To date, there is quite a lot of information in the literature on the use of BTX-A to improve biceps and triceps contraction, that is, to restore the balance of agonist and antagonist muscles [31]. Under conditions of successful reinnervation (spontaneous or postoperative reconstruction), function may be suboptimal due to overactivity of the antagonist muscles, which impedes movement in the reinnervated muscles. Authors described 8 cases (5 girls, 3 boys) of average age 12.5 months, follow-up period 5–22 months, with significant muscle imbalance, but signs of restoration of innervation of muscles who received BTX-A injections in triceps, pectoralis major and/or latissimus dorsi. After one injection, all parents reported improved function. The total score on the active movement scale changed significantly between the pre-BTX-A injection period and 1 month ($p = 0.014$) and 4 months ($p = 0.022$) after BTX-A injection. However, there are other studies claiming that injecting BTX-A to improve the latissimus dorsi and teres in pectoralis major and subscapularis contractures is not effective enough given the large mass of these muscles. Intermittent injections of botulinum toxin into the triceps have shown excellent clinical results in improving upper extremity movement through biceps strength. However, the best indicators were recorded in children of the younger group (from 4 months) in combination with daily therapeutic physical exercises of the injured upper limb [32].

During the dynamic observation of patients, it is necessary to clinically examine and describe the results according to the Mallet scale, which takes into account the amplitude of movements of the upper extremity. That is, if it is difficult for a child to raise his palm to his mouth without bending the trunk more than 45° (Cookie test), then he needs surgical reconstruction of the brachial plexus [33].

Diagnosis using ENMG is mandatory, but there are peculiarities due to the age of the patient. Thus, in children up to 3 months of age, the results of ENMG may not reflect damage to the brachial plexus due to polyneuronal innervation of the upper limb [34–36]. However, in persons of the older age group (5–6 years), this diagnostic technique allows determining the electrical conductivity of individual muscles and assessing their potential for further active muscle transpositions.

X-ray examination of the shoulder joint is appropriate for severe muscle contractures, which may lead to the development of secondary bone deformities. During radiography of the shoulder joint, a relatively small articular surface of the scapula is visualized in relation to the articular surface of the humerus, which causes instability of the shoulder joint. CT scan with 3D modeling is considered the most productive analysis for such disorders, which allows qualitative assessment of glenoid dysplasia and calculation of the degree of SHEAR deformation. According to the results of this examination, it becomes possible to plan further surgical interventions, in particular, on the bones of the shoulder girdle [37, 38].

For a long time, the methods of treating Duchenne–Erb obstetric paralysis were different. Since 1903, when R. Kennedy introduced the resection of the proximal plexus neuroma and the application of the primary suture, and H. Fairbank became interested in secondary deformations, muscle imbalance and intra-rotator position of the shoulder with its adduction. Later, J. Wyeth and W. Sharp, together with A. Taylor, performed a series of surgical procedures for primary nerve reconstruction in newborns. Then, for almost half a century, the issue of surgical care in the case of obstetric brachioplexitis was not given due attention until H. Seddon in 1947 tried to restore the traction injury of the brachial plexus by means of nerve grafts, but with disappointing postoperative results [39–43].

The main microsurgical interventions were proposed by Millesi et al. Later, A. Gilbert showed good results of early microsurgery in the form of nerve grafts. The criteria for early microsurgical intervention are persistent symptoms of C_V–C_{VI}–C_{VII} paralysis at 3 months of age and the absence of biceps function [46–48]. Y. Allieu et al. performed transplantation of additional and intercostal nerves in case of severe injuries of the brachial plexus. Later, microsurgical techniques were supplemented with transposition of free muscle grafts and vascularized nerve grafts [49–51]. At the end of the 1990s, quite a lot was published about the technique of transposition of the phrenic and contralateral S_{VII} nerves [44–53].

Interventions on the muscular system are considered secondary reconstruction for injuries of the C_V–C_{VI} brachial plexus, which occur due to incomplete recovery of the function of the upper limb against the background of constant manual therapy or following microsurgical interventions [49].

H. Fairbank performed a dissection of the upper part of the teres major and subscapularis muscles in combination with an anterior capsulotomy of the shoulder and, subsequently, complications were observed in the form of a late anterior dislocation of the humeral head [50].

J. Sever eliminated the intra-rotator contracture by releasing the pectoralis major and minor muscles and the subscapular muscle without capsulotomy of the shoulder joint [51], and J. L'Episcopo demonstrated the release of the subscapular muscle with transposition of the teres major, and later, the broadest muscle of the back to the posterior edge of the capsule of the shoulder joint with transaxial fixation [52]. R. Zachary described the technique of transposition of the latissimus dorsi muscle and teres major in the position of the external rotators of the shoulder [53]. E. Zancolli performed a Z-tenotomy of the teres major muscle, moving the distal end of the tendon through the anatomic quadrilateral space, and sutured to the proximal part of the rotator cuff in a position of 90° shoulder abduction. In addition, he performed a dissection along the pectoralis major muscle, subscapularis, coracoid-brachialis, and short head of the biceps. In long-term results, this improved muscle elongation. Also, to maintain balance with medial rotation, he introduced the transposition of part of the large round muscle to the tendons of the subscapular muscle [54]. M. Hoffer et al. carried out transposition of the large round muscle to the broadest muscle of the back on the rotator cuff of the shoulder [55]. F. Pichon and H. Carlioz suggested resection of only the proximal part of the subscapular muscle (minimally invasive technique) [56]. A. Narakas corrected the deficit of abduction and external rotation of the shoulder by transferring the muscle that lifts the scapula to the supraspinatus and teres major along with the latissimus dorsi and transferred to the infraspinatus, ensuring balance of the shoulder joint. G. Phipps and M. Hoffer performed surgical treatment of 56 children with complications of abduction and external rotation of the shoulder and performed transposition of the latissimus dorsi and teres major to the subspinatus muscle. In the further results (follow-up time of 5 years), improvement of active and passive movements up to 46° was noted, but recurrence of intra-rotator contracture was recorded in 3 patients [57].

M. Hoffer modified two surgical techniques (L'Episcopo–Sever), taking into account frequent recurrences and progression of deformities. He suggested performing Z-lengthening of the large round muscle with cutting it off from the diaphysis of the humerus, lengthening the subscapular muscle by horizontal dissection into superficial and deep parts, which allows for improved abduction and outward movements of the shoulder. With an additional posterior approach, the broadest and the large round muscles are identified, separated and carried to the subspinatus muscle, where they are fixed. Postoperative results on the Mallet scale improved by an average of 60°, the range of active and passive movements of the injured upper limb increased. Despite the small percentage of complications, partial deficit of internal rotation of the shoulder, a number of researchers consider the Hoffer technique effective for long-term reconstruction of the injured shoulder. Also, regardless of the presence of functional growth, stabilization of the head of the humerus in the glenoid, which prevents the progression of bone deformities, is positive.

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P. Waters and A. Peljovich released the teres major, the latissimus dorsi, the pectoralis major muscles with the transposition of the tendons to the rotator cuff at the point of its attachment to the greater tubercle of the humerus [58]. Analysis of the biomechanics of tendon transposition allows us to conclude that transposition to the greater tubercle of the humerus is more effective than fixation to the diaphysis of the humerus.

M. Al-Qattan performed a transposition of only the latissimus dorsi muscle to the rotator cuff of the shoulder. Observation of patients was carried out for about 4 years; 2 of 12 subjects had recurrence of deformity, and the others had the following results: average active external rotation of 30° (20°–60°) and shoulder abduction of 140° (90°–170°). The score according to the Mallet scale was IV [59].

A. Pagnotta et al. transpositioned the teres major, latissimus dorsi, teres minor, supraspinatus muscles to the rotator cuff of the shoulder. The best results were observed in patients with C_V–C_{VI} injuries than with CVII–CVIII ones [60].

A. Aydin et al. released the subscapular muscle, transferred the latissimus dorsi, the teres major muscles to the rotator cuff of the shoulder. Good results have been recorded in patients who had a preoperative abduction of less than 90°. Abduction, on average, improved from 62.5° to 131.4°, and external rotation from 21.4° to 82.6° [61].

P. Waters and D. Bae performed a transposition of the latissimus dorsi, teres major, subspinatus muscle to the rotator cuff of the shoulder in combination with lengthening of these muscles. From further postoperative results, it is known that shoulder function improves significantly, but does not affect glenoid retroversion and subluxation of the humeral head [62].

In 2006, R. Nath, using the Narakas technique as a basis, improved abduction and flexion of the shoulder in the case of childbirth injury C_V–C_{VI} by means of neurolysis and decompression of the axillary nerve together with muscle transfer. He proposed the «Quad Procedure» technique with the release of the latissimus dorsi muscle and its transfer to the external rotators, the release of the teres major muscle to stabilize the scapula, the «sliding» release of the subscapular muscle without transpositions, and the most important surgical step — decompression of the axillary nerve. Subsequently, the technique was supplemented with the «Mod Quad» procedure and comprised the release of the latissimus dorsi muscle, the teres major muscle with their transfer to the lower edge of the teres minor muscle, the release of the subscapular muscle and the lengthening of the pectoralis major muscle [63]. This technique has demonstrated long-term good results not only in pediatric patients, but also in post-traumatic cases in adults. Range of motion according to the Mallet total score improved in two patients from 15 and 18 to 21, and active external rotation increased by a total of 40° [64]. In addition, in view of the presence of persons with severe bone deformities, in particular, a high position of the scapula (SHEAR — deformity), anterior subluxation of the humeral head, R. Nath proposed a modified surgical technique on the bones of the upper girdle after conducting a preliminary literature analysis of osteotomies of the humerus in obstetric Duchenne–Erb monoparesis [65].

The described variants of osteotomies allow fixing the upper extremity in a more esthetic position, preserving the deformity in the shoulder joint and slightly improving the range of motion of the injured extremity [66]. The «Triangle Tilt» technique was based on osteotomies of the clavicle in the mid-distal third, the acromial process at the point of its connection with the spine of the scapula, and the medial angle of the scapula to reduce its pterygoid shape. This method is used to change the angle of inclination of the plane of the acromial-clavicular triangle and return the head of the humerus to a neutral position in the joint cavity. Thus, the «Triangle Tilt» modification improves the condition of the glenoid of the shoulder joint and prevents the loss of range of motion [67].

With the development of surgery, arthroscopic surgical interventions on the shoulder joint began to be used for the treatment of abnormalities. A number of authors reported in a retrospective analysis of the treatment of children with shoulder monoparesis by shoulder arthroscopy that the criteria for the use of arthroscopy are as follows: limitation of external rotation, shoulder abduction, the initial stage of glenoid dysplasia (Water's dysplasia scale I–IV) [71]. The operation involved partial anterior capsulotomy of the shoulder joint, lengthening of the medial glenohumeral ligament, and partial tenotomy of the subscapularis muscle tendon. Its purpose was to increase external rotation >45°. In the postoperative period, there was an improvement in function on the Mallet scale +3.8 points (from 17 to 20.8). Joint balance in external rotation and abduction improved from 48 to 54 points.

A. Miyazaki reported on arthroscopic anterior release of the shoulder joint in a complex with transposition of the pectoralis major muscle supplemented with a homologous tendon graft and fixed in the posterior-superior part of the greater tubercle of the humerus. However, the technique had complications in the form of violation of medial rotation and imbalance of the shoulder joint [69].

According to the retrospective analyzes described in the literature, it is clear that the L'Episcopo–Sever operation modified by M. Hoffer is optimal for the group of Mallet II patients (without bone deformities). In the postoperative period (follow-up period 46 months), 25 patients had an improvement in abduction of the injured upper limb and external rotation of the shoulder, moving from Mallet II (abduction < 30°, external rotation < 0°, raising the hand to the mouth was not possible) to Mallet IV (abduction

Table 3

Comparative review of osteotomies of the humerus according to R. Nath (2006)

Author	Year	Number of patients	Osteotomy level	Period of observation (year)	Improvement of abduction of the shoulder (by Mallet)	Improvement of external rotation (by Mallet)
Faysse	1972	51	above/below the level of attachment of the deltoid muscle	3,0	1,5	2,5
Goddard	1984	10	above the attachment of the deltoid muscle	4,5	9,0	30,0
Kirkos	1988	22	between the subscapularis and pectoralis major	4,0	27,0	66,0
Al-Qattan	2002	15	below the attachment of the deltoid muscle	3,0	15,0	1,8
Oksu	2003	20	distal to the point of attachment of the pectoralis major tendon	8,0	15,0	25,0
Akinci	2005	35	distal to the point of attachment of the pectoralis major tendon	2,0	15,7	10,0
Waters	2006	27	above the place of attachment of the deltoid muscle	3,7	15,0	10,0

> 90°, external rotation > 20°, hand-to-mouth without restrictions), 3 individuals had some postoperative restrictions, switching from Mallet II to Mallet III [70].

Interventions not only on the muscular system make it possible to have a complex effect on the deformation. The methods proposed by R. Nath prevent further disability of the child. The literature describes the results of a ten-year retrospective analysis of patients who underwent «Mod Quad» intervention in combination with «Triangle Tilt». Statistically, there was an improvement in the overall Mallet functional score, the average value being 18.8 ± 2.1; $p \leq 0.01$ compared to the preoperative mean total Mallet score of 14.5 ± 1.2. Functional improvement was not only maintained for a long period, but also improved — the average total Mallet score (20.35 ± 2.3; $p \leq 0.01$) [71, 72]. In 2015, a meta-analysis was carried out on the use of derotation osteotomy of the shoulder in comparison with the «Triangle Tilt» technique. 14 cases of surgery of the humerus in children with birth C_V–C_{VI} trauma are described, 10 patients underwent osteotomy of the humerus, and 4 underwent surgery with an inclination of the acromial-clavicular triangle. A modified Mallet total functional score was used. Humeral surgery studies showed a 1.4 improvement; 2,3; 5.0 and 5.6 total Mallet score, while the Triangle Tilt operation showed an improvement of 5.0; 5.5; 6.0 and 6.2 points.

Conclusions

Considering the significant layer of scientific and practical studies of obstetric Duchenne–Erb paralysis, there remain a number of questions regarding the diagnosis and treatment of children with this impairment. Based on the review of the literature, we can state that each of the described methods of surgical correction of muscle imbalance has certain disadvantages, the percentage of complications, relapses, and the lack of adequate postoperative rehabilitation. It is worth noting the Hoffer and Nath surgical methods, as a result of their use, the postoperative results were the most successful and long-lasting, according to the total Mallet score of 5.6 ($p < 0.001$) and 6.2 ($p < 0.0001$).

Also worthy of attention is arthroscopy of the shoulder joint in children with mild or moderate girdle deformities of the upper limb. However, an analysis of the literature shows that this intervention is appropriate only for younger children.

Our findings allow us to conclude that the study of a complex approach to the treatment of obstetric trauma C_V–C_{VI} is still relevant today. Further detailed study of surgical techniques and the impact on glenoid remodeling, in particular, the use of osteotomies and active tendon-muscle transpositions is a promising scientific and practical direction. The continuation of the search for improving the functional state of the upper limb in children encourages the discovery of new diagnostic criteria and the invention of modifications of known operative interventions.

Conflict of interest. The authors declare no conflict of interest.

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BIRTH INJURY, DUCHENNE-ERB'S OBSTETRIC PALSY. DIAGNOSIS AND TREATMENT (LITERATURE REVIEW)

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