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OBSTETRIC PARALYSIS

ITS ETIOLOGY, PATHOLOGY, CLINICAL ASPECTS AND TREATMENT, WITH A REPORT OF FOUR HUNDRED AND SEVENTY CASES *

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Obstetric paralysis, a paralysis produced during birth, is due to an injury to the nerves of the brachial plexus. The resultant paralysis is characteristic; the arm hangs vertically, the elbow extended, the forearm pronated and the whole arm inwardly rotated. The paralysis is usually flaccid.

I shall endeavor in this paper, by a review of all the literature, to give the reader the various theories as to the causes of the paralysis, as well as to offer the conclusions I have reached by a study of 470 cases. Certain experimental work which I have done, with the idea of determining clearly the etiology and pathology, will be described and conclusions drawn therefrom. The pathologic and clinical aspects of the condition will be discussed and analyzed, and the treatment, operative and nonoperative, will be dealt with under appropriate headings. Definite conclusions will be drawn from the study of about 500 cases, which will show conclusively that traction on the brachial plexus, and a resultant injury of the plexus, is the one cause of the condition.

Up to within a year or so most of us were reasonably content to accept the theory that the paralysis in these cases was due to a stretching or tearing of some of the roots of the brachial plexus, due to a forcible separation of the head and shoulders during labor. Other theories have been discussed and have been given some credence, but recently a new one has appeared. It seems that it is about time for us to take an account of stock and see which of these various ideas which have been advanced are reasonable and based on pathologic findings and clinical facts.

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Obstetric paralysis was first described by Smellie[1] in 1768, who believed the condition due to long pressure on the arm while the child was in the pelvis; but it was first brought prominently to the notice of the medical profession in 1872 by Duchenne, who described four cases in infants and attributed the condition to pressure of forceps or fingers in the axilla on the nerve trunks.

Duchenne[1] recognized that the lesion might occur in obstetric operations, such as disengaging the upraised arm in a breech or footling presentation, in delivering after version, or in making traction on the arm of the child after the birth of the head, and quotes cases to support this theory. These procedures result in direct traction on the cords of the plexus, and when force is used probably cause injuries to the nerves. It was not until 1874 that Erb[1] described the same type of paralysis in adults, since which time it has been commonly known as the Erb-Duchenne paralysis. Erb showed that pressure above the shoulder on the junction of the fifth and sixth cervical nerve roots, the so-called Erb's point, caused the characteristic grouping of the paralyzed muscles. He laid the occurrence of the paralysis especially "to the energetic application of the so-called Prague grip (Fig. 1), in which the fingers are applied like a fork over the back of the child's neck, with an after-coming head, and so endangering the integrity of the brachial plexus by energetic traction and compression.

Stransky,[1] in a most careful review of the whole literature up to 1902, presents the subject in detail and most conclusively. He reviews Smellie (1768), Danyau (1851), Guéniot (1867), and Depauls' work, the latter cited by Seeligmuller. He reports ninety-four cases from various authors whose works he has reviewed. Stransky believed that pressure as well as hard pulling in some cases was an adequate cause, especially if ether had been used and the child was asphyxiated. The following authors are quoted from Stransky's article:

Seeligmuller thought that pressure from forceps often caused hemorrhage about the plexus. Thorburn (1886) reported a case of lower arm paralysis, and believed the tearing of the nerves to be due to hyperextension of the shoulder as the arm was drawn above the head, but also ascribed it to pressure of the clavicle on Erb's point from the bad position of the arm.

Roulland (1884) gave all the various positions in which the condition could occur, and apparently believed it due to direct or indirect pressure on the plexus. Arens (1889) believed it due to hemorrhage or tearing of the nerves.

1. Stransky: Centralbl. f. d. Grenzgeb. d. Med. u. Chir., July, 1902, p. 497, with complete bibliography to date, 1902.

Küstner (1888) advanced a theory that has been rejected at once by all other writers who have had any extensive experience with the cases, namely, that the trouble is usually due to a fracture of bones or separation of the humeral epiphysis.

Danchez (1891) believed the condition to be spontaneous, from pressure on the circumflex nerve of the arm while the child was caught in the pelvis, or that it might be traumatic from finger or instrumental pressure. He also believed that when the lower arm was

Fig. 1.—The delivery of the after-coming head, with the occiput posterior, by means of the Prague grip (Kerr).

involved the condition was one of "pseudoparalysis," as also did D'Astros (1892), that is, not a paralysis from nerve injury, but an arm held motionless on account of bruising and consequent pain, or as the result of bone injury. Gowers believed the paralysis to be due to pressure from forceps, and Weil (1896) that it was due to trauma, especially with an after-coming head. Peter thought it due to pressure of the forceps or strong lateral bending of the head, with a delayed

shoulder, or turning of the head in breech cases. Guillemot (1896) likewise supported the theory that the condition was due to compression of forceps or a strong pull; and Jolly (1896) believed it due to pressure, chiefly with an after-coming head.

Stransky quotes the experimental work of Fieux (1896), Schoemaker (1899), Stolper (1901), Küstner (1888), and Landold, as follows:

Fieux opposed Erb's views, in that Erb's point was too small and that the pressure would have to be too sharply localized, so that on the whole the theory that finger pressure or forceps could produce it was unlikely. Pressure of finger he also rejects, for there was nothing for the finger to compress the plexus against. He comes finally to traction on the upper roots as the longest side of the triangle formed by the cords of the plexus, with lateral inclination of the head, as tending to increase the distance between the head and shoulder. He produced the paralysis in rabbits by pulling the head forcibly to one side. He showed that the amount of separation which occurred between the ends of the cut roots of the brachial plexus, when the shoulder was held down and the head carried to the opposite side with as much force as is used in ordinary labors, is as follows: The two upper cords, or fifth and sixth cervical, separated from 26 to 28 mm., the third, or seventh cervical, only 12 mm., and the lower two, the eighth cervical and first dorsal, only 8 mm. The point at which the rupture occurs is from a quarter to half an inch from the point of emergence from the spinal canal near the junction of the fifth and sixth cervical roots. Fibers of the suprascapular nerve always ruptured among the first.

Schoemaker also conducted experiments on cadavers with the plexus exposed, and could always tear the fifth and sixth cervical, but never the seventh and eighth. He also thought that the clavicle could cause pressure on the plexus by having it caught between the clavicle and first rib and spine. He was opposed to the theory that pressure from the fingers caused the injury. Küstner (second paper) and Landold also did experimental work and believed the injury due to traction. Stolper agreed in the main with Fieux and Schoemaker, but rejected the possibility of pressure on the plexus in breech cases, and believed that clavicular pressure might cause the paralysis. However, he believed that stretching was the main factor.

Taking up now other authors, some of whom published their articles previous to 1902, and are quoted by Stransky, I will give comprehensive abstracts from their original articles.

Lovett[2] (1892) reports nine cases and discussed the conditions of

2. Lovett, R. W.: The Surgical Aspect of the Paralysis of New-Born Children, Boston Med. and Surg. Jour., July 7, 1892.

the labor, most of which were long, hard and instrumental. He believes that the paralysis is due to some direct injury to the brachial plexus and is generally associated with strong traction made on the head. Out of nine cases, four had the right arm affected, four the left and one case was not noted.

Carter[3] (1893) believed strongly that overstretching of the cords of the brachial plexus is the cause of the paralysis. He reported sixteen cases of his own, with an analysis of the conditions at labor, besides comparing his cases and observations with those reported by Lovett[2] and Burr. He believed that in a left occipito-anterior position the right arm would be the one affected, and in right occipito-anterior position the left arm would be the one to be injured. Nine of his own cases showed paralysis on the right and seven on the left. Burr's cases (quoted by Lovett) showed the right arm involved nine times in nine cases, regardless of position. Carter also discusses the factors of pressure of forceps on the plexus, the hook, and the finger pressing directly on the plexus in the neck, pressure of the finger in the axilla and overextension of the arm. He does not believe that these factors are essential in the production of the paralysis.

Walton[4] (1896) states that "neither the seat of the lesion nor the method of its production has been absolutely determined, but that the preponderance of evidence appears to establish the brachial plexus rather than the spinal cord as the point of injury." He discusses the relations of the position of the fetus to the paralysis of the right or left arm, and reaches about the same conclusion as Carter, except that he believes that the injury to the plexus is brought about by pressure on the plexus by its being caught between the upper edge of the clavicle and the first rib. He believes that a more careful study should be made of the positions and presentations of these children so as to determine the definite mechanics of the injury. He believes that the suprascapular nerve is independently stretched in the separation of the head from the shoulder, the distal point of fixation being either the suprascapular notch or the outer edge of the scapular spine, around which the nerve immediately passes, or both.

Haynes[5] (1897) reports three cases. He quotes Starr, who says:

> It is the pressure of the obstetrician's fingers which causes the injury in the majority of cases, and I have noticed that in 75 per cent. of the cases seen the paralysis was in the left arm, which finds its explanation in the greater

3. Carter, C. F.: Obstetrical Paralysis, with Reference Especially to the Pathology and Etiology. Boston Med. and Surg. Jour., 1893, cxxxviii, No. 18.

4. Walton, G. L.: The Etiology of Obstetrical Paralysis, Boston Med. and Surg. Jour., Dec. 24, 1896.

5. Haynes, W. H.: Obstetrical Paralysis of Infants, Brooklyn Med. Jour., May, 1897.

length of the middle finger of the hand which is doing the damage. In the act of traction there is a tendency of the obstetrician to flex the fingers, and then the tip of the finger is pressed deeply into the side of the child's neck.

This is very interesting, but hardly scientific. Haynes presents no new ideas on the subject.

Robinson[6] (1899) reports seventeen cases, in only one of which was birth reported as normal. All the others had a definite history of the labor being tedious and difficult. In eleven the presentation was cranial; in three special mention was made of difficulty in delivering the arms; four others had forceps applied. He states that J. E. Simpson has shown that the heads of boys are larger than the heads of girls, and therefore the heads of the latter would not dilate the way for the shoulders as well as the former. In his own series thirteen babies out of seventeen were girls, which would bear out this theory that there was an insufficiently dilated canal for the shoulders and that they therefore caught, or were with difficulty delivered, and in so doing there was a strain put on the cords of the plexus.

J. J. Thomas[7] (1905), Warrington and Jones[8] (1896) and Stone[9] (1900) believed the paralysis to be due to overstretching of the nerves of the plexus at birth, and Thomas reports two cases of bilateral paralysis of the lower arm type, following difficult labors with face presentation, in which he believed the injury to be the result of excessive lordosis or hyperextension in the face position, a view also concurred in by Jolly.

Bullard[10] (1907) likewise believes that overstretching of the nerve trunks is the cause of the paralysis, and that traction on the head in the axis of the body is less injurious than when the traction is made obliquely so that the head is inclined to one side when the traction is made. Rotation of the head to the opposite side also stretches the nerves. This is a factor which Walton also considers of the greatest importance. Firm resistance should be offered in order to have the force effective on the nerves, which may be supplied by a shoulder caught behind the pubes or by an after-coming head in a breech delivery (Fig. 2). Asphyxia is also a favorable condition, in that, with the child in that condition, all muscles are fully relaxed and

6. Robinson, H. B.: Traumatic Birth Paralysis of the Upper Extremity, St. Thomas Hospital Reports, 1899, xxvi.

7. Thomas, J. J.: Two Cases of Bilateral Birth Paralysis of the Lower Arm Type, with bibliography, Boston Med. and Surg. Jour., Oct. 19, 1905, cliii, No. 16.

8. Warrington and Jones: Observations on Paralyses of the Brachial Plexus. Lancet, London, Dec. 15, 1906.

9. Stone, J. S.: Injuries about the Shoulder Joint at Birth, Boston Med. and Surg. Jour., March 8, 1900, cxlii, No. 11.

10. Bullard, W. N.: Obstetric Paralysis, Am. Jour. Med. Sc., July, 1907.

their resistance is absent. Under this condition the nerves, without their usual support and protection, are more easily torn. He found that the cases generally occurred when the labor was long and difficult, when instruments were used in abnormal presentations, especially breech, and when the child was asphyxiated. In regard to the position of the occiput, it has been stated that in a left occipito-anterior position the right arm would be the one paralyzed, as the right shoulder would be the one caught behind the pubes; but this was not borne out by the few observations he was able to make, for in seventeen

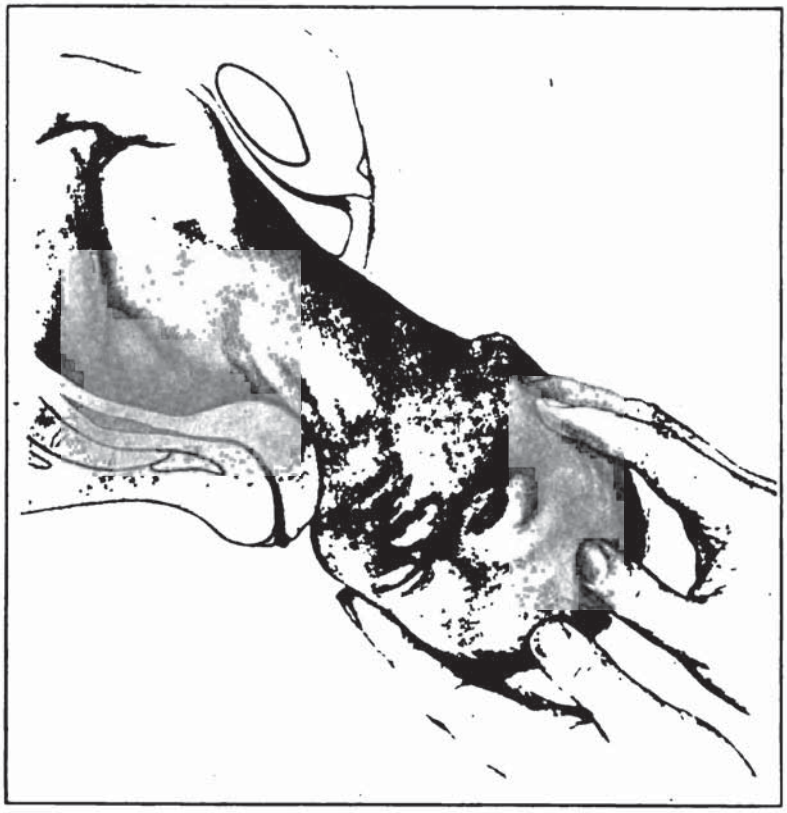

Fig. 2.—Stretching of nerves by oblique traction when the shoulder is caught under the pubes.

cases of left occipito-anterior position eight of the infants were paralyzed on the right and nine on the left.

Taylor[11] (1907) states that the cause of brachial birth palsy is due to tension or overstretching of the nerves of the brachial plexus. This he has confirmed by numerous dissections and experiments on infantile cadavers. The overstretching was caused by forcible separa-

11. Taylor, A. S.: Results from the Surgical Treatment of Brachial Birth Palsy, Jour. Am. Med. Assn., 1907, xlviii, 96.

tion of the head and shoulders in vertex presentation by pulling on the head, and in breech presentation by pulling on the shoulder, by the so-called Prague method (Fig. 1). He reports the delivery of a breech case when he felt the roots of the plexus tear under his fingers, which was later confirmed by necropsy.

Osterhaus[12] (1908) likewise believes the injury to be due to overstretching.

Bailey[13] (1908) believes the condition concerns the obstetrician more than it does any other practitioner. He states that while pressure is the generally accepted cause, he is of the opinion that overstretching and traction on the plexus is the real one. He states that

Fig. 3.—Stretching of nerves by oblique traction in delivering the posterior shoulder when caught on the perineum (Bumm).

if the axis of the head is drawn away from the long axis of the body by 30 degrees, the cords of the plexus are drawn to the danger point. This is liable to happen in vertex presentations to hasten the delivery of the shoulder, and in breech presentations to hasten the delivery of the after-coming head. It may also happen in extraction by forceps,

12. Osterhaus, Karl: Obstetrical Paralysis, New York Med. Jour., Nov. 7, 1908.

13. Bailey, P.: Brachial Birth Palsy, Bull. Lying-In Hosp., New York, March, 1908.

and in spontaneous birth the delivered head by its own weight may cause traction on the plexus (Figs. 3 and 4).

Frazier and Skillern[14] (1911) speak of the older theory that the brachial plexus injuries were caused by the plexus being crushed or squeezed between the clavicle and first rib, or transverse processes of the cervical vertebrae. Subsequent observations, however, have proved that in all cases the essential element in the causation is traction on the nerves.

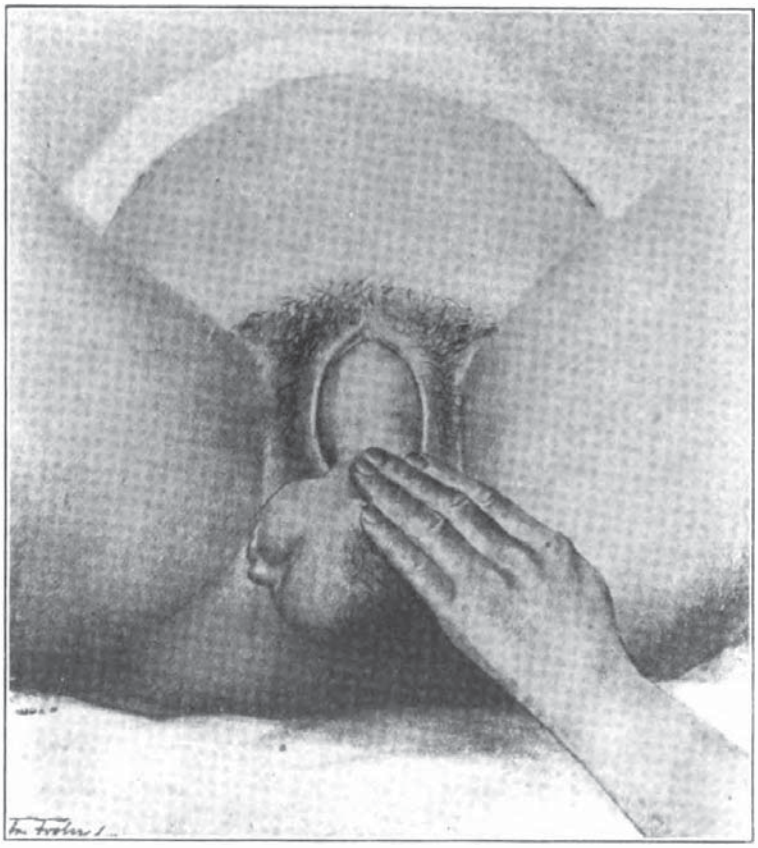

Fig. 4.—Separation of head and shoulder, with shoulder caught behind the pubes (Nagel).

Lange[15] (1912) believes the paralysis is due to a tearing of the capsule of the shoulder joint, which at first limits motion because of pain and then from habit. He was the first to suggest the theory which T. T. Thomas has taken up, that the condition is purely secondary to a shoulder joint injury. It should rightly be called Lange's theory.

14. Frazier and Skillern: Suprascapular Subcutaneous Lesions of the Brachial Plexus Not Associated with Skeletal Injuries, Jour. Am. Med. Assn., 1911, lvii, 1957.

15. Lange: München. med. Wchnschr., No. 26, 1912.

Frauenthal[16] (1912) believes also in the overstretching theory and reports cases, but is rather optimistic as to his results.

T. T. Thomas[17] (1914), in an interesting theoretical discussion of the problem, based on a study of nine cases averaging 6.5 years, concludes that the paralysis is secondary to a primary traumatic dislocation of the shoulder occurring at birth, associated with a tear in the joint capsule and a consequent involvement of the plexus in the exudate, practically Lange's theory, as given above. He does not explain why the exudate always avoids the major portion of the plexus in the region of the shoulder joint, or why it practically always works its way at least two inches above the clavicle and picks out the junction of

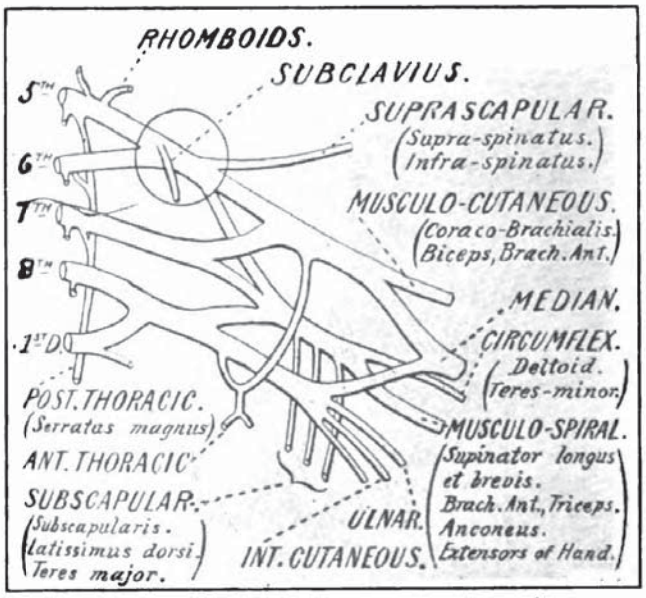

Fig. 5.—Brachial plexus, showing Erb's point. The subscapular nerve in this illustration comes off below Erb's point, but generally arises from the fifth nerve above its junction with the sixth cervical root.

the fifth and sixth cervical nerves to produce the characteristic paralysis. This theory of his, which is purely philosophical, is ingenious, but not reasonable, nor is it based on clinical or pathologic evidence. Erb's point is small and it requires definite injury at this point to produce the characteristic paralysis, as well as injury above this point on the fifth cervical root to produce the paralysis of the supraspinatus and infraspinatus from trauma to the suprascapular nerve which comes off the fifth cervical just above or below Erb's point (Fig. 5).

16. Frauenthal: Erb's Palsy, Am. Jour. Obst., 1912, lxv, No. 4.

17. Thomas, T. T.: The Relation of Posterior Subluxations of the Shoulder Joint to Obstetrical Palsy of the Upper Extremity, Ann. Surg., 1914.

Fairbank[18] (1913) is another believer in the traction theory, and he reports forty cases, thirty-two of which were vertex presentations and seven breech, which rather refutes Tubby and Sherren, whom he quotes and who believe that it occurs equally in the two presentations. He also states that long, difficult labors, in which forceps were used, predisposed to the injury (Figs. 6, 7 and 8).

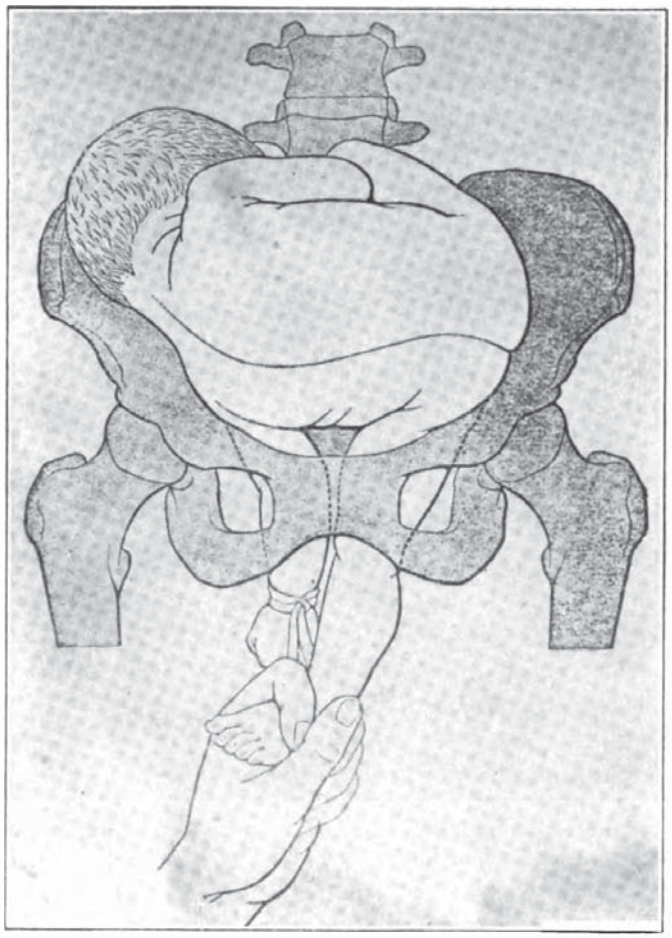

Fig. 6.—Version in dorso-anterior position, first stage; a difficult labor, predisposing to injury (Faraboeuf and Varnier).

Peltesohn[19] (1914) has found a number of cases which he reports as "false birth palsies." He describes typical end-results of cases of obstetric paralysis. He states that the condition is due to injury of the upper epiphysis of the humerus at birth. In true Erb's paralysis there is no disturbance of the epiphysis.

18. Fairbank, H. A. T.: Birth Palsy; Subluxation of the Shoulder Joint in Infants and Young Children, Lancet, London, May 3, 1913.

19. Peltesohn, S.: Injuries of the Upper End of the Humerus in Birth Palsies, Berl. klin. Wchnschr., June 22, 1914, p. 1162.

Gaugele[20] (1914) states that so-called obstetric paralysis is not a true paralysis, and the cause of the condition is an injury to the capsule and soft parts with subsequent contraction. Injury to the epiphysis or other injury is not uncommon. He evidently bases his conclusion on the study of four cases, and is not familiar with the work of other observers.

Van Neck[21] (1914) believes that other conditions than injury to the plexus may simulate obstetric paralysis, such as epiphyseal injuries of the head of the humerus, congenital developmental errors of the plexus, and shoulder turning resulting in a tear of the capsule. These all present definite clinical pictures, and by Roentgen ray and careful clinical examinations the diagnosis should be made easy and not confused with obstetric paralysis.

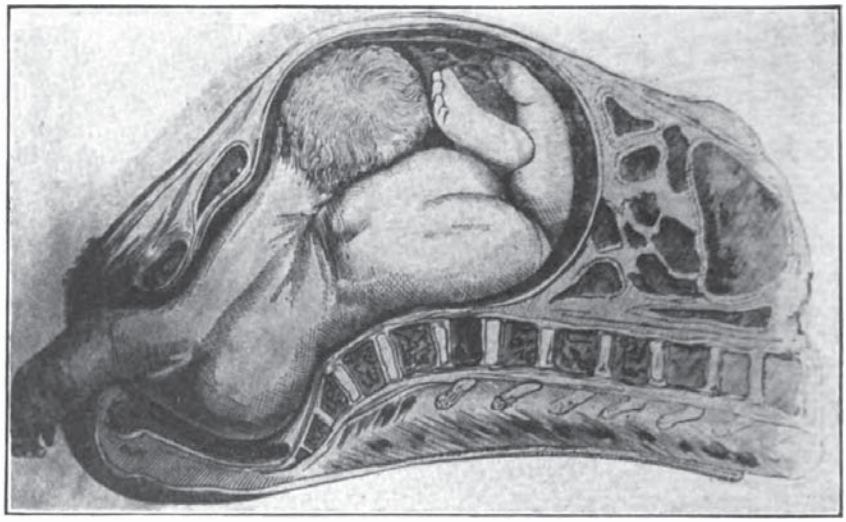

Fig. 7.—Neglected shoulder presentation; section through frozen corpse; a difficult labor, predisposing to injury (Chiara).

Gordon[22] (1914) believes also in the traction theory, as well as the theories of direct pressure on the plexus by the obstetrician's finger, the hook, and pressure by the clavicle and transverse processes.

Platt[23] (1915) is also a follower of the traction theory, and bases his ideas on five cases. He quotes other authors, including Lange and Vulpius, the former believing in the laceration of the capsule theory

20. Gaugele, K.: So-Called Obstetrical Paralysis of the Arm, Ztschr. f. orthop. Chir., 1914, xxxvi, Nos. 3 and 4.

21. Van Neck: Congenital or Obstetrical Lesions of the Shoulder and Brachial Plexus, Jour. méd. de Bruxelles, 1914, No. 11.

22. Gordon, A.: An Unusual Form of Birth Palsy, Jour. Am. Med. Assn., 1914, lxiii, 2282.

23. Platt, H.: Birth Palsy, Brit. Med. Jour., May 8, 1915.

and the latter in the theory of epiphyseal displacement as causes of the paralysis and subsequent deformity.

Darling[24] (1915), in an extensive study of the various lesions of the brachial plexus and a discussion of the various theories, accepts the ones based on definite nerve findings and pathology, and believes that traction on the cords of the brachial plexus is the generally accepted one in view of clinical and experimental evidence.

Fig. 8.—Forcible separation of head and shoulder in a shoulder presentation, putting the plexus on a stretch, which is almost sure to result in injury to the nerves (Kleinwächter).

Sharpe[25] (1916) has demonstrated that direct injury of the nerves always occurs, as shown by operation on the plexus in fifty-six cases;

24. Darling, H. C. R.: Med. Jour. Australia, Oct. 9, 1915.
25. Sharpe, W.: The Operative Treatment of Brachial Plexus Paralysis, Jour. Am. Med. Assn., 1916, lxvi, 876.

in every case finding definite pathologic evidence of injury. He believes the injury is caused by overstretching of the plexus at birth, due generally to a prolonged, forcible separation of the head and shoulder by lateral extension during a difficult labor.

This rather hasty review of practically all the literature on this subject from the etiologic point of view shows that the majority of observers incline toward the traction theory, which is in turn definitely supported by pathologic and clinical evidence. It is not questioned that fracture and epiphyseal displacement occur, and that they may be associated with an injury to the brachial plexus as a separate entity, but that they are the one cause of the usual type of birth palsy cannot be accepted. I have seen a number of cases of fracture of the upper end of the humerus occurring at birth which simulated brachial palsy, but on careful study were properly diagnosed. The after-course was quite different from that seen in brachial plexus injuries.

PATHOLOGY

There are generally two well-recognized types of paralysis seen. The more common one consists of a lesion which involves the fifth and sixth cervical roots and the suprascapular nerve and produces a paralysis of only the muscles of the upper arm, with the exception of the supinators. This type is known as the upper arm type. The less usual type, the so-called lower arm, a whole arm type, is the result of injury not only to the fifth and sixth cervical roots, but the seventh and eighth and possibly the first thoracic as well. Here the whole arm is flaccid; there is a wrist-drop and paralysis of the small muscles of the hand. There rarely occurs the pure lower arm type of paralysis without any involvement of the upper cords of the plexus, the so-called Klumpke's paralysis, several cases having been reported by J. J. Thomas, Jolly, Guillemot, Seeligmuller, Thorburn, Raymond, Comby and Danchez. These cases show a paralysis usually the result of stretching of the plexus from overextension of the head in cases of face presentation, and due to injury to the lower cords of the plexus, namely, the seventh and eighth cervical roots. They may at times be bilateral. It is in this type that one often sees inequality of the pupils, owing to the fact that the sympathetic fibers from the deep cervical ganglionic plexus enter the spinal cord through the first dorsal and at times through the eighth cervical roots. Injury therefore to these roots leads to an unopposed action of the motor occuli nerve.

Pathologically, in the milder cases the stretching or tearing forces result in a greater or less degree of hemorrhage or edema into the nerve sheaths. In others there may be a rupture of the perineural sheath, accompanied by hemorrhage into the substances of the nerve trunk, associated with a tearing apart or separation of the nerve fibers.

TABLE 1.—AUTHORS WHO HAVE REPORTED CASES, THE DATES OF THEIR REPORTS AND NUMBER OF CASES REPORTED

Authors	Date	Number Cases Reported	Authors	Date	Number Cases Reported
Duchenne	1872	4	Schoemaker	1899	2
Nadaud	1872	3	Haslinger	1899	2
Erb	1874	2	Bollenhagen	1899	1
Ducouneau	1876	2	Robinson	1899	17
Seeligmuller	1877-1882	8	Steiner	1900	1
Roulland	1884	1	Thomas, H. M.	1900	3
Thorburn	1886	1	Maygrier	1901	1
Arens	1889	1	Stolper	1901	1
Henoch	1890	1	Peter, cited by Stransky	1902	2
Danchez	1891	4	Oppenheim, cited by Stransky	1902	1
Cited by Danchez:					
Budin	....	1	Koster, cited by Stransky	1902	4
Babinski	....	1			
Monnier	....	2	Schultze, cited by Stransky	1902	1
Burr	1892	8	Thomas, J. J.	1905	2
Lovett	1892	9	Bullard*	1907†	178
D'Astros	1892	1	Murphy	1907	1
Bailly and Onimus, cited by D'Astros	....	1	Taylor, A. S.	1908	10
			Osterhaus	1908	2
Comby, cited by D'Astros	....	1	Rhode	1909	1
Carter	1893	16	Frauenthal	1912	4
Hochstetter	1893	1	Fairbank	1913	40
Weil	1896	1	Lange	1913	17
Fieux	1896-7	2	Thomas, T. T.	1913	9
Jolly	1896-7	3	Peltesohn	1914	5
Guillemot	1896	12	Gaugele	1914	4
Walton	1896	2	Gordon	1914	1
Haynes	1897	3	Van Neck	1914	3
Warrington and Jones	1896	2	Platt	1915	5
Cibert	1897	2	Sharpe	1916	56
Plauchu	1898	1			
Fifty-eight authors. Total number of cases reported to date 457. Number of cases reported in this paper					470

* The Bullard cases are included in this paper, which actually gives a total of reported cases of from 279 to 470.
† Forty-three in detail.

This latter condition leads, of course, to permanently impaired function and the formation of scar tissue in the nerve track. In the more severe cases of the upper arm type there is a partial or complete division of the fifth and sixth cervical roots, which leads to a more permanent form of paralysis than usual, and the formation of a more extensive area of scar tissue.

The force producing these lesions is variable and so the lesions are variable. The nerve roots are often frayed out inside the sheath instead of being torn across evenly, and in this way the lesion may be incomplete at any given cross section of a nerve, but involves different fibers at different levels. This scar tissue contracts in time, and not only effectually prevents the regeneration of the nerves, but may by its contraction press on and destroy the few fibers which may have escaped the original injury.

When there has been a complete or partial evulsion of the fifth and sixth cervical nerves from the spinal cord the condition pathologically is as follows: The spinal meninges over the affected area are thickened, fibrous and adherent to the cord. The affected side of the spinal cord is smaller than normal, and the injured areas of the cord may be invaded by the scar tissue. The anterior horns may be more or less disturbed, with a reduction in the number of the cells, which show various stages of degeneration; adjacent nerve tracks are more or less damaged. The anterior and posterior roots, as well as the brachial plexus on the affected side, are smaller than normal. Changes also take place in the cerebrum analogous to those found after amputation, such as a reduction of the Betz cells and a gross lesion of the fibers in the motor, intermediate and precentral area (Robinson[6]).

The other type, known as the lower arm or whole arm type, is the result of either a lesion involving all the nerves of the plexus, or, in the distinctly lower arm type, in which the lower arm and hand are alone involved, the so-called Klumpke's paralysis, in which the lesion probably involves the eighth cervical and first dorsal roots alone. This type generally results from traction applied in a breech case with the arm extended, or to traction in the axilla in a vertex presentation. It may be seen also in adults, when the first dorsal root is overstretched, as evidenced by some of the cases reported by T. T. Thomas.[17] Pathologically, the conditions are similar to those seen in the other types, depending on the severity of the injury. No case in which operation has been performed has failed to show a definite pathologic lesion of the brachial plexus, definitely corresponding to the muscles involved.

Danyau (quoted by Stransky[1]) in 1851 showed by necropsy that the nerves of the plexus had been torn and were surrounded and

invaded by scar tissue. Boyer[26] also reports necropsy findings, and states that the "opposite side of the spinal cord was distorted and otherwise altered by the injury and resulting fibrotic changes." Practically all observers, especially those who have operated in these cases, have found definite changes in the plexus due to injury and scar tissue formation. Among these, for detailed study, may be mentioned Fairbank, Warrington and Jones, Osterhaus, J. J. Thomas, Stone, Taylor and Prout.[11] Prout's description of the pathology is classic and will be quoted freely as follows:

Prout states that the nerve sheath in any overstretching process must give way before the nerve itself, as it supports the nerve. When the sheath is torn, as it always is in cases of birth palsy, the arterioles belonging to it and supported by it are ruptured, and a hemorrhage into the substance of the nerve and its sheath results. These facts are of the greatest importance, since they determine the ultimate extent and final character of the lesion. Were it not for the obstructive features of the repair process in the nerve sheath, we might expect a more or less complete recovery in the vast majority of cases.

Four pathologic specimens showed on study the following conditions: The usual seat of the lesion was at the junction of the fifth and sixth cervical nerves. The perineural sheath presented many old dense pigment deposits, the site of old hemorrhages. In some portions the perineural sheath was buckled inward on the nerve fibers, strangulating them and preventing their regeneration. Evidences of strangulation were present not only at these points, but also in the nerve fibers underlying these pigment deposits. There was an obliteration of the myelin sheath above and below. In the more severe cases the strands of the plexus involved came to an abrupt termination in a mass representing an old organized hemorrhage. In these cases there was a severing of the nerve fibers, which were often thrown into folds for some distance from the primary lesion. Repair of the nerve sheath takes place before regeneration of the nerve fibers, and if this has buckled inward on the nerve bundles following relief of tension, the nerve fibers are inevitably going to be strangulated and their regeneration prevented.

AUTHOR'S EXPERIMENTS[27]

The author, by numerous dissections on infantile cadavers, has shown that traction and forcible separation of the head and shoulder puts the upper cords, the fifth and sixth cervical roots of the brachial plexus, under dangerous tension. This tension is so great that the two upper cords stand out like violin strings. Any sudden force

26. Boyer, G. F.: Proc. Roy. Med. Soc., Neurol. Sect., 1912, p. 31.

27. Work done in the Laboratory of Surgical Pathology, Medical School of Harvard University, by courtesy of Dr. E. H. Nichols, director.

applied with the head bent to the side and the shoulder held would without question injure these cords. Further observation shows that forcible abduction and elevation of the arm and shoulder put the lower cords of the plexus, the eighth cervical and first thoracic on a stretch, and when much force is applied it may well lead to a tear, rupture or other injury to these segments. This condition is seen in breech cases, with arm extended. It may also follow sudden strain when the arm

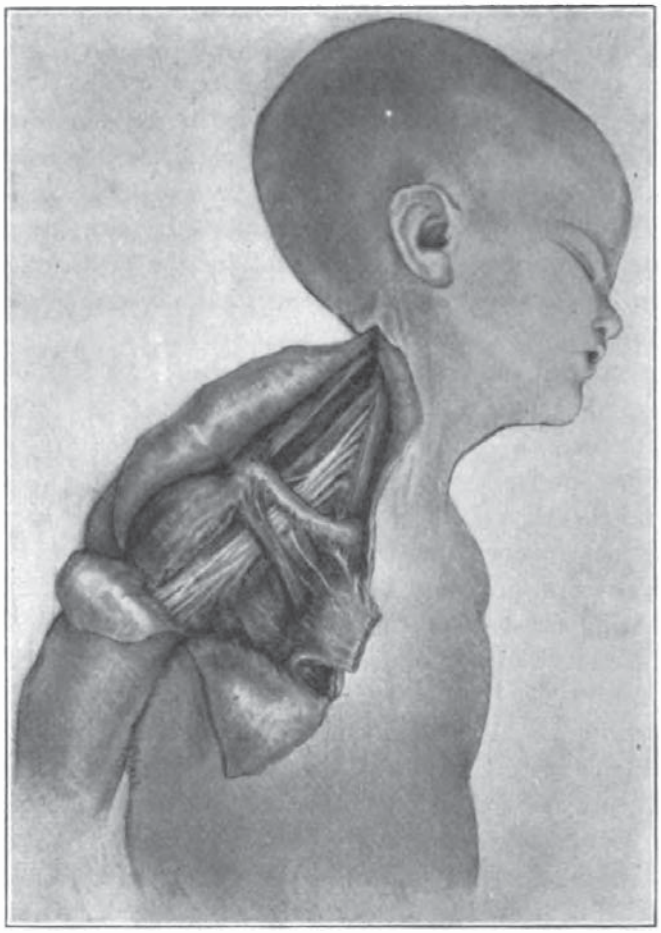

Fig. 9.—Dissection of the brachial plexus in a baby, with the head and shoulder in natural relation.

is elevated, such as the so-called hostler's paralysis, caused by the sudden elevation and strain of the arm which occurs when a hostler holds a rearing horse. With the shoulder held and the head carried to one side, with the clavicle intact, considerable force was necessary to injure the plexus. The suprascapular nerve always snapped first, apparently for the reason that it had not so much freedom of play as the others. Even with considerable force the fifth and sixth cervical

nerves could not be completely torn across at Erb's point, but frayed out inside the sheath, following a partial tearing or rupture of the sheath, which always gave way first. In some cases there could be produced an evulsion from the spinal cord of the fifth and sixth cervical roots.

With the clavicle removed, the whole weight of the shoulder came practically directly on the plexus, and less force had to be exerted to cause an injury, which under these conditions was generally greater in extent, but presented the same general characteristics. It was most

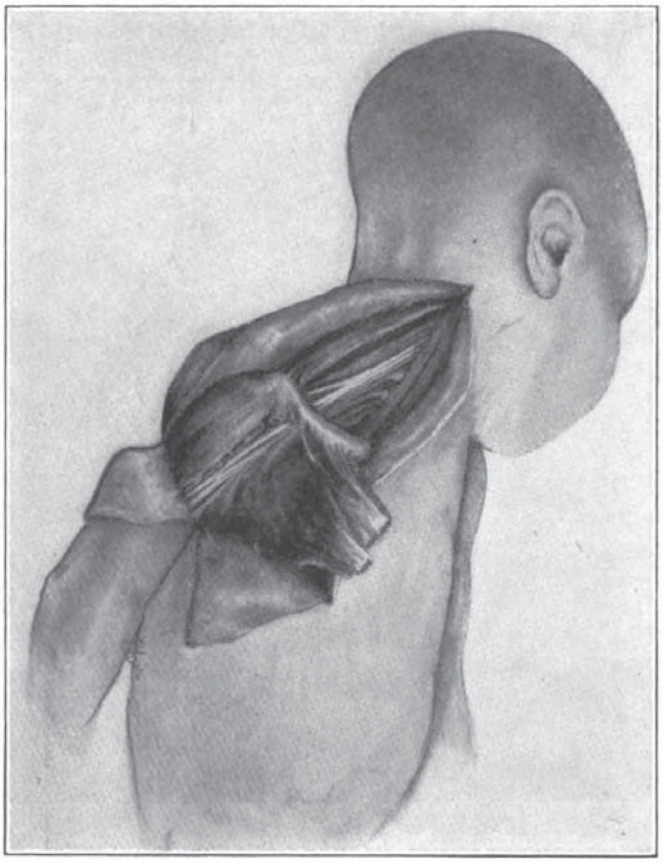

Fig. 10.—Same as Figure 9, with the head and shoulder forcibly separated.

difficult to put the eighth cervical and first thoracic roots on a stretch unless the arm was abducted or hyperextended with great force.

With the clavicle intact there was apparently always enough room, even with the arm elevated and hyperextended forcibly, between the clavicle and plexus so that direct pressure from the intact clavicle on the plexus did not seem a possible cause of the paralytic condition. A fractured clavicle of course allows the weight of the shoulder to drag on the plexus, and so predisposes to greater injury from traction.

Rotation of the head combined with forcible abduction apparently does not increase the degree of tension greatly, certainly not enough to cause additional damage. In no case, even with all the force I could apply with my hands, could I rupture the joint capsule, or even separate the humeral epiphysis. Neither could I dislocate the head of the humerus. The clavicle can be broken without great force, but fracture of the other bones which go to make up the shoulder joint is practically impossible. Most birth fractures occur in the clavicle, or in the humerus, at about the junction of its upper and middle third. Stone[9] states in the experimental work which he did that the humeral epiphysis could be easily separated, but I failed to confirm this.

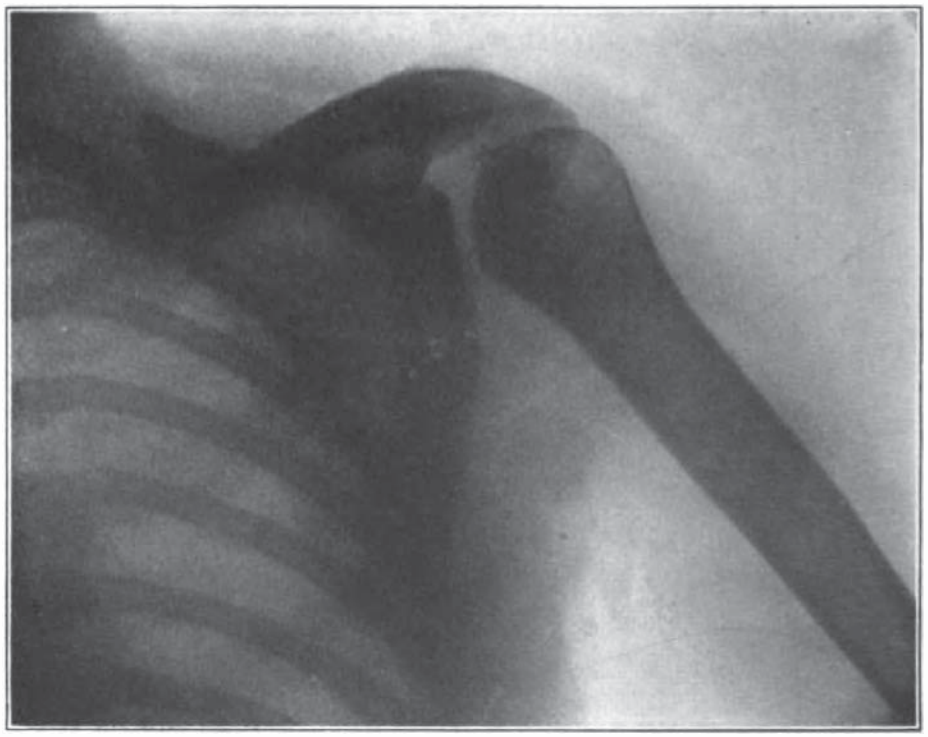

Fig. 11.—Roentgenogram of the shoulder of a patient 18 years of age. Note the hooking of the acromion and subluxation of the head of the humerus, with elevation and outward rotation of the scapula.

At birth the shaft of the humerus is nearly wholly ossified, but the two extremities are cartilaginous. The scapula at birth is largely osseous, with the exception of the glenoid fossa, the coracoid and acromial process, and the posterior border and inferior angle, which are still cartilaginous. It is on account of these conditions that fractures in these regions at birth are practically nonexistent. It is not possible to produce a paralysis of the Erb type by the fracture of any bone but the clavicle.

In order to get a clear idea as to what happened to an exudate from a ruptured capsular ligament of the shoulder, in studying Lange's theory, I injected the shoulder joints of several infants with methylene blue, and then caused a rupture of the anterior portions of the joint capsule. The infants were then allowed to lie in a preserving solution on their backs for several weeks, following which time a dissection was made. In no case did the methylene blue go above the clavicle, but completely surrounded and invaded the plexus in the axilla. This would in life lead to a paralysis of the whole arm below the joint, but would in no way affect the nerves above the clavicle, and in no case would there be the typical picture of obstetric paralysis, that is, paralysis of the fifth and sixth cervical nerves. As I have stated before, why the exudate should leave the nerves alone in immediate

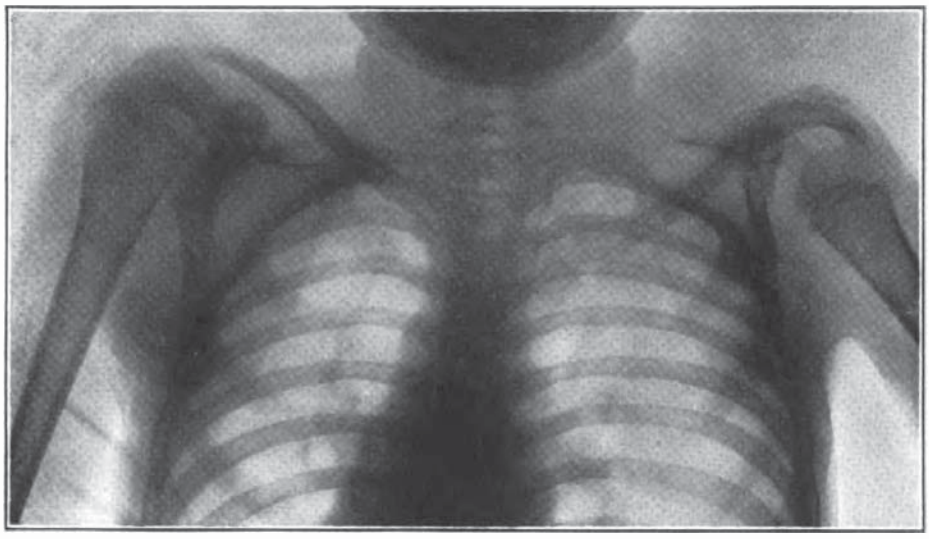

Fig. 12.—Roentgenogram of the shoulders of a boy, aged 16, showing the same characteristics as Figure 11. The normal shoulder is shown on the left.

proximity of the shoulder joint and seek out Erb's point, the junction of the fifth and sixth cervical segments, at least two or three inches above the clavicle, Lange, Thomas and others have not made quite clear. It evidently does not happen. Why also should the suprascapular nerve always be involved, which generally arises from the fifth cervical at about Erb's point? One thing impressed me, and that was the evident vulnerability of the upper cords of the plexus under any degree of traction and I was surprised that the paralysis was not of much more frequent occurrence (Figs. 9 and 10). Figure 9 shows dissection of a baby's plexus with the head and shoulders in natural relations. Figure 10 shows the head and the shoulder forcibly separated. Note the folding together of the cords of the whole plexus, especially the fifth and sixth cords.

Roentgen-Ray Findings.—One hundred and nine of the recently observed 170 cases of obstetric paralysis have had roentgenograms taken of both shoulders on one plate. These patients have varied in age from 2 days to 18 years. In only two cases had there been fracture, one of the clavicle and one of the upper third of the humerus. Both fractures had healed without incident. These cases are classified in Table 2 according to their ages at the time the roentgenogram was taken.

A study of the roentgenograms taken in these cases shows the following conditions:

In the first year there is usually nothing seen of bony deformity. There may be a slight posterior subluxation of the shoulder joint,

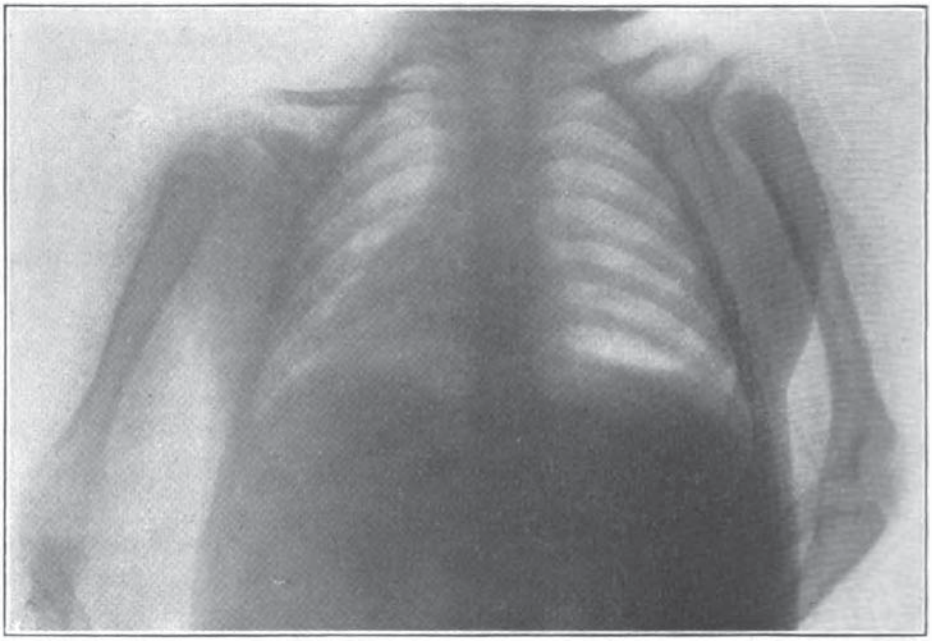

Fig. 13.—A younger patient than that shown in Figure 12. An outward displacement of the scapula is seen on the right.

but there is never any acromial deformity evident by roentgenogram or clinically. No case has been observed in which the epiphysis has been displaced so far as could be seen by comparison with the normal shoulder. The epiphysis, as well as the shaft of the humerus, is always smaller than the unaffected side, which condition is undoubtedly due to atrophy from disuse. The scapula is practically always elevated and outwardly rotated, due apparently to the pull of the intact inward rotators and the levator anguli scapulae.

As time goes on and the child gets older, one begins to see increasing evidences of bony deformity, occasionally more joint subluxation

than at first, increasing outward displacement and elevation of the scapula, and acromial deformity. The deformity of the acromion consists of a bending downward and forward or a hooking of its outer end, which apparently, having no bony resistance to meet as normally in the head of the humerus, projects downward in front of the subluxated and inwardly rotated head. This hooking seems to vary directly with the degree of posterior subluxation and inward rotation of the humerus and tends to increase as the child gets older, provided

TABLE 2.—CONDITION SHOWN BY ROENTGENOGRAM IN 109 CASES

Ages, Years	Subluxation of Joint	Acromial Deformity	Elevation and Displacement Outward of Scapula	Joint Apparently Normal
*	11	..	16	15
1	6	3	7	5
2	5	1	5	5
3	4	3	5	4
4	4	4	6	4
5	6	6	6	
6	3	4	5	2
7	5	3	6	
8	2	1	3	
9	4	4	4	
10	3	3	3	
11	2	2	2	1
12	1	1	1	
13	2	1	2	
14	3	2	3	
15	1	1	1	
16	1	1	1	
17				
18	1	1	1	

* Age from 1 day to (2) years.

subluxation is present. No case has been observed in which there has been a total subluxation or dislocation of the shoulder joint backward. The clavicle usually is shorter and its curves are more acute than its normal fellow (Figs. 11, 12 and 13).

Clinical Findings.—When the child is first seen, if within a few days or weeks after birth, the following picture is classic. The arm lies limp at the side, extended and inwardly rotated, with complete inability to abduct, elevate, outwardly rotate or supinate. The muscles

paralyzed in the typical upper arm type are as follows: Deltoid, supraspinatus, infraspinatus, teres minor, biceps, supinator longus, and occasionally the serratus magnus, coracobrachialis and supinator brevis. The arm cannot be actively flexed at the elbow, but as a rule the lower arm is not affected so far as flexion and extension of the wrist and flexion and extension of the fingers go (Figs. 14 and 15).

The greater part of the motor nerve supply to these paralyzed muscles depends on one root alone, although fibers from more than one root can be traced to individual muscles of the arm. The root distribution of the nerves of the brachial plexus is as follows (Quain[28]):

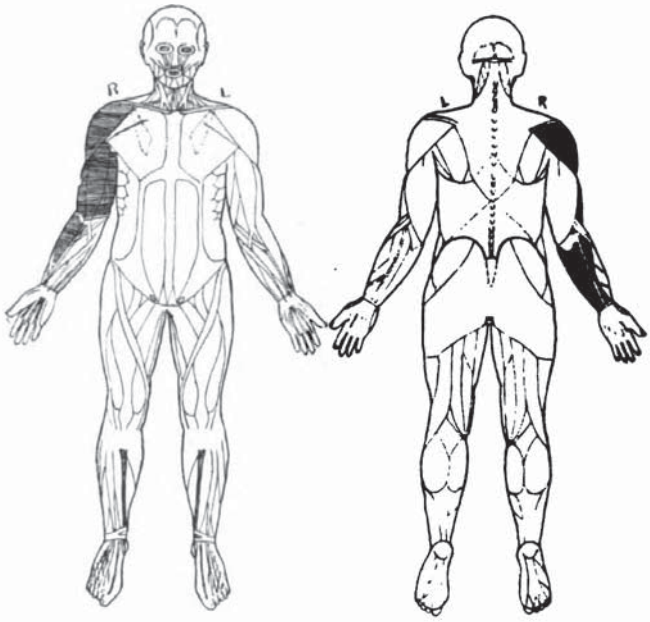

Fig. 14.—Typical upper arm type of obstetric paralysis in a girl of 10 weeks; the muscles shown in white are normal, those in dark shading are paralyzed.

The fifth cervical supplies the levator scapulae, rhomboidei, serratus magnus, supraspinatus, infraspinatus, teres minor, subscapularis, deltoideus, biceps brachii, brachialis anticus (?), pectoralis major (?), teres major.

The sixth cervical supplies the serratus magnus (?), supraspinatus (?), infraspinatus (?), teres minor, subscapularis, teres major, deltoideus, pectoralis major, biceps brachii, brachialis anticus, pronator teres, flexor carpi radialis, supinator longus and brevis, extensor carpi radialis, abductor opponens and flexor brevis pollicis.

The seventh cervical supplies the serratus magnus, pectoralis major and minor, latissimus dorsi (?) teres major, coracobrachialis, triceps

28. Quain: Anatomy, iii, Part 2, p. 354.

brachii anconeus, flexor sublimis digitorum (?), flexor profundis digitorum (?) flexor longus pollicis (?) pronator quadratus, extensor radialis, extensores digitorum, extensor carpi ulnaris (?). abductor opponens (?) and flexor carpi pollicis (?).

From the eighth cervical are supplied the pectoralis major and minor, latissimus dorsi, triceps, anconeus, flexores digitorum, flexor carpi ulnaris, pronator quadratus, adductor pollicis, interossei, abductor flexi brevis and opponens, and abductor minimi digiti.

From the first dorsal are supplied the pectoralis major and minor, flexores digitorum, flexor carpi ulnaris, pronator quadratus.

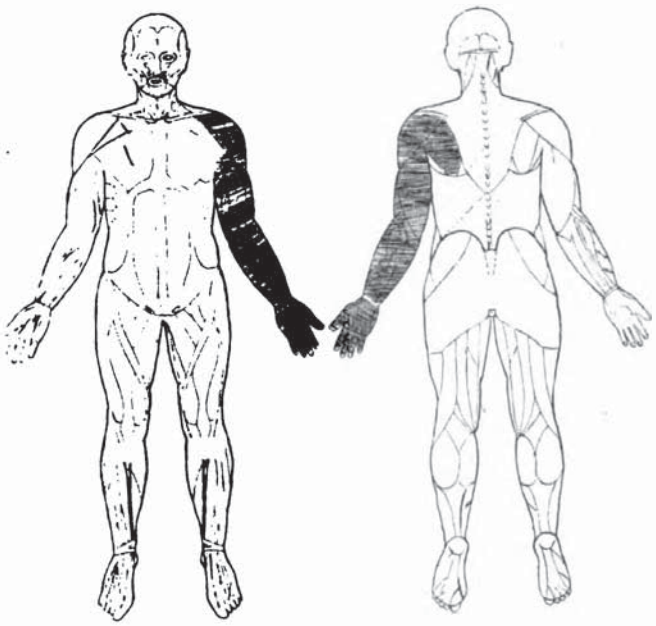

Fig. 15.—Typical lower or whole arm type of obstetric paralysis in a girl of 3 months; the muscles shown in white are normal, those in dark shading are paralyzed.

Tracing back the nerves to their origin, we find the following facts:

From the outer cord: The external anterothoracic follows back to the sixth, seventh and fifth (?) cervical; the nerve to the coracobrachialis to the seventh cervical; the musculocutaneous to the fifth and sixth cervical; the outer head of the medianus to the sixth and seventh cervical.

From the posterior cord: The upper subscapular is traceable to the fifth and sixth cervical; the lower subscapular to the fifth (?) and sixth cervical; the circumflexus to the fifth and sixth cervical, and the musculospiralis to the sixth, seventh and eighth cervical (Fig. 5).

It should be noted that a number of these muscles have more than

one source of supply. Expressed in terms of motion the condition is as follows:

Flexion of the elbow is carried out by the fifth cervical; extension of the elbow by the seventh cervical; pronation of the hand by the sixth cervical; supination of the hand by the fifth cervical; flexion of the wrist by the eighth cervical, and extension of the wrist by the seventh cervical.

In the upper arm type then, the nerves involved are the suprascapular, from the fifth cervical root and outer cord of plexus, going to the supraspinatus and infraspinatus muscles. The musculocutaneous from the fifth and sixth cervical roots and outer cord of the plexus, going to the coracobrachialis, biceps and brachialis anticus. The circumflex from the fifth and sixth, and possibly the seventh and eighth and posterior cord of the plexus, going to the deltoideus and teres minor. The musculospiralis from the fifth, sixth and seventh, and also possibly some fibers from the eighth cervical and posterior cord of the plexus, going to the supinator longus and brevis, brachialis anticus, triceps, anconeus and extensors of hand.

The fact that in the upper arm type practically the only muscles supplied by the musculospiralis which are paralyzed below the elbow are the supinators goes to show that either the injury is not extensive or that the nerve root supply is well divided. No two diagrams of the brachial plexus among all that I studied were alike. The cut of the one shown is the most satisfactory, and, as far as I could tell, the most usual type of formation of the plexus (Fig. 5).

In order to get this definite and constant paralytic muscle grouping, the injury would have to be located at about the junction of the fifth and sixth cervical nerve roots, just above the point of origin of the suprascapular nerve. This junction point is called Erb's point, from his classic description of the type of paralysis seen following injury at that point.

The inability to raise or abduct the arm at the shoulder is due to the paralysis of the deltoideus and supraspinatus. Outward rotation cannot be accomplished because of the paralysis of the infraspinatus and teres minor, and the arm cannot be internally rotated owing to the internal rotators, namely, the teres major, subscapularis and latissimus dorsi, being already fully contracted, due to lack of opposition.

The arm cannot be flexed at the elbow, owing to the paralysis or weakness of the biceps, brachialis anticus, coracobrachialis and supinator longus; and supination cannot be carried out owing partially to the inward rotation in which the arm is held and the weakness or paralysis of the biceps and supinator longus and brevis.

In regard to sensation, it may be stated that it has been impossible

TABLE 3.—Analysis of 394 Cases of Obstetric Paralysis, Showing Condition at Different Ages, Age When Signs of Recovery Were Noted, and in the Older Patients the Condition on Entrance to Clinic

Age	Complete Paralysis		Partial Recovery		Total Recovery		Elevates to Shoulder or Above		Wrist Drop	Paralysis of Hand, Partial or Complete
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower		
2 weeks	11	..	..	..	..	..	..	..	..	..
3 weeks	5	..	4	..	..	..	1	..	..	..
5 weeks	7	..	7	..	..	..	..	..	..	..
6 weeks	3	1	2	1	..	..	..	..	1	1
7 weeks	7	..	7	2	..	..	1	..	..	..
2 months	8	2	14	..	1	..	6	..	..	..
10 weeks	1	..	7	..	..	..	4	..	..	..
3 months	3	3	27	1	..	..	10	1	2	..
4 months	..	..	12	1	..	..	6	1	1	1
5 months	..	1	9	..	..	..	7	..	..	..
6 months	..	..	15	1	..	..	15	1	1	..
7 months	..	..	10	..	..	..	9	..	..	..
8 months	..	3	11	3	..	..	9	1	3	3
9 months	..	..	12	..	..	..	11	..	..	..
10 months	..	..	3	..	..	..	2	..	..	..
1 year	..	..	48	7	1	..	47	5	6	4
2 years	..	..	27	5	..	..	26	3	5	3
3 years	..	1	16	2	..	..	15	1	3	3
4 years	..	..	19	2	2	..	19	2	2	1
5 years	..	..	7	2	..	..	7	2	3	1
6 years	..	..	12	2	1	..	12	1	2	2
7 years	..	1	6	2	..	..	6	2	3	2
8 years	..	..	3	..	1	..	7	..	..	..
9 years	..	..	4	..	..	..	4	..	..	..
10 years	..	..	3	..	1	..	2	..	..	..
11 years	..	..	6	1	..	..	7	..	1	..
12 years	..	..	2	..	..	..	2	..	..	..

in the early cases to determine any changes from the normal, on account of the age of the patient. Likewise, electrical reactions have not been carried out, for this examination would mean anesthesia, which did not seem justifiable in such young children, when one already had all necessary data.

During the first week, in the early cases, the child may cry if the arm is handled or moved, especially in abduction, but this soon disappears. In one or two cases there has been some swelling and tenderness noted by palpation over the plexus above the clavicle. This condition, however, apparently had no connection with the degree of paralysis present. The hand grasp is usually good and the child flexes and extends the wrist and fingers well. The later developments in the upper arm cases, as the child grows and gets older, with or without exercises and massage, are as follows: The persistence of the inward rotation and adduction deformity, the so-called policeman's tip position; the inability in most cases to fully or freely supinate; the inability to get the hand to the mouth without raising the elbow, due to inability outwardly to rotate; the inability to put the hand to the head or behind the back.

In the lower arm type all these conditions hold, besides the additional ones due to the paralytic conditions of the lower arm and hand, resulting generally in a useless dangle arm.

Atrophy of the muscles in these cases of obstetric paralysis is never very marked, except in some cases of the lower arm type. One never sees the extreme atrophy so noticeable in cases of infantile paralysis. This lack of marked atrophy is undoubtedly due to the fact that the nerve impulses are rarely fully blocked and that the muscles practically never, except in rare cases, wholly lose their entire enervation. Some normal nerve impulses pass through the scar tissue at the site of the lesions, owing to incomplete destruction or injury of the nerve, and so keep the muscle tone up to a certain point. There is always a definite shortening of the arm, however, in all cases, due probably as much to nerve injury as lack of use.

Referring to Table 3, which shows the detail of the cases reported, we may note that there are 400 of the upper arm type of paralysis. These in the main showed the conditions mentioned above.

SUBSEQUENT DEVELOPMENTS

Whole Arm Type, Lower Arm Type.—There were seen sixty-four cases of this type in this present series. In this classification those cases which showed any nerve involvement beyond that usually shown by an injury of the fifth and sixth cervical roots were placed. These cases represented those injuries mainly to the whole of the plexus, or at least the seventh and eighth cervical and the first dorsal roots.

Pupillary inequality and narrowing of the palpebral fissure were not unusual with this type. Wrist-drop was the usual condition, associated with the usual inability to supinate and the additional inability to extend the lower arm. Paralysis of the flexors and extensors of the wrist and fingers were common, associated with paralysis and atrophy of the intrinsic muscles of the hand. Often the proximal phalanges are hyperextended, and the distal ones flexed, due to the paralysis of the interossei or lumbricalis manus muscles. There is, of course, no power to grip and the fingers cannot be moved. There is usually ulnar displacement or adduction of the hand. These cases, almost without exception, represent severe tearing injuries to the roots of the

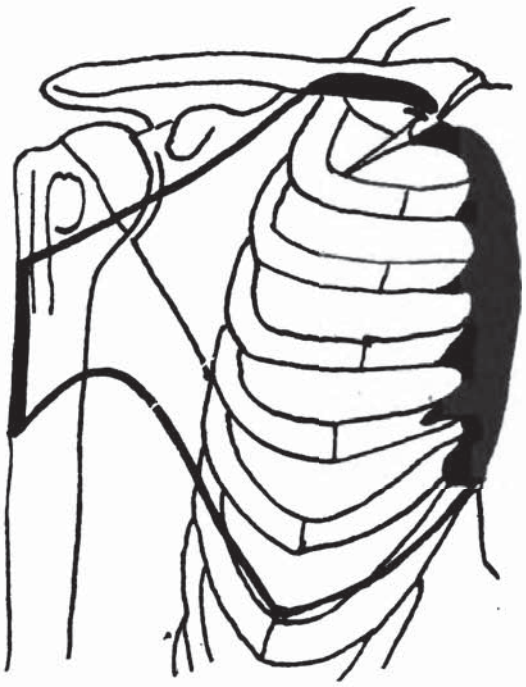

Fig. 16.—Pectoralis major of right side; outline and attachment areas (Gerrish).

plexus, and although some of the muscles may recover in part, particularly the upper arm and shoulder groups, the lower arm ones practically never recover, even after attempted operative repair of the plexus. It is in these cases that sensation is more apt to be impaired than in the usual upper arm type. A not uncommon type seen is one showing simply a wrist-drop, associated with the usual picture of upper arm paralysis and evidence of injury to the fifth, sixth and seventh cervical roots. These cases, as far as results go, should be classed with the simple upper arm type. Few cases have been recorded in which the two lower roots alone have been involved. These have been reported fully by J. J. Thomas.[7]

The complications may be divided into two classes, early and late. The early complications are those accompanying the paralysis and present at birth. The following may be mentioned:

Facial paralysis is usually mild and on the same side as the paralyzed arm and is probably from forceps pressure on the facial nerve.

Fracture of clavicle is not rare.

Separation of epiphysis of the head of the humerus may occur, but no case is noted in this series; it might be grouped under the pseudoparalysis of D'Astros and Danchez.

Dislocation of the humerus sometimes is present, usually infraspinatus. This complication is not noted in this series, but is recorded by other observers.

Fracture of the upper third of the humerus may also occur.

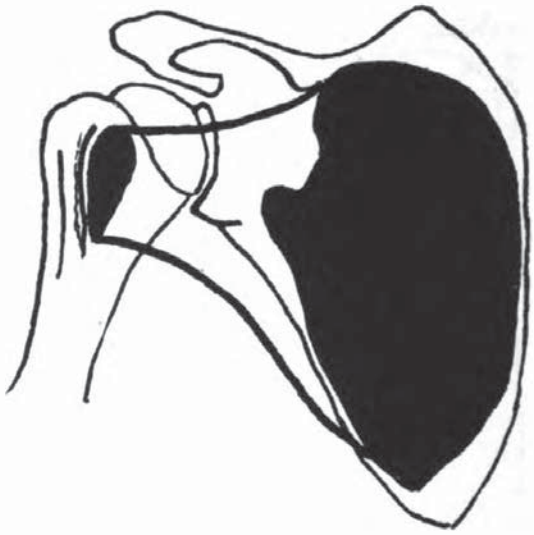

Fig. 17.—Subscapularis of right side; outline and attachment areas (Gerrish).

As late complications the following may be mentioned:

Posterior subluxation of the humerus is common and due to contraction of unparalyzed pectoralis major, subscapularis and teres major (Figs. 16 and 17).

Hooking of the acromion may occur, as has been already noted above.

Anterior subluxation of the humerus, due to the pull of the contracted pectoralis major and the stretching of the subscapularis, is not uncommon.

Contraction of the biceps and the brachialis anticus, leading to some degree of permanent flexion deformity at the elbow and occasionally dislocation of the head of the radius, may occur.

An analysis of Table 4 may be of interest. In the first place, there is no reason to expect any difference in regard to the sex, unless one

is ready to accept Simpson's theory that girls' heads, being smaller, and so not dilating the canal sufficiently, would subject them to a more difficult labor, and so to a greater percentage of occurrence of injury to the brachial plexus. These figures, representing by far the largest number of cases so far reported, and outnumbering all others reported by all observers, do not confirm his theory.

The right arm was affected 272 times and the left 186, about 68 per cent. in favor of the right arm. This bears out Sharpe's figures in his series of fifty-six operative cases. Nine babies had both arms affected.

The types of paralysis differed, the most usual one being the so-called upper arm type, 400 being recorded, as against the so-called lower or whole arm type, in which, besides the fifth and sixth cervical cords being injured, the seventh and eighth cervical and first dorsal

TABLE 4.—CONDITIONS EXISTING AT THE TIME OF BIRTH

Boys	235	
Girls	236	
Total		471
Right arm affected	272	
Left arm affected	186	
Both arms affected, upper arm type	2	
Both arms affected, lower or whole arm type	1	
Both arms affected, type not noted	6	
Upper arm type	400	
Lower or whole arm type	64	
Difficult labor	418	
Ether used	363	
Forceps used	317	
Normal labor	32	
Asphyxiation of child	102	
Head presentation (including face)	219	
Breech presentation (including foot and version)	66	
Position not known	186	
Fractured clavicle	14	
Arm broken	3	
Cord around neck and arm	2	
Cord around neck	2	
Pupils unequal	16	

were injured. Of the latter type sixty-four cases were recorded. In nine cases with both arms affected the lower or whole arm type of paralysis showed generally.

It has been conceded by practically all authors that a difficult labor was a predisposing factor in the causation of paralysis. In this series 418 cases were definitely recorded as long, laborious and difficult; 363 at least had ether and 317 had forceps used; thirty-two were apparently normal labors and 102 were recorded in which the child was asphyxiated.

All the conditions noted above imply the application of force combined with great muscular relaxation of the child, conditions peculiarly favorable for the production of such an injury. A moderately large number, it is recorded, had the head delivered naturally, but the shoulders stuck, and at that time force was applied.

In regard to the presentations, 219 at least were vertex or face presentations and sixty-six were breech. The latter classification includes versions and footlings. In 186 the position was not recorded, but a large majority of these were probably vertex. These figures do not bear out either Tubby or Sherren (quoted under Fairbank[18]), who state that the paralysis occurs equally in head or breech presentations. Fairbank's own figures refute this also, for he reported in forty cases thirty-two vertex and seven breech. These figures cover 285 cases of the author's in which the presentation was definitely known.

The other conditions occurring at birth may be noted in Table 4, and I want to add a word about only one of them, namely, that of unequal pupils. This condition is probably overlooked in some cases, and is a most important symptom, in that it means that through injury to the cervical sympathetic there may be definite injury to the plexus either of the lower cords, the eighth cervical or first dorsal, which have communicating bands with the cervical sympathetic, or injury in the spinal cord itself to the fibers of the sympathetic system. The prognosis in these cases is usually not so good as in those which do not show this sign.

TREATMENT

As to treatment, these cases at once resolve themselves into two divisions, namely, those to be treated with massage and exercises, principally those of the upper arm type; and those to be treated by operation on the plexus, usually those of the lower arm type. Unless the early treatment has been adequate, the upper arm type will also come to operation; not for plexus repair, but to correct contraction deformities. This operation, which I have devised, will be spoken of later.

At first, in order to prevent contraction of unparalyzed muscles, it seems best to put the arm at rest in such a position that the muscles cannot become contracted. This may be done by holding the arm in a plaster cast, or by the use of a light wire splint, in an abducted, elevated and outwardly rotated position, with the hand supinated. This position can be maintained between massage and gymnastic treatments, and insures a better subsequent position of the arm. It also takes the drag off the paralyzed muscles, allowing them to regain their strength more quickly, and prevents subsequent shoulder joint deformity, such as subluxation and acromial hooking and overgrowth.

Massage and exercises are of the greatest importance and should be done daily if possible. It is most unwise to allow a child to become obsessed with the fact that it has an arm which cannot be used. Exercises which have been described in detail by J. J. Thomas[29] are

29. Thomas, J. J.: Obstetrical Paralysis with Especial Reference to Treatment, Boston Med. and Surg. Jour., April 2, 1914, clxx, No. 14.

most satisfactory, and have been developed during the past twenty years in the neurologic department of the Children's Hospital. The treatment should be continued for several years at least, and if contractures develop in the subscapularis and pectoralis major, they must be divided before any further range of action in the arm is to be hoped for.

In regard to the operation on the plexus in the usual upper arm type of case, it might be said that in the experience of this clinic it has not been found necessary. In the lower arm type of cases the situation is quite different, but it cannot be too strongly emphasized that no operation on the plexus will be of any great use in restoring functional activity to the arm, unless contracted and restricting muscles are divided, and careful after-treatment persisted in for a long period.

In regard to the operative treatment on the plexus in the lower arm type of case, it may be stated that it has been done a number of times without any benefit. The plexus in all cases was found to be so badly torn and so bound down and invaded by scar tissue that any kind of repair was impossible. In spite of the work done by A. S. Taylor,[11] Stone,[9] Fairbank[18] and others, there has been no case as yet which has shown an anatomic or physiologic cure, or even a marked improvement. This may be due to the fact that in the first place the plexus was impossible to repair, and secondly, granted that the plexus repair was in part possible, the muscular contractions and joint deformities were not recognized and properly treated, without which the attempt to obtain plexus repair would be a waste of time and effort.

The following operation was devised, following suggestions made by Fairbank.[18] It differs from Fairbank's operation in that the shoulder joint is not opened. Opening this joint leads to adhesions of the capsule, which are troublesome and fatal to the best functional results. In addition, I have found that complete division of the pectoralis major is always advisable, in that it is practically always tightly contracted, and so holds the arm adducted and prevents abduction and outward rotation. The subscapularis tendon can usually be easily found with the arm abducted and outwardly rotated after the division of the pectoralis major, and can be divided without opening the joint capsule.

OPERATION

An incision is made situated on the anterior aspect of the arm and extending from the clavico-acromial joint to a point below the lower edge of the pectoralis major tendon. The incision is carried down between the deltoid and clavicular portions of the pectoralis major, tying or retracting the cephalic vein. The tendon of the pectoralis major is isolated and divided on a director. Turning the cut pectoralis

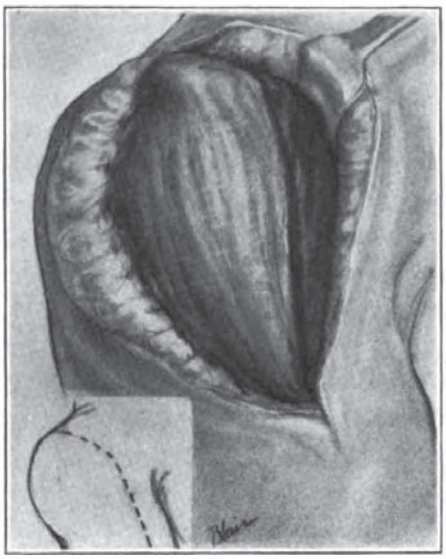

Figure 18

Figure 19

Fig. 18.—The skin incision and the incision between the deltoid and pectoralis major.

Fig. 19.—The pectoralis major cut and the deltoid and the pectoralis major retracted; the long head of the biceps is in the floor of the wound.

Figure 20

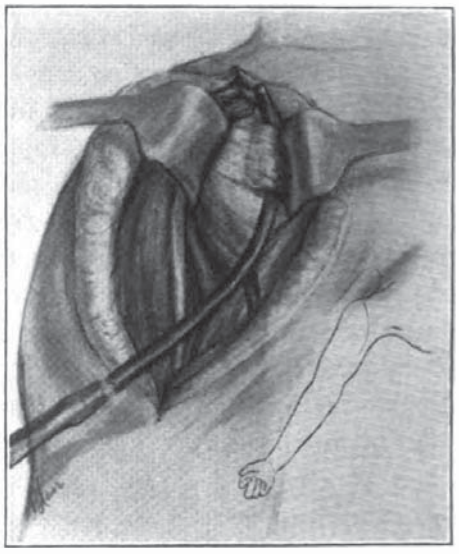

Figure 21

Fig. 20.—The joint capsule with the insertion of the subscapular tendon on inner aspect.

Fig. 21.—A sound is passed under the tendon of the scapularis, the arm being abducted and rotated out to its limit.

major back and retracting the deltoideus gives a good view of the long head of the biceps and the joint capsule, as well as the short head of the biceps and coracobrachialis. The arm is now abducted and outwardly rotated, bringing into view the transverse fibers of the tendon of the subscapularis at its point of insertion into the joint capsule at its inner and anterior aspect. This tendon is isolated and a sound or other blunt instrument is passed under it, and it is then divided. In this way not only is the pectoral divided, which, when contracted, prevents abduction, but also the subscapularis is divided,

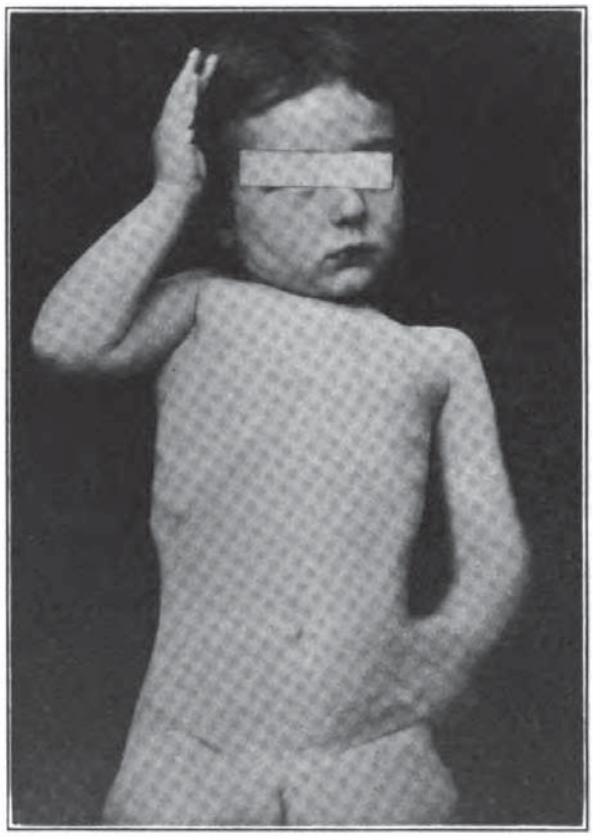

Fig. 22.—E. L., October, 1915. Before operation on right arm.

which, when contracted, prevents outward rotation. It is better to divide the subscapularis by this method, rather than to open the joint capsule, after Fairbank's method, for it does not lead to subsequent adhesion of the capsule to the joint cartilage and consequent loss of motion.

After these two structures have been cut, outward rotation and abduction will usually be found to be perfectly free. In case either is at all restricted, the coracobrachialis or the short head of the biceps may be found to be tight, and the partial division of these structures

will always lead to full freedom in outward rotation and abduction. If the head of the humerus is blocked by the hooking downward of the acromion in front of it, so that the posterior subluxation cannot be fully reduced, an osteotomy can be easily done on the acromion, through the upper end of the original incision.

If there is an anterior subluxation of the joint, which occurs rarely, the pectorialis major is the only muscle which needs to be divided. A division of the subscapularis would only tend to increase a deformity already present. The pectoralis major and deltoideus are then joined with interrupted catgut sutures, and the skin closed by a continuous catgut suture. The arm is then put into a plaster cast extending from the crest of the ilium to the tips of the fingers, the arm being abducted, elevated, outwardly rotated and the hand supinated. This cast should be worn only about two weeks, at the end of which time baking,

Fig. 23.—E. L., April 12, 1916. Three months after operation on right arm.

massage and exercises should be started and continued daily for several months. After two or three weeks a wire splint may be substituted for the cast, in that it is lighter and more comfortable (Figs. 18, 19, 20 and 21).

RESULTS OF OPERATION

Twelve patients so far have been operated on. The first few operations were done by Fairbank's method and the patients were kept in plaster for the length of time advised by him, namely, three months. It is too long. Although they were improved, it has required persistent effort and considerable difficulty to restore motion in the shoulder joint, besides muscle strength, and the results were not commensurate with the time and effort expended.

Recently, since I have been doing the operation described above, combined with early treatment, that is, by giving massage, manipulation

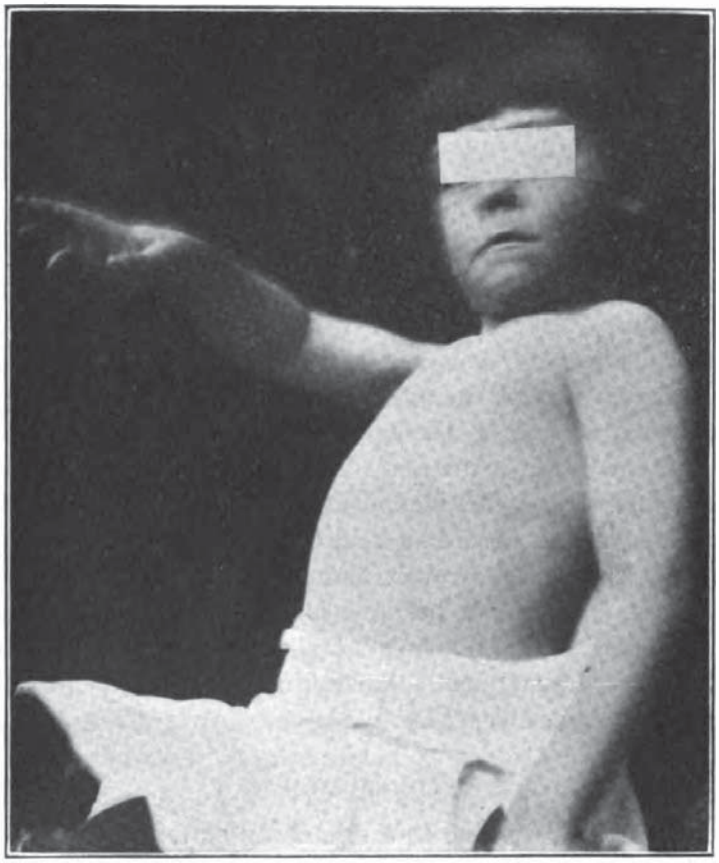

Fig. 24.—R. B., Nov. 17, 1915. Right arm before operation.

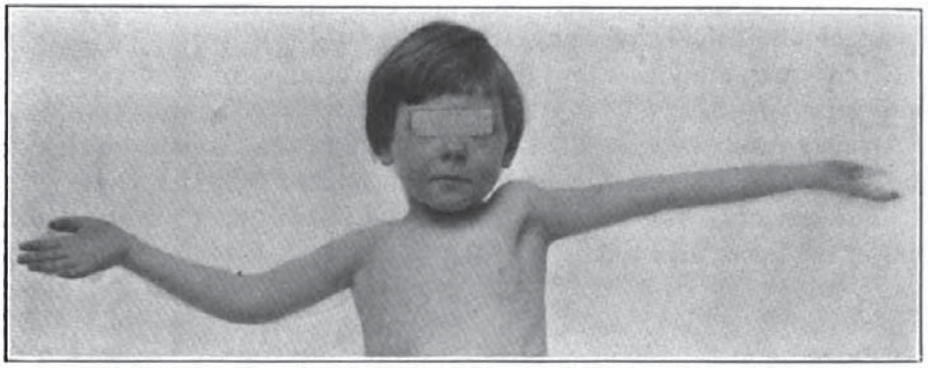

Fig. 25.—R. B., April 26, 1916. Five months after operation on the right arm.

and exercises, at the end of two weeks the results have been much better. This is what might have been expected. Once the contractions are divided, long fixation is obviously unnecessary (Figs. 22, 23, 24 and 25).

PROGNOSIS

The prognosis in all upper arm type of cases is good, provided the case is watched from the start, and treatment properly carried out. The patients are practically all able to raise the arm to the shoulder level and can use the hand and lower arm well, except for varying degrees of supination. Abduction and outward rotation are rarely regained without division of the contracted muscles, provided they have been allowed to contract.

In the lower arm type the outlook is not so good, although many of the patients regain use of the upper arm in spite of the persistent paralysis of the lower arm and hand. These cases should all be explored for repair of the plexus as far as possible, but even then very little hope can or should be held out to the parents. The general principle of treatment, however, should be carried out over a long period of time. Much can be done along orthopedic lines for these patients, and they should not be generally neglected as they have been in the past, with the statement that nothing can be done, or that they will get well of themselves (Table 3).

CONCLUSION

Obstetric paralysis is due to a stretching or tearing of the cervical roots of the plexus brachialis. It occurs in boys as frequently as in girls. It occurs more often on the right than on the left side.

The upper arm type is much more frequent than the lower arm type. It affects both arms very infrequently.

It is practically always associated with a difficult labor, in which ether and forceps have been used and force has been applied. Not uncommonly is the baby asphyxiated.

Head presentations show the larger percentage of occurrences of both types of cases.

It may rarely be associated with fracture of the clavicle, but is not the result of a fractured humerus or a dislocated shoulder joint.

The prognosis for a useful arm is good in the upper arm type and bad in the lower arm type.