Erb's Palsy: LONG-TERM RESULTS OF TREATMENT IN EIGHTY-EIGHT CASES

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Erb's Palsy

Long-Term Results of Treatment in Eighty-eight Cases*

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Recognition of cephalopelvic disproportion by obstetricians and improved means of managing this complication of labor have dramatically decreased the incidence of obstetrical paralysis of the upper extremity. At The Hospital for Special Surgery 491 new patients with Erb's palsy were seen from 1928 to 1939 [11], whereas from 1939 to 1962 there were only 123 patients. On the obstetrical service at The New York Hospital the incidence of this complication has decreased steadily from 1.56 per 1,000 live births in 1938 to 0.38 per 1,000 in 1962.

Despite this decrease the present report is justified by the fact that nowhere in the medical literature has any series of patients with such injuries been followed into adult life to determine the functional, cosmetic, psychosocial, and economic end results.

Of the 123 patients seen at The Hospital for Special Surgery from 1939 to 1962, eighty-eight were available for follow-up examination and form the basis of this report. The average period of follow-up was eighteen years with a range of from one to thirty-five years. More than half were followed over fifteen years

TABLE I

Follow-up

	Years						
	1 to 2	3 to 5	6 to 10	11 to 15	16 to 20	21 to 30	Over 31
Length of follow-up (No. of patients)	5	9	10	15	22	20	7
Age at follow-up (No. of patients)	8	10	18	14	14	11	13

(Table I). Since many of the older papers on this subject [5,12,14,15,19] dealt with far larger numbers and discussed the morbid anatomy and surgical procedures well, this report will be restricted to observations based on careful follow-up of patients for prolonged periods.

Etiologic Factors

An obstetrical history is of importance in determining the etiology.

Delivery

Only thirteen of the 123 patients were said to have had a normal delivery, whereas fifty-six had what were called difficult deliveries and, as would be expected in hospital charts, the character of fifty-four deliveries was not recorded. Breech delivery occurred in eleven patients or 9 per cent of the total, twice the normal rate. It is noteworthy that all four of our patients with bilateral involvement had breech

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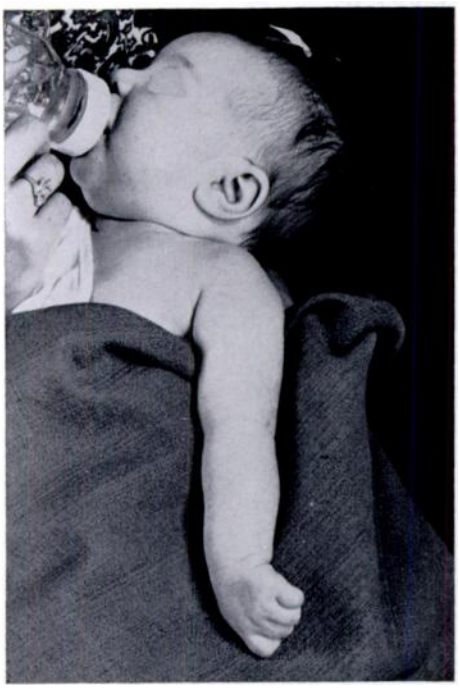

FIG. 1-A

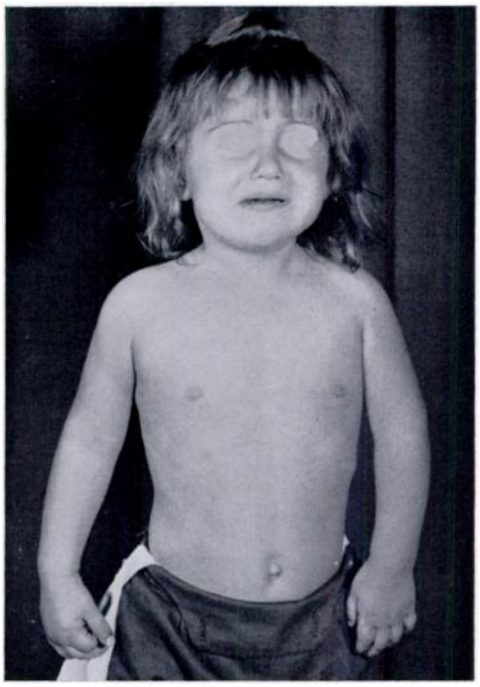

FIG. 1-B

Figs. 1-A and 1-B: Contractures can persist despite spontaneous recovery.
Fig. 1-A: Three-month-old baby with typical deformity of Erb's palsy.
Fig. 1-B: Three years later, there has been full motor recovery but contracture persists because treatment was not given.

deliveries, implying stretch to both arms in the overhead position. In one patient the condition followed a Caesarean section and was the result of hard labor and attempted delivery before Caesarean section proved to be necessary.

Birth Weight

The birth weight was of real significance as an etiologic factor. The average weight of the infants with Erb's palsy in this series was high—nine pounds eight ounces, compared with the United States mean of seven pounds eight ounces. The range in this series was from five to sixteen pounds.

Diagnosis and Early Prognostication

The diagnosis of a brachial plexus injury is easily made in the newborn infant when one upper extremity is not moved actively and the passive range of motion is equal on both sides. If the active and passive motions are equally restricted, injury to the proximal humeral epiphysis, the Putti-Scaglietti [13] lesion, should be suspected and confirmed by roentgen examination. In fact, roentgenograms of the upper extremity of all infants with suspected or proved Erb's palsy should be routinely obtained.

In newborn infants and also in older children it is often difficult to localize accurately the anatomical lesion. Overlap of innervation resulting in incomplete loss of motor power in the muscles innervated by the different trunks of the brachial plexus makes anatomical diagnosis difficult, and we could find no real advantage to such a diagnosis either for management or for prognosis. Classification into upper (Erb [3]), lower (Klumpke [6]), or whole arm (Erb-Duchenne-Klumpke [2]) types is useful in that it quickly conveys a general picture of the pattern of involvement. Of far greater use and prognostic importance is a clinical description, joint by joint,

FIG. 2-A

FIG. 2-B

Figs. 2-A and 2-B: Persistent abduction contracture from bracing.
Fig. 2-A: Six-month-old child whose left hand was subsequently tied to the head of the crib for three months. No additional treatment was prescribed.
Fig. 2-B: Two years later, the child has persistent abduction contracture. Maximum passive adduction on the left is shown.

of the degree of involvement, particularly for patients whose care may not remain the responsibility of one physician from year to year. Such information allows an over-all plan of management to be followed and ensures, for example, that a patient will not be left with a worthless hand and elbow but a shoulder rendered nearly normal by successful surgery.

In the neonatal period, the degree of severity and the time when an end point of spontaneous recovery can be expected are difficult to estimate. Some of the apparently more severely involved extremities made spontaneous recoveries after many months. The time required for maximum recovery varied from one to eighteen months.

Early Management

Complete spontaneous recovery of function is hoped for in all patients, but it is impossible to predict which patient will recover fully and which will not. A wide difference in the incidence of complete recovery has been reported. Wickstrom [19] found the incidence to be 13.4 per cent, whereas in our institution only 7 per cent recovered fully. The fact that few of our patients were newborn infants may explain this discrepancy. Regardless of the incidence of expected spontaneous recovery and the transience of the paralysis in some patients, contractures and deformities can occur rapidly. Hence every child in whom a diagnosis of birth palsy is suspected or made should receive early therapy. One should not await spontaneous recovery since limitation of motion or deformity may persist despite complete return of muscle power if therapy is delayed (Figs. 1-A and 1-B).

Frequent, diligent, and gentle exercises, putting all joints of the involved extremity through a full range of passive motion, are the cornerstone of early management of the patient with obstetrical palsy. Such therapy will prevent or decrease any contractures. If some degree of paresis persists, prevention of contractures will allow greater latitude in the choice of reconstructive procedures. As

in deformities complicating poliomyelitis, it is a basic axiom of treatment that fixed deformity must be overcome before tendon or muscle transfers are performed to produce more normal function. A well planned physiotherapeutic program will obviate the necessity for release operations, such as the Sever procedure, and will allow more patients to be rehabilitated actively by a muscle transfer, such as the l'Episcopo [7] operation. We fully agree with Taylor [18] that no stretching, no massage, and no active therapy should be given during the first few days after birth because of the acute traumatic neuritis present at that time.

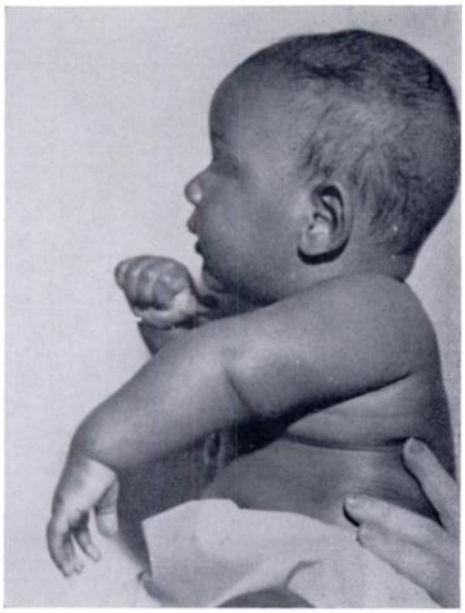

FIG. 3

Child treated in braces for the first four years of life. Resultant edema and deformity of the elbow. Follow-up examination when the patient was twenty-four years old demonstrated radial-head subluxation.

Braces, strapping, Statue-of-Liberty or other splints, or tying the arm to the head of the crib have been recommended by many and are still mentioned in orthopaedic textbooks [4,8,9,16]. These procedures are attractive because they are supposed to prevent the most obvious deformity—the internally rotated and adducted shoulder. Sever [14], in 1916, recommended such bracing; but, in 1925 [15], after an experience encompassing 1,100 patients, he retracted this recommendation and stated that braces delay recovery (Figs. 2-A and 2-B).

Milgram [10] also pointed out, in 1939, that there is definite danger of over-immobilization in the position of abduction, stating that abduction contracture of the shoulder is frequent (sixteen of his twenty-three patients), real, severe, persistent, disabling, deforming, and what is more important, as a rule, unnecessary.

This opinion was supported by our follow-up study. Among our 123 patients, seventy-one were given braces and forty-two were not. Of the seventy-one with braces, fourteen had no additional physiotherapy and all fourteen had external rotation-abduction contractures, one so severe that a derotation osteotomy of the humerus was required.

When physical therapy supplemented passive bracing, no such iatrogenic contractures occurred. However, since the physician must depend upon the parent to perform the prescribed physiotherapy and cannot be assured that it is being

TABLE II

RESULTS OF OPERATIVE TREATMENT (SHOULDER)

	Number of Patients		
Active abduction and elevation	<90°	90°–135°	135°–180°
	11	21	8
Active external rotation	<Neutral	Neutral–30°	30° or more
	12	13	15
Sever release	22		
Osteotomy	6		
l'Episcopo transfer	3		
Arthrodesis	9		

TABLE III

RESULTS OF OPERATIVE TREATMENT (ELBOW)

	Number of Patients		
Flexion contracture	0°–30°	31°–60°	61°–90°
	5	4	3
Active flexion	<90°	91°–120°	>120°
	1	1	10
Radial head resection	7		
Flexorplasty	3		
Other	2		

TABLE IV

RESULTS OF OPERATIVE TREATMENT (FOREARM)

	0°–30°	31°–60°	61°–90°
Pronation contracture		1	5
Supination contracture		1	3
Active pronation	3	3	4
Active supination	7	3	0
Osteotomy*	3		
Pronator section*	4		
Tendon transfer	6		

* Three patients had both procedures.

TABLE V

RESULTS OF OPERATIVE TREATMENT (HAND AND WRIST)

	Good	Fair	Poor
Function*	17	8	11
Opponensplasty			5
Tendon transplant for extensor power			17
Crossed extensor transfer			6
Wrist arthrodesis			8

* Good—pinch and fine manipulative activities possible,
Fair—used for grasping of large objects,
Poor—used for stabilizing objects only.

done often enough or in the proper manner, we feel that routine use of braces is dangerous. Furthermore, it may be that prolonged maintenance of young joints in non-physiological positions may produce some of the bizarre joint disruptions, particularly of the elbow, which we have observed (Fig. 3).

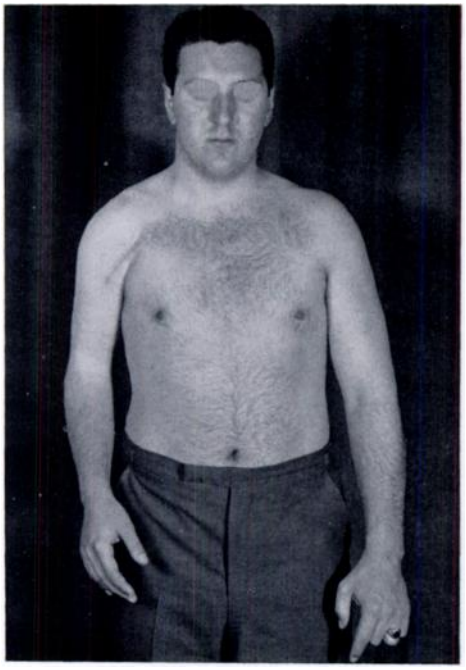

FIG. 4-A

FIG. 4-B

Figs. 4-A and 4-B: Passive release procedures produce cosmetic not functional improvement.
Fig. 4-A: Sever procedure performed at the age of four.
Fig. 4-B: Sixteen years later there is a good cosmetic result with poor function.

Later Management

When a child is old enough for an accurate assessment of motor power, the degree of functional loss can be evaluated and reconstructive surgery can be undertaken. The youngest child operated on in this series was two years old, but all the others were four years old or older. This would seem a better age to expect patient cooperation both before and after operation.

Sixty-two of the eighty-eight patients evaluated in this series had some type of reconstructive procedure (Tables II through V). In all, eighteen different procedures were performed for a total of ninety-eight operations. The particular procedure chosen for a given patient reflected the success or failure of preoperative physical therapy in overcoming contractures.

In twenty-two patients, a fixed internal rotation and adduction contracture of the shoulder was present and passive release by section of the subscapularis and pectoralis major as described by Sever was performed (Figs. 4-A and 4-B). In six older patients with this deformity osteotomy of the humerus was performed (Figs. 5-A through 5-C). In seven patients with pronation deformities of the forearm, osteotomy of the radius, section of the pronator teres, or both procedures, were done to achieve passive correction. The results of these passive procedures were generally cosmetically satisfactory to the patient but rarely resulted in significant functional improvement.

Where contracture had been successfully avoided, active muscle transfers were performed. At the shoulder, transfer of the lattisimus dorsi and teres major to act as external rotators according to the method of l'Episcopo was performed three times (Figs. 6-A and 6-B), and at the elbow, a Steindler flexorplasty (three times) or triceps transfer to the biceps was done to improve flexion. In the forearm, active supination was improved by transfer of the flexor carpi ulnaris to the dorsum of the

FIG. 5-A

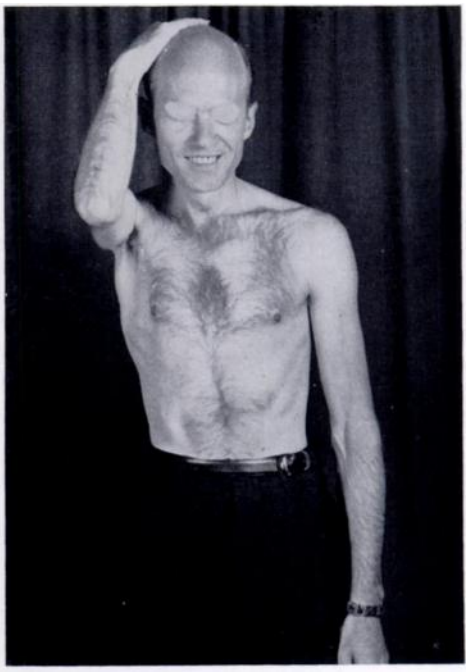

FIG. 5-B

FIG. 5-C

Figs. 5-A, 5-B, and 5-C: Passive correction in the older patient.

Fig. 5-A: At age sixteen. Internal rotation deformity prior to osteotomy of the right humerus.

Fig. 5-B: Twenty-five years later. Improved function.

Fig. 5-C: Roentgenogram at age forty-one showing deformity of the humeral head and coracoid process, seen in many patients with Erb's palsy.

radius (six patients). In the hand and fingers, function was improved by a variety of transfers (opponensplasty, subcutaneous transfer of flexor carpi ulnaris and flexor carpi radialis to the dorsum of the wrist, and the so-called "crossed extensor" transfer [17]). An example of the last is illustrated in Figures 7-A and 7-B. After resection of the pronator quadratus to relieve pronation contracture, the flexor carpi radialis is routed through the interosseous membrane and anastamosed to the extensors of the long, ring, and little fingers. The tendon of flexor carpi ulnaris is similarly routed through the interosseous membrane, crosses the other flexor tendon, and is anastamosed to the thumb and index extensors. Independent wrist and finger extension was achieved in six such procedures.

The results of these muscle transfers were cosmetically and functionally satisfactory to the patient. Procedures of this type remove a deforming factor and supply an active corrective force.

Arthrodesis of the shoulder (nine patients) and of the wrist (eight patients) was performed in older patients with fixed deformities. After fusion existing active

FIG. 6-A

FIG. 6-B

Figs. 6-A and 6-B: Active tendon transfers produce the best functional improvement.
Fig. 6-A: Range of shoulder abduction and external rotation at age seven, prior to l'Episcopo procedure.
Fig. 6-B: Postoperative range of abduction and external rotation.

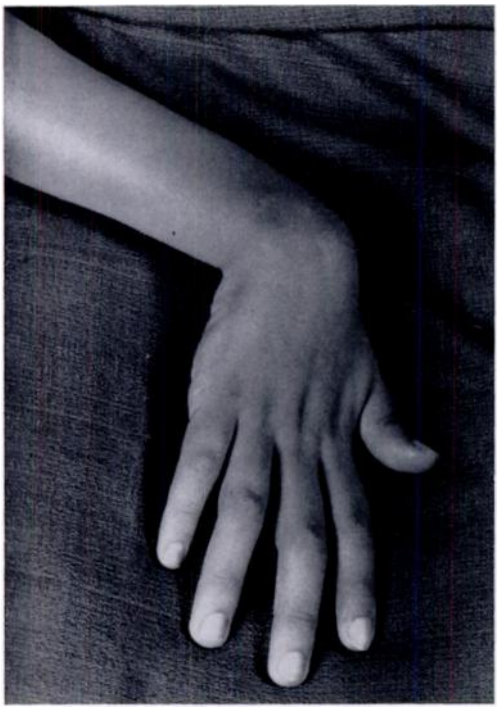

FIG. 7-A

FIG. 7-B

Figs. 7-A and 7-B: Improved hand function by tendon transfer.
Fig. 7-A: Typical deformity of the hand and wrist before operation.
Fig. 7-B: After crossed tendon transfer (see text), independent wrist and finger extension can be achieved.

muscles could perform more efficiently since the deformed joint was stabilized in a functional position.

Elbow-Joint Deformities

Involvement of the elbow joint in Erb's palsy was described previously [11]. In the current series, thirty-eight of the eighty-eight patients had involvement of the elbow. There are three problems observed at the elbow in this disease. The first and most common one is a flexion contracture which may be due to overaction of the

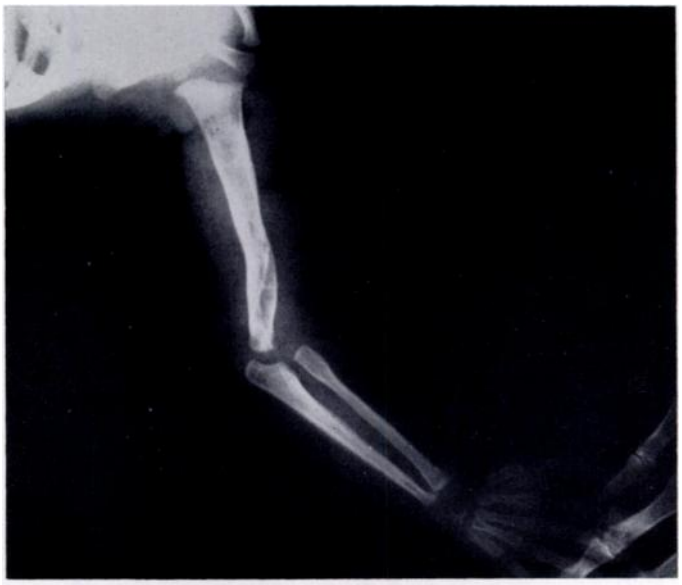

FIG. 8

Dislocation of the radial head at the age of four months. The extremity had been braced since the birth of the infant.

flexors, or to osseous changes related to the original trauma or to the effects of early bracing. Contractures of less than 45 degrees were seen in thirteen patients and more severe contractures were seen in eleven.

The second common problem was posterior dislocation of the radial head. This occurred as early as four months after birth in the present series (Fig. 8) and was documented in fourteen patients. Aitken [1] found thirty-three deformed elbows in a series of 107 patients with Erb's palsy. Twenty-seven of these thirty-three had posterior dislocation of the radial head and bowing of the ulna. He advocated bracing in the young patients and radial-head resection and ulnar osteotomy in older patients. In our experience radial-head resection has been unsuccessful in restoring function and may be a potentially hazardous procedure. Regrowth of the radial head can occur if resection is done early. Also, in one patient, radial-head resection failed to prevent a progressive deformity which resulted in a useless elbow and severe disability (Figs. 9-A through 9-F).

This latter patient illustrates the third, and most severe, problem about the elbow observed in this series. The problem of a relentlessly progressive disruption of the entire elbow joint—a medial sliding dislocation of the ulna and dislocation of the radial head—had not been reported previously. The roentgenograms demonstrate the following changes: (1) increased curvature of the ulna; (2) anterior angulation of proximal radial metaphysis; (3) flattening of the trochlea; and (4) posterior and medial dislocation of the ulna. Once this elbow deformity began to develop, attempts to prevent it by splinting and radial-head resection were unsuccessful. Figures 10-A through 10-E show the results in a patient in whom shoulder function was successfully restored while progressive disruption of the elbow joint occurred. We are unable to explain why this deformity develops or what to do to prevent it; our treatment has been to no avail.

Psychological, Social, and Economic Results

Among the eighty-eight patients who were re-examined, the level of psychological, social, and economic adjustment was excellent. All but one patient were

FIG. 9-A

FIG. 9-B

Figs. 9-A through 9-F: Radial-head excision does not prevent progressive deformity of the elbow.
Figs. 9-A and 9-B: At the age of eight, there was posterior dislocation of the radial head.

FIG. 9-C

FIG. 9-D

At the age of thirty, roentgenograms showed medial shift of the ulna.

outwardly cheerful. Although aware of their disability, they minimized the effect it had on their lives. One patient had succeeded in denying her arm completely, carried it behind her back, and was resentful of the fact that the hospital had recalled her for an examination. Twenty-four patients were older than twenty-one years at the time of evaluation. All but the one previously mentioned had married and had begun to raise families; they were either gainfully employed or were managing households.

Only two of the twenty-four adult patients were employed in positions which required bimanual dexterity: one was a typist and the other a professional baseball

FIG. 9-E

FIG. 9-F

At the age of thirty-two, after excision of the radial head. The joint is completely disrupted.

player. Many patients had made remarkable adjustments to their disability. One man reached the semifinals of an amateur prizefighting contest when he was eliminated by the supervising physician who felt that his arm was an unfair disadvantage. A patient with bilateral Erb's palsy of the whole arm type, probably the most severely disabled patient in the entire series, was employed as a supervisor

FIG. 10-A

FIG. 10-B

Figs. 10-A through 10-E: Progressive elbow deformity compromising an otherwise excellent functional result.

Figs. 10-A and 10-B: Function of the shoulder and elbow at the age of four.

FIG. 10-C

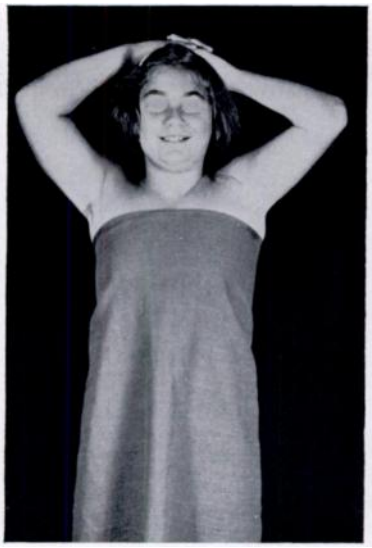

FIG. 10-D

FIG. 10-E

Figs. 10-C and 10-D: At the age of ten, there is excellent restoration of shoulder function by l'Episcopo transfer; there is, however, persistent limitation of elbow function.

FIG. 10-E: Roentgenogram, made at the age of ten, showing disruption of the elbow joint.

of a milk distributing company. He explained that they had had to make him an executive because he broke too much merchandise when he worked as a deliverer.

Although the patients represented all the socioeconomic strata, it is interesting that none were receiving welfare benefits.

Summary

1. A long-term follow-up in eighty-eight patients with obstetrical palsy (Erb's) is presented.

2. Although the incidence has decreased over the years, this birth injury still occurs and presents problems in diagnosis and prognosis as well as early and late management.

3. Maximum recovery may require eighteen months.

4. Contractures can and do occur quickly. All infants in whom the diagnosis is suspected should be treated immediately. The most important aspect of early treatment is the prevention of contractures by passive exercises. Bracing is inherently dangerous since it may cause permanent contractures and should be avoided.

5. Existing contractures or deformities must be corrected before reconstructive procedures are performed.

6. At the time of follow-up virtually all the adult patients in this series were living useful, active lives.

7. The most neglected, perplexing, and disabling problem still is that of the deformed elbow. Thirty-eight of the eighty-eight patients examined in the follow-up had some form of elbow involvement.

References

1. AITKEN, JOHN: Deformity of the Elbow Joint as a Sequel to Erb's Obstetrical Paralysis. J. Bone and Joint Surg., **34-B**: 352–365, Aug. 1952.
2. DUCHENNE, G. B. A.: De l'électrisation localisée et de son application à la pathologie et à la thérapeutique. Ed. 3, pp. 357–362. Paris, Bailliere, 1872.
3. ERB, W. H.: Ueber eine Eigenthumliche Localisation von Lahmungen in Plexus Brachialis. Verhandl. D. Naturhist. Med. Ver. Heidelberg, N.F., **2**: 130–161, 1874.
4. GARTLAND, J. J.: Fundamentals of Orthopaedics, p. 116. Philadelphia, W. B. Saunders Co., 1965.

5. JOHNSON, E. W.: Brachial Palsy at Birth. Internat. Abstr. Surg., 111: 409–416, 1950.
6. KLUMPKE, A.: Contribution a l'etude des paralysies radicularies du plexus brachial. Paralysies radiculaires totales. Paralysies radiculaires inferieures. De la participation des filets sympathiques oculo-pupillaires dans ces paralysies. Rev. Med., 5: 591–616, 1885.
7. L'EPISCOPO, J. B.: Restoration of Muscle Balance in the Treatment of Obstetrical Paralysis. New York J. Med., 39: 357–363, 1939.
8. MACAUSLAND, W. R., JR., and MAYO, R. A.: Orthopaedics. A Concise Guide to Clinical Practice, pp. 110–111. Boston, Little Brown and Co., 1965.
9. MERCER, WALTER, and DUTHIE, R. B.: Orthopaedic Surgery, p. 612. Baltimore, The Williams and Wilkins Co., 1964.
10. MILGRAM, J. E.: Discussion of I'Episcopo [7].
11. PATTERSON, R. L., Jr.: Obstetrical Paralysis. Physiother. Rev., 20: 291–295, 1940.
12. PLATT, HARRY: Opening Remarks on Birth Paralysis. J. Orthop. Surg., 2: 272–294, 1920.
13. SCAGLIETTI, OSCAR: The Obstetrical Shoulder Trauma. Surg., Gynec., and Obstet., 66: 868–877, 1938.
14. SEVER, J. W.: Obstetric Paralysis: Its Etiology, Pathology, Clinical Aspects and Treatment, with a Report of Four Hundred and Seventy Cases. Am. J. Dis. Child., 12: 541–578, 1916.
15. SEVER, J. W.: Obstetric Paralysis: Report of Eleven Hundred Cases. J. Am. Med. Assn., 85: 1862–1865, 1925.
16. SHANDS, A. R., JR.; RANEY, R. B.; and BRASHEAR, H. R.: Handbook of Orthopaedic Surgery, p. 250. St. Louis, The C. V. Mosby Co., 1963.
17. STRAUB, L. R.: Personal communication.
18. TAYLOR, A. S.: Brachial Birth Palsy and Injuries of Similar Type in Adults. Surg., Gynec., and Obstet., 30: 494–502, 1920.
19. WICKSTROM, JACK: Birth Injuries of the Brachial Plexus. Treatment of Defects in the Shoulder. Clin. Orthop., 23: 187–196, 1962.

DISCUSSION

DR. JACK WICKSTROM, NEW ORLEANS, LOUISIANA: I wish to congratulate the authors on this excellent presentation and on their achievement of finding eighty-eight of 123 patients for follow-up examination an average of eighteen years after treatment.

I am generally in agreement with their findings and conclusions. I would disagree, however, with their statement regarding specific root involvement and its value in estimating prognosis. In laboratory experiments on fetal cadavera I found that disruption of the lower plexus components occurred with approximately half the force required to disrupt components of the upper plexus. I also found that patients with involvement of the whole plexus or lower plexus had slower and more incomplete return of function indicating more severe damage to the nerves than did those patients with upper plexus involvement.

There are two other points regarding prognosis. Paralysis of the parascapular muscles indicated by inability to retract or shrug the shoulder and the presence of a Horner's syndrome both indicate a poor prognosis. The nerve fibers which innervate the parascapular muscles and go to the stellate sympathetic ganglion originate from the roots before they form the trunks of the brachial plexus. Nerve injury at this level is repaired incompletely.

I cannot agree entirely with the authors' indictment of protective bracing as the sole cause of the abduction contracture of the shoulder. I have seen patients who received no initial splinting or other treatment before they were seen at the age of two to eighteen years, yet they had abduction contractures of the shoulder. This contracture probably occurs because of the constant abduction required to compensate for lack of external rotation caused by the internal rotation contracture.

I heartily agree that restoration of active muscle balance by the L'Episcopo transplant is preferable to the simpler Sever release of the internal rotation contracture and also that in older patients with fixed internal rotation contractures a humeral osteotomy causes cosmetic improvement; however, in my experience the kinetics and function of the shoulder were also improved in a significant percentage.

My experience with procedures to restore or improve function at the elbow, wrist, and hand have been less than exhilarating. Tendon transfers in these patients do not function as well as in patients with lower motor neuron dysfunction as in poliomyelitis. This has suggested, especially in patients with lower plexus involvement, that root disruption may have caused cord and upper motor neuron damage. Another explanation is that in the child with a birth injury to the brachial plexus functional cerebral motor patterns of coordination do not develop. In either case procedures which improve functional position or correct gross motion about the major proximal joint are most successful, whereas those that attempt to improve fine coordinated function in the hand are generally unrewarding

It is reassuring to know that the psychosocioeconomic adjustment of these patients was so successful.