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# BRACHIAL PLEXUS PALSY IN NEWBORN INFANTS

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**ABSTRACT.** Experience in the diagnosis, treatment, and evaluation of residua of brachial plexus paralysis in 25 infants is presented. Associated defects substantiate the traumatic nature of the deliveries.

The electromyogram proved a valuable tool in the exact delineation of the pathology and in determination of prognosis.

Early optimum treatment prevented atrophy and

contractures. Of the 20 babies with adequate follow-up, approximately  $\frac{1}{2}$  recovered by 6 months with minimal deficit, over  $\frac{1}{2}$  recovered by 1 year with moderate residua to include persistent weakness, delay in bone growth, dislocation, and peculiar posturing of the arm; and the other three infants showed significant handicaps. *Pediatrics*, 48: 18, 1971, BRACHIAL PLEXUS, NEWBORN INFANTS, ELECTROMYOGRAM.

PARALYSIS of the brachial plexus in newborn infants has been a topic of considerable interest in the annals of obstetrical history. In 1764 an obstetrician by the name of Smellie<sup>1</sup> first recorded a connection between birth trauma and this palsy, in a book on mid-wifery. In 1872 Duchenne<sup>2</sup> also ascribed the injury to manipulation at delivery and almost simultaneously Erb<sup>3</sup> described the lesion in adults, localizing so-called Erb's point in the supraclavicular region as the exit of C5, C6 roots, the most frequently traumatized components of the plexus. In 1885 Madame Dejerine-Klumpke,<sup>4</sup> as an extern in Paris, first associated the pupillary changes on the same side as the paralysis which involved the eighth cervical and first thoracic nerve roots. Paralysis of the diaphragm with Erb's palsy was recognized by Weigert<sup>5</sup> in 1920 and more recently by Bellini.<sup>6</sup> Numerous articles<sup>7-13</sup> on late surgical revision and transfers of muscles about the shoulder were published reviewing results of hundreds to over 1,000 cases, as in the papers of Sever in 1916<sup>14</sup> and 1925.<sup>15</sup> Although the incidence of obstetrical palsy has appreciably decreased because of knowledgeable management of difficult labour by the obstetrician, the occurrence is still not negligible. The partial or total loss of an extremity, ag-

gravated by increasing disfigurement with growth, cannot be viewed lightly even if one child is thus affected. Emphasis in this presentation has been placed on diagnosis, electrical delineation of extent of injury, prognostication, early optimum management, and residual problems.

## MATERIALS AND METHODS

Twenty-five patients are herein presented (Table I). They represent infants born primarily in the metropolitan area hospitals of Washington, D.C. between 1967 and 1969, and who were referred to the Children's Hospital for medical care. Eleven infants were seen under 1 month of age, nine under two months, three under 3 months, and two at 5 months of age. Fifteen of the infants are female, 10 male. The right arm was affected in 15 babies, the left in seven, and three babies had bilateral involvement. In Scagliatti's series of nerve and orthopedic injuries of the shoulder<sup>16</sup> there was also a ratio of 2:1 in favour of right-sided involvement. He explained the predilection on the basis of the more common LOA presentation which leaves the right shoulder impinged longer against the pubic arch.

The obstetrical history was complicated in all 25 patients. There were long, hard labours even in the multiparous women. Al-

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TABLE I  
CLINICAL DATA FOR 25 INFANTS WITH BRACHIAL PLEXUS PALSY

<i>Patient</i>	<i>Sex</i>	<i>Age First Seen</i>	<i>Birth Weight</i>	<i>Extent of Involvement</i>	<i>Associated Pathology</i>	<i>Recovery—Electrical and Functional</i>	<i>Residuae</i>
L. S.	F	6 days	12 lb	Bilateral C5C6 (L) C5-T1 (R)	Fx (L) clavicle (L) axillary tear; adrenal haemorrhage; hyperactive DTRs	6-7 mo	None apparent at 7 months
B. M.	F	1 week	7 lb 10 oz	Bilateral C5C6C7 (R) + peripheral radial C5C6C7C8T1 (L)	Fx (L) clavicle; subluxation cervical spine C2-C3	6 mo	No significant deficit at 6 months
L. N.	F	8 weeks	6 lb 13 oz	C5C6 (R)		5 mo	No significant deficit at 5 months
L. H.	F	3 days	7 lb 1 oz	C5C6C7 (L)	Subluxation shoulder and slipping radial epiphysis	5 mo	No significant deficit at 5 months
B. C.	M	6 weeks	8 lb 5 oz	C5C6 (R)	Mild facial palsy (R)	6 mo	Minimal winging at 8 months
C. G.	F	12 weeks	?	Bilateral C5C6 (R) C5 (L)	Cephalo-hematoma	4½ mo	Died at 7 months; cystic lesion of brain and hydrocephalus
N. M.	F	4 weeks	5 lb 2 oz	C5, C6, C7 (R)		9 mo	Length discrepancy at 2 years
L. M.	M	8 weeks	9 lb 1 oz	C5C6C7 (R)		14 mo	Weak triceps wrist and finger extensors
T. M.	F	7 weeks	11 lb 7 oz	C5C6C7 (L)	Left facial palsy	14 mo	Scapula winging 10° flexion contracture of elbow
D. J.	M	4 weeks	8 lb 6 oz	C5C6C7 (L)	Sepsis at birth	10 mo	Good function minimal posture problem at 3 years

## BRACHIAL PLEXUS PALSY

TABLE I (Continued)

<i>Patient</i>	<i>Sex</i>	<i>Age First Seen</i>	<i>Birth Weight</i>	<i>Extent of Involvement</i>	<i>Associated Pathology</i>	<i>Recovery—Electrical and Functional</i>	<i>Residuae</i>
C. H.	F	1 week	9 lb 11 oz	C5C6C7 (L)	Dislocated humerus	8 mo	Contractures at shoulder; open reduction at 8 months
C. G.	M	3 weeks	9 lb 6 oz	C5C6C7 (R)		8 mo	Slightly weak parascapular muscles
M. E.	F	4 weeks	9 lb	C5C6 (R)		10 mo	Slightly weak parascapular muscles; smaller humerus
A. H.	M	4 weeks	8 lb 11 oz	C5C6 (R)		7 mo	Slight winging
P. C.	M	2 weeks	7 lb 10 oz	C5C6C7 C8 (R)	Fx clavicle; hyperactive DTRs; ankle clonus	8 mo	Marked weakness parascapular muscles at 13 months
M. B.	M	8 weeks	9 lb 1 oz	C5C6 (L)	Posterior dislocation of shoulder	7 mo	Slight winging
J. J.	M	7 weeks	8 lb 5 oz	C5C6C7 (R)	Fx (R) humerus	7 mo	Weak extensors
C. R.	F	2 weeks	11 lb 12 oz	C5C6C7 (R)	Partial (R) facial palsy	12 mo—electrical recovery	Functionally not using arm despite good sensation
P. H.	F	10 weeks	9 lb 5 oz	C5-T1 (R)	(R) Horner's myelogram showed avulsion	At 24 months—still weak wrist and finger extensors	30 months—poor sensation weak wrist and finger extensors
F. H.	M	8 weeks	11 lb 10 oz	C5-T1 (R)	Sweat loss 100%; sensory loss	12 months—electrical recovery at first dorsal interosseus	26 months—Marked length discrepancy, flexion contracture; elbow decreased sensation

TABLE 1 (Continued)

<i>Patient</i>	<i>Sex</i>	<i>Age First Seen</i>	<i>Birth Weight</i>	<i>Extent of Involvement</i>	<i>Associated Pathology</i>	<i>Recovery— Electrical and Functional</i>	<i>Residuae</i>
C. C.	F	12 weeks	?	C5C6C7 (R) peripheral radial	Fx (R) humerus	15 months— no radial nerve con- duction	Contracted arm devoid of no treatment
T. R.	F	12 weeks	12 lb	C5C6 (R)		14 months — good electrical return	Severely con- tracted shoulder, elbow and wrist; marked winging; no treatment
D. R.	F	8 weeks	9 lb 11 oz	C5C6C7 (R)	Mild facial	No follow-up	
R. D.	M	5½ months	?—Twin Gestation	C5C6 (R)		No follow-up	
Y. G.	F	5 months	6 lb 13 oz	C5C6 (L)	Mild (L) torticollis	No follow-up	

most all the mothers were under heavy sedation during labour and were anesthetized for the delivery. A relaxed, usually large, asphyxiated infant who would be vulnerable to undue separation of bony segments and over-stretching and injury of soft tissues was the rule in our cases. There were three breech deliveries, one transverse lie, one shoulder presentation, and one persistent occiput posterior presentation. The others were presumably the more common vertex presentation. Twelve of the 25 babies weighed over 9 lb. Only seven weighed under 8 lb. The range was from 5 lb, 2 oz, to 12 lb.

#### CLINICAL PICTURE

The characteristic clinical picture was present in most of the infants. The arms were in tight adduction and internal rotation at the shoulder, extension and pronation at the elbow, and the overpull of the flexors against the usually involved wrist and finger extensors gave the typical "wait-

er's tip" posture. Winging of the scapula with scapulo-humeral contractures was the rule even in the youngest infant. Paralysis involved the abductors, external rotators of the shoulder, scapulothoracic muscles, flexors and supinators of the elbow. If C7 supplied muscles were affected, the ulnar wrist extensors, thumb, and finger extensors would be too weak to counteract the antagonist pull; tight contractures of the wrist and fingers would ensue. In the total brachial plexus involvement, the arm would hang limply to the side of the infant without movement, and the hand would be dry, atrophic, and small. Sensory loss frequently would not correspond to the extent of motor involvement, and sensation was also last to return. Diminished to absent deep tendon reflexes at the biceps, triceps and brachioradialis would confirm lower motor neuron injury.

In the process of a difficult delivery, the injury to the infant may affect not only the peripheral plexus but may result in a gamut



FIG. 1. Two-and-a-half-month-old infant with partial paralysis of the right arm.

of associated defects. Mild facial palsies occurred in four infants, one affecting the terminal branch to the orbicularis oculi. Two infants had subluxation of the shoulder, one associated with minimal slippage of the capital head of the radius. One had torticollis on the same side as the involved limb, which may have been the cause for the difficult delivery and treatment was modified by not allowing vigorous stretching of the affected sternocleidomastoid muscle. Two had fractures of the humerus. Two infants had fractured clavicles, one of whom had radiologic evidence of subluxation of the cervical spine and a hematoma along the right radial groove. This infant not only had a bilateral Erb's paralysis, but a peripheral radial nerve lesion as well. Traction injury to the cervical cord is a real possibility as seen in two other infants who demonstrated upper motor neuron signs, i.e., hyperactive lower extremity deep tendon reflexes, sustained ankle clonus and persistent Babinski responses; one of these had an avulsed axilla and a periadrenal haemorrhage as well. One patient had a Horner's syndrome, and an accompanying

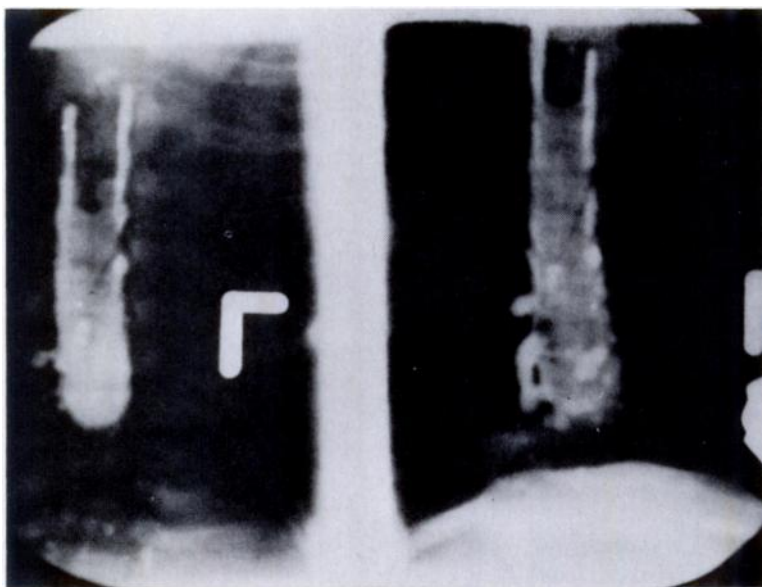


FIG. 2. Myelogram showing avulsion of C7, C8, T1.

TABLE II  
EXAMPLES OF THE ELECTROMYOGRAPHIC EVOLUTION IN THREE PATIENTS

	<i>LH Left arm</i>	<i>LM Right arm</i>	<i>FI Right arm</i>
<i>1 month</i>	Decreased motor unit activity in deltoid, biceps, triceps. Rare motor units in supraspinatus. Fibrillations and sharp waves in all muscles including wrist extensors.		
<i>2 months</i>	Increasing motor unit activity yielding low-amplitude irregular interference patterns. Fibrillations present in all muscles. Increased polyphasic potentials.	Decreased motor unit activity in supraspinatus, deltoid, biceps, triceps; absent in wrist and finger extensors; slight decrease in wrist flexors. Denervation potentials most profuse in biceps and wrist extensors. "Nascent polyphasics" in C5C6 muscles.	Silent EMG in all muscles of the right arm and shoulder to include pectoralis major. Denervation potentials profuse. Stimulating ulnar, median and radial with 1 msec duration current yielded feeble response.
<i>4 months</i>	Good motor unit activity in all muscles. Rare unsustained fibrillations present. All peripheral nerves conducting.—Clinical recovery—good shoulder abduction, forward flexion and supination of elbow. Minimal scapula winging.	Good motor unit activity in all muscles except wrist and finger extensors. Fair interference patterns in shoulder girdle muscles. Denervation potentials still present in C7 muscles.	Few polyphasic potentials in deltoid, supra and infraspinatus, triceps, and biceps. Profuse denervation. Clinically—a flail arm.
<i>6 months</i>			Increased motor unit activity in all muscles above elbow. Few motor units in wrist flexors and extensors.
<i>7 months</i>		Few motor units in extensor indicis proprius and thumb extensors. Radial nerve not clinically conducting.	
<i>8 months</i>			Normal motor unit activity above elbow, common extensors and flexors. Some activity in extensor indicis proprius. No activity in hand.—Clinically—no sweating forearm extensor surface and fingers. Decreased sensation in hand.
<i>12 months</i>			Motor unit activity appearing 1st dorsal interosseus. Denervation potentials persist in hand.



TABLE II (Continued)

	<i>LH Left arm</i>	<i>LM Right arm</i>	<i>FIH Right arm</i>
<i>1½ months</i>		Normal motor unit activity in all muscles. No denervation potentials seen. All nerves conducting. Clinically—use of arm much improved. Persistent weakness of wrist and finger extensors. Sensation and sweating intact.	
<i>2½ months</i>			Electrical recovery. Clinically—marked length discrepancy. Decreased sweating and sensation in hand. Uses it assistively.

myelogram showed avulsion of the C7, C8 and T1 roots (Figs. 1 and 2). Hypesthesia and hypohidrosis occurred in most infants, and complete loss occurred in one.

Wickstrom<sup>12</sup> and later Adler<sup>17</sup> pointed out the difficulties in localizing the anatomical lesion accurately in neonates. Like Vercau<sup>18</sup> in Rumania, we have found the electromyogram extremely useful in topographically delineating the extent and severity of injury. It provides a baseline reference for later prognostication. Chronaxies are less satisfactory determinations in small infants because electrically induced muscle contractions are difficult to separate from small restless movements. Furthermore, higher current intensities produce skin irritation and discomfort in these infants.

Electromyography, employing a Model B TECA instrument\* and 28 gauge Teflon-coated monopolar needles was performed at the initial examination. Serial studies at intervals of 6 to 8 weeks depicted the evolution of the disorder. Reduced voluntary motor unit activity and presence of denervation potentials in the form of fibrillation and sharp wave potentials reflected lower motor neuron injury. Regeneration was signified by the appearance of small polypha-

sic ("nascent") motor units. As recovery progressed there were increased numbers of motor units, decrease in denervation potentials, and ultimately the return of excitability of nerves to electrical stimuli. The absence of motor unit activity coupled with paucity of denervation potentials and non-conductivity of the peripheral nerves were particularly ominous findings, indicating degenerative changes in the muscles.

Electromyographic examination in the present group of infants revealed the following: 11 extremities had localized Erb's palsy (C5, C6), 12 had C5, C6 and C7 supplied muscles affected, and five had complete brachial plexus involvement (C5-T1). The extent of involvement did not necessarily correlate with the rapidity or delay in recovery. Most of the "pure" Erb's paralysis involving C5, C6 components were the earliest to recover. Yet, there were several infants who made only partial recoveries. Some of the C5, C6, C7 involved infants, two of the complete brachial plexus affections, and the infants who had bilateral involvement made more rapid and more substantial recoveries than some of the topographically less extensive lesions. The electromyographic return usually preceded the clinical evidence of function by 1 month (Table II).

\* TECA Corporation, 220 Ferris Avenue, White Plains, New York 10603.





FIG. 3. Residual problems: inability to supinate forearm. Six-month-old boy with mild involvement of C<sub>5</sub>, C<sub>6</sub>, minimal involvement of C<sub>7</sub>.

### TREATMENT

The traumatic neuritis usually affecting the brachial plexus in the first few days of life precluded active physical therapy. However, by 1 week to 10 days of age, gentle range of motion of the shoulder, elbow, wrist, and small joints of the hand was performed. Supportive wrist splints to prevent flexion contractures and stabilize fingers and thumb in good alignment were devised. If range of motion and support of the extremity is maintained, the use of "Statue of Liberty" splints is no longer recommended; this type of splint reinforces development of abduction contractures and may lead to over-immobilization. Dynamic splints to reinforce and reeducate wrist and finger extensors have also been used in the C7 injured infants.

The use of electrotherapy in the prevention of fibrosis of denervated muscles is a controversial subject. It is our clinical impression, in agreement with other proponents of its use,<sup>19-22</sup> that the stimulating current to be effective must be of sufficient intensity to cause maximal muscle contraction. The contraction must take place under

isometric conditions; and to obtain the best possible results it must be started early. It will not retard previous atrophy, but can prevent further wasting pending nerve regeneration. In our infants, electrotherapy was begun early, utilizing galvanic current of sufficient intensity to cause strong contraction. To minimize skin irritation and pain, large moistened electrodes were used. Frequency of treatment depended on the reliability of the parents. A home stimulator was prescribed for daily use in the more severely involved infants. Total duration of electrical treatment did not exceed 20 minutes. As muscle function returned, electrotherapy was discontinued and muscle reeducation instituted.

Meticulous range of motion exercises to the joints of the affected extremities was another critical aspect of treatment. Preliminary examination of some of the youngest infants in this group revealed evidence of developing contractures. Scapula winging, limitation in rotation and abduction of the shoulder, tightness in supination at the elbow, flexion deformity of the wrist, and thumb in tight adduction were common.



FIG. 4. Residual problems: winging of the scapula. Thirteen-month-old boy with functional recovery by 5 months showing parascapular weakness.

The patients seen at 5 months of age or who received no treatment, developed serious restrictions in joint mobility. Particular attention was paid to firm manual stabilization of the scapula with careful stretching of the shoulder joint to prevent scapulo-humeral adhesion. Reeducation of the maneuver of supination at the elbow was stressed. As recovery proceeded, avoidance of substitution, except in the case of complete muscle loss, and prevention of bizarre posturing of the arm was emphasized. The infant at this point was usually reaching for and mouthing objects, transferring from one hand to the other. The use of both hands in play and feeding was encouraged.

### RESULTS

This regimen of treatment has proven relatively effective in the prevention of atrophy and contractures. Of the 25 patients described herein, three were lost to follow-up. One baby died at 7 months of age of a cystic lesion of the brain and hydrocephalus.

She had bilateral Erb's palsies at birth but was recovering well at the time of her demise. Two other infants were seen on subsequent visits but the parents did not avail themselves of treatment for their children. Both had fixed contractures of the shoulder and elbow; one had a shrivelled atrophic arm devoid of sensation, which probably would not have been amenable to treatment.

Of the remaining 20 children, six showed resolution of the problem except for minimal parascapular muscle weakness by 6 months of age. Eleven children required 10 to 12 months for return of function. In none of these children was the recovery 100%. Almost all showed peculiar posturing of the arm in abduction at the shoulder, tightness in internal rotation, and disinclination to supinate the forearm (Fig. 3). Although there was no evidence of scapulo-humeral adhesions in many of this group, there was still minimal winging of the scapula (Fig. 4).

Sequelae from damaged C7 root supplied muscles were significant in 4 of the 11 children. They could not effectively extend the elbow, wrist, or fingers. As they grew, progressive resistive exercises to include "wheelbarrow walking" were initiated (Fig. 5). Two other children had persistent dislocation of the shoulder, one requiring open reduction at 8 months of age because of a slipping epiphysis. In three children in this second group, radiographic studies showed minimal atrophy of the scapulae and shortening of the humeri on the affected sides.

The last group of three children showed rather serious residua, but all were markedly involved babies at birth—one had a C5, C6, C7 involved arm; the other two had complete paralysis of the brachial plexus. Of the latter, one had an associated Horner's syndrome and myelographic evidence of avulsion of roots C7, C8 and T1. This baby at the end of 18 months showed sequelae primarily of the C7 root supplied muscles and loss of sensation on the dorsum of her hand. The other baby with total paralysis and loss of sweating and sensation from the axilla down, showed progressive

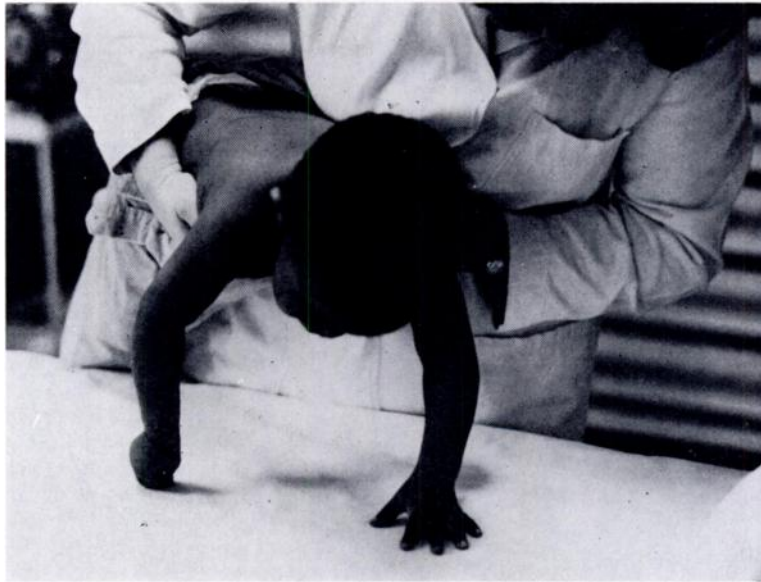


FIG. 5. A boy with C5, C6, C7 involvement. He cannot effectively extend the elbow, wrist, or fingers.

return. Fifteen months later he had motor unit activity in the 1st dorsal interosseus, increasing hidrosis, and sensation in the palm and tips of the fingers. In spite of evident neurologic improvement he would not use his deltoid or triceps, using the trapezius instead in shoulder elevation activities. The arm and hand are appreciably smaller than the uninvolved limb (Fig. 6).

A more profound and worrisome problem involves the last baby of this group. She had a partial paralysis and showed good neuromuscular return by 14 months of age. Despite the fact that she has good sensation in that extremity, she ignores and refuses to use it. This lack of preferential use of the arm reflects an almost apraxic state. Wickstrom<sup>23</sup> has attributed this dysfunction to the lack of development of "functional cerebral motor patterns of coordination." Zalis<sup>24</sup> also recognized this problem and postulated that the transitory interruption of peripheral nervous pathways occurring at birth blocked the establishment of normal motor patterns of movement, and possibly with the organization of body image. He found in animal experimentation, that rabbits injured shortly after birth, despite good

neuromuscular recovery, made the poorest functional recovery; whereas, the animals injured later in life were able to make excellent recovery. Attempts at sensory stimulation, massage, calling the infant's attention to the arm in various positions as it relates to her body have been questionably successful in minimizing this problem.

#### SUMMARY

Experiences involved in the clinical study, treatment, and assessment of residua of 25 babies with varying degrees of brachial plexus palsy is presented.

The use of the EMG to confirm the clinical diagnosis, delineate extent of injury, and prognosticate recovery has been stressed.

Early and careful treatment in maintenance of joint range, prevention of muscle fibrosis and atrophy by electrical stimulation, and adequate splinting has been discussed.

Of the 20 babies with adequate follow-up, six recovered by 6 months with minimal problems, 11 showed fair recovery with a variety of deficits, and three showed serious residua. Persistent problems include delay in bone growth despite intensive muscle ac-

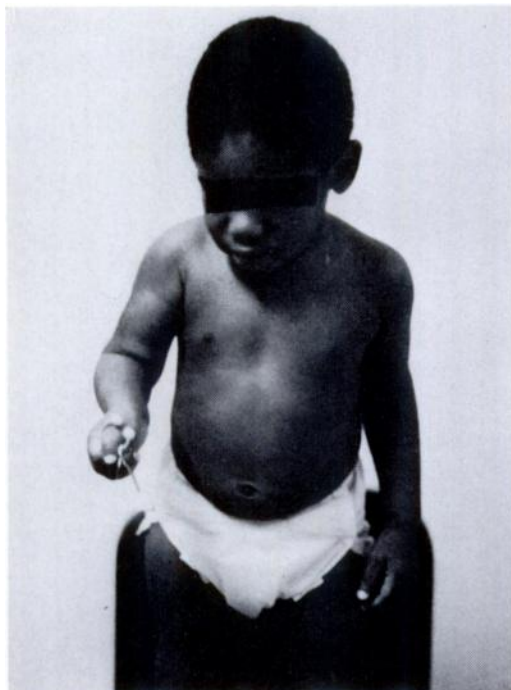


FIG. 6. An 18-month-old boy with complete brachial palsy. He now has muscle activity in the hand, return of sensation, and sweating. Note hitching of shoulder, peculiar posturing, and smallness of affected arm.

tivity with use of electrical stimulation, peculiar posturing of the arm despite seemingly adequate neuromuscular recovery, and unawareness of the affected arm despite good motor and sensory return.

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