# Neurological Sequelae of Brachial Plexus Nerve Block *

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THE IMMEDIATE complications of brachial plexus nerve injection performed via the supraclavicular route have been described sufficiently in many papers. There is, however, little recognition of the fact that delayed sequelae may ensue from damage to nerves. Recently Johnson and Greifenstein [9] have called attention to this problem. Over a period of several years sporadic instances of persistent neurological symptoms following brachial nerve block have been brought to our attention mostly by referring surgeons. An accumulation of five such cases has led us to search the literature for similar cases, to review our past experience and to report our findings at the present time.

## Literature Review

The brachial plexus was injected first with a local anesthetic under direct vision by Halsted in 1884.[14] In 1911 Hirschel [7] and Kulenkampff [10] independently described the technic of blind injection through a supraclavicular approach. Subsequently several variations in this technic were tried and many series of brachial plexus injections have been reported with little reference to the problem of neurologic damage. Kulenkampff and Persky in 1928 [11] reported 1,000 personal cases with mention of only one instance of nerve irritation but referred to a number of other cases. Thus Hirschler [8] in 1913 reported three cases from a large but indeterminate series. One case of median and radial nerve injury followed reduction of a dislocated shoulder. Two others had persistent anesthesia in an area that could not be implicated in the original injury or subsequent operation. Neuhof in 1914 [15] described musculospiral nerve paralysis following brachial plexus anesthesia. Damarjian [3] in a series of 100 cases found three patients with vague paresthesias lasting several days and two others with paresthesias in the ulnar nerve distribution lasting three weeks. DePablo and Diaz-Mallo [17] stated significantly, "Especially interesting are the meralgias with paresthesia which have been pointed out by many authors." Five patients in their series of 3,000 cases had neurological symptoms which abated within 20 days. In a report of 1,100 cases of brachial plexus anesthesia Bonica *et al.*[2] found four instances of transient minimal degrees of analgesia and paresis in the ulnar nerve distribution. These were attributed to pressure on the nerve due to the position of the arm during operation. The report of Moberg [12] is perhaps the most revealing in that the complications were discovered during routine examination after surgery for hand injuries. Among 300 cases of brachial block 17 patients had persistent paresthesias. Dhuner [4] described involvement of the median, radial and ulnar nerves in a patient following operation for Dupuytren's contracture of the hand. Adriani [1] noted a case of medial cord paralysis after block. Finally Johnson and Greifenstein [9] reviewed 432 brachial plexus anesthesias and found six patients who had significant nerve injuries that were "apparently related to anesthesia." It is worth mentioning that in few of these papers was there a

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deliberate attempt made to ascertain the true incidence of neurologic damage through careful postanesthetic examination. The nature of the original injury or the type of operation performed were not described, and little reference is made to the use of a tourniquet for the attainment of a bloodless operative field. These omissions make it difficult to interpret the cause of the ensuing neurological damage. It is apparent, however, that the sequelae were not severe nor were they permanently incapacitating.

## Case Reports

**Case 1.** A. F. (PBBH #E3169) was a 55-year-old truck driver admitted to the hospital for excision of a ganglion on the volar aspect of the right wrist. He had been in good health until he wrenched his wrist in August 1956. A mass which appeared was diagnosed as a ganglion. After it had been broken deliberately by blunt force the mass slowly reappeared. The wrist became lame and the hand grip weakened. Because of his large stature, the body weight of 204 pounds, and a history of excessive alcohol consumption brachial plexus nerve block was thought to be the anesthetic of choice.

On November 1, 1956, preoperative medication consisting of 100 mg. of pentobarbital and 75 mg. of Phenergan by mouth and 8 mg. of morphine by hypodermic injection had little effect. Brachial block was performed via the supraclavicular approach with 25 cc. (500 mg.) of a solution of 2% Xylocaine without epinephrine. Paresthesias were difficult to elicit, and a hematoma formed. However, two radial and two median nerve paresthesias were produced. The patient later recalled these as "shots" in the neck and "shocks" radiating from the neck and shoulder into the muscles of the arm and down into the fingers. Excision of the ganglion required supplementary local infiltration anesthesia on the ulnar side of the arm. A tourniquet was not employed.

Postoperatively there was little pain and the patient was discharged on the first postoperative day. Soon after discharge he began to experience nightly attacks of pain in the shoulder and arm which awakened him and made it seem as if he were being beaten with a stick. During the day the arm felt lame and the thumb and index finger felt dead. Three weeks after operation he was referred to the anesthesia department by his surgeon for evaluation. On physical examination he appeared tremulous and the sclerae were injected. A recent scar on the volar aspect of the right forearm near the wrist extended from the radial side to the midline. Soreness was present on pressure in the supraclavicular fossa. Muscle function was normal. The chief sensory abnormality was a patchy diminution in sensation to pin prick over the arm and forearm with the exception of the eighth cervical and first thoracic dermatomes. Position, vibratory and temperature sensations were intact. As a therapeutic measure stellate ganglion block was performed with partial relief of symptoms He failed to appear for further treatment. When called on the telephone nine months later he complained still of numbness in the thumb, soreness in the neck and paresthesias in the arm. He had also developed a duodenal ulcer.

### Comment

This man had injured his wrist, but neurological examination was negative before operation. A tourniquet was not used for hemostasis. The feeling of numbness in the thumb might have been related to the surgical incision. However soreness in the neck, the paresthesias and the sensory deficit, especially since the ulnar nerve was spared, suggest that the anesthesia was at fault. Performance of the block was difficult and a hematoma formed. Involvement of nerve fibers of small diameter, as indicated by diminution in the sensation to pin prick, suggested injury by the local anesthetic or hematoma. This complication was discovered by the surgeon and undoubtedly would have passed unknown to the anesthetist. It does not seem that the choice of anesthesia was in error but that the technic was faulty. This case suggests the need for better preoperative medication and routine early postanesthetic examination.

**Case 2.** A. W. (PBBH #P6461) was a 78-year-old retired storekeeper who had previous admissions for repair of an inguinal hernia, treatment of calcific tendonitis of the shoulder, and for anterior resection of the sigmoid colon for carcinoma. He lived alone supported by public assistance. At the age of 13 he sustained traumatic amputations of the second and third fingers of the right hand at the proximal interphalangeal joints. For the past four to five years he had further difficulty in using the right hand because of a Dupuytren's contrac-

ture. At first he refused but finally acceded to operation because of progessive disability. Brachial plexus anesthesia was chosen to avoid the undesirable effects of general anesthesia in this elderly man undergoing excision of a Dupuytren's contracture.

On April 13, 1956, brachial plexus nerve block was performed via the supraclavicular approach with 30 cc. of a solution of 1% Xylocaine containing 1 : 200,000 epinephrine and 0.1% Pontocaine. Preanesthetic medication consisted of pentobarbital 100 mg. by mouth, atropine 0.4 mg. and Demerol 25 mg. intramuscularly. Detatils of the injection were not recorded. A tourniquet of the inflatable cuff type was used on the arm for hemostasis for a period of 2 hours and 10 minutes. Anesthesia was satisfactory and at the termination the hand was splinted in plaster.

On the ninth postoperative day the patient complained of supraclavicular tenderness and pain in the hand. Neurological examination suggested neuritis of the radial and median nerves. Four months later when seen in the out-patient department he was greatly depressed and threatened suicide because of unbearable pain in the arm and hand. The pain was of a "pins and needles" type, and the hand appeared hot, dry, and swollen. Additional physical findings included ankylosis of the fourth and fifth proximal interphalangeal joints, absence of sensation to pin prick in the fourth and fifth fingers with little motor weakness. A series of stellate ganglion nerve blocks was performed in association with physiotherapy. There was dramatic relief of pain each time. Swelling of the hand disappeared and the skin temperature became normal. Despite improvement complaints were shifted to pain in the shoulder and to the inability to use his hand. He remained depressed in spirit and continued to voice many complaints.

## Comment

This elderly man presented many problems of an emotional and organic nature. Brachial plexus block was perhaps a poor choice in a patient who had had prior difficulty in the shoulder. The decision to operate on a man so disabled might likewise be questioned. A complicating factor in the interpretation of the neurological findings was the prolonged application of the tourniquet for hemostasis. This was recognized as a definite error in surgical technic. Two hours of ischemia in the presence of probable arteriosclerosis may have caused anoxic or direct damage to peripheral nerves. According to a neurologist, however, the neurological deficit suggested injury to the brachial plexus rather than peripheral nerves. Therefore anesthesia was suspect. Furthermore in tourniquet paralysis, larger nerve fibers such as those transmitting touch or motor power are affected rather than smaller fibers that carry pain and sympathetic impulses.[13] Paresthesias are usually absent but hyperalgesia and a strong affective reaction are usually present in the tourniquet syndrome. Insofar as local anesthesia is concerned there is no clinical or experimental evidence to suggest that prolongation of anesthesia with epinephrine is deleterious. Xylocaine has been reported to produce neurological damage that was eventually attributed to contamination with copper ions.[19] Finally the symptoms in this case were typical of the not uncommon shoulder-hand syndrome seen in elderly people with degenerative diseases.

**Case 3.*** D. S. was a 28-year-old woman who entered the Hospital of the University of Pennsylvania for lysis of adhesions of the extensor tendon of the ring finger on the left hand. She had previously been well and had no abnormal neurological findings. On December 6, 1952, she was given 100 mg. of pentobarbital by mouth, Demerol 50 mg. and atropine 0.4 mg. by subcutaneous injection for preanesthetic medication. Brachial plexus block was performed via the supraclavicular approach employing 25 cc. of a solution of 0.5% U-0045 lactate, a local anesthetic on trial. Multiple paresthesias in the shoulder and hand were elicited. Nerve block was satisfactory. Anesthesia lasted for 12 hours, surprisingly long.

On December 20, during a postoperative office examination the patient complained to her surgeon of pain in the neck and shoulder with radiation into the arm and little finger that had been present ever since discharge from the hospital. Hot or cold applications produced a peculiar sensation in the hand while the little finger felt numb. On examination there was no neurological deficit. These abnormal sensations lasted for about a year during which considerable time and money were

* We are indebted to Dr. Cletus Schwegman of the Dep't of Surgery, Univ. of Penna. Hospital, for permission to report this case.

expended on physiotherapy. As a result of this experience the patient developed a morbid dread of needles and injections.

### Comment

In contrast to the other cases it seemed obvious in this patient, despite the absence of objective neurological signs, that irritation of small fibers in the brachial plexus must have resulted either from needle insertions or the injection of local anesthetic. The production of many paresthesias suggest that the block was more traumatic than need be. There was no mention of hematoma formation. The local anesthetic injected was a newly synthesized substance that subsequently proved to be undesirable for a variety of reasons. Again this case emphasizes the need for a meticulous technic and above all the employment of time proven and reputable local anesthetic agents.

**Case 4.** M. C. (PBBH #4316), a 53-year-old surgical artist, fell while ice skating and sustained a Colles fracture of the right wrist. She had been in good health and the physical examination was negative save for a typical deformity of the wrist. Because she had recently eaten, brachial plexus nerve block was chosen for reduction of the fracture.

On December 9, 1956, pentobarbital 100 mg. and Phenergan 25 mg. were given by mouth for preanesthetic sedation with a fair sedative effect. Brachial block was performed via the supraclavicular approach using 15 cc. of a solution of 2% Xylocaine without epinephrine. Paresthesias were elicited in a radial and ulnar nerve distribution. During manipulation of the wrist the patient felt pain that was relieved with the inhalation of 40% nitrous oxide in oxygen. Considerable pressure was applied directly over the fracture with traction to effect a satisfactory reduction.

On the first postoperative day the patient complained of hyperesthesia and paresthesias in the third finger. There was absent sensation to pin prick on the volar aspect of the third and on the volar and ulnar aspects of the fourth finger. Other sensations and motor power were intact. Following discharge these subjective discomforts gradually abated. After 8 months there were occasional twinges of numbness and tingling in the middle finger.

### Comment

There seems to be little evidence to implicate anesthesia in this complication although it must be suspect. Probably pressure over the median nerve at the time of reduction produced the sequelae. The case illustrates the value of a careful postanesthetic examination in the discovery of residual neurological deficit. Brachial plexus anesthesia ought perhaps to be avoided in individuals whose fingers are needed for the performance of fine work.

**Case 5.** C. L. (PBBH 5J635) was a 48-year-old housewife with pain in the right wrist of 9 months duration. Two months before admission to the hospital she noted further pain in the region of the styloid process of the radius aggravated by motion of the wrist and thumb. Preoperative diagnosis was deQuervain's disease. Her health was otherwise excellent and the neurological examination negative. She received 100 mg. of pentobarbital by mouth for preoperative medication with a good sedative result. A brachial plexus block was performed with the injection of 20 cc. of a solution of 1.5% Xylocaine containing 1 : 300,000 of epinephrine. Definite radial paresthesias were elicited, and a hematoma formed. The upper arm was ringed with 30 cc. 0.5% Xylocaine as a tourniquet was to be used. The latter remained inflated for a period of 25 minutes. Postoperatively for several days the patient complained of supraclavicular tenderness and paresthesias radiating to the arm. The hand was pain free and the neurological examination negative.

### Comment

This patient's subjective complaints mimicked those she had experienced during performance of the nerve block. Although short lived they probably were related to the administration of anesthesia. In contrast to Case 2 the tourniquet seemed blameless in this instance. The formation of a hematoma again raised the possibility of irritation from this source.

## Authors' Delayed Followup Study

During the years 1955–1956, 106 brachial plexus nerve blocks were provided for operations on the upper extremity at the Peter

Bent Brigham Hospital. These anesthetics were administered by anesthesia residents and surgical interns at various stages of training. One or two years after operation letters of inquiry were sent to all these patients. The following questions were asked in an effort to discover unrecognized neurological sequelae:

1. Did the local anesthetic injection bother you at the time of operation? If so, how?
2. How has your arm felt since you left the hospital?
3. Would you choose this type of anesthesia again? If not, why?

Only 53 (50%) of the patients replied to the questionnaire. The others could not be located. Of those who responded 29 had no complaints and would have submitted to this type of anesthesia again. Six others had no residual complaints but would not choose brachial plexus anesthesia again because of discomfort during injection and during the operation. In three of these supplementation with general anesthesia was required because of inadequate pain relief. Seven patients described residual soreness or vague paresthesias but further inquiry revealed that these complaints were transient. Four patients had persistent neurological symptoms of significant duration. Two of these cases (Cases 1 and 2) had been called to our attention by their surgeons. One other (Case 4) had been discovered by us during routine postoperative rounds. The last case (Case 5) was unknown to surgeon and anesthetist both.

## Comment

Although this is a small series of cases and the percentage of responses to the inquiry poor, the replies indicate that brachial plexus nerve block can be a distressing experience for some patients and that minor neurological sequelae resulting from anesthesia may pass undiscovered. The need for the deliberate production of paresthesias to insure a successful block and the occasional failure to achieve this result account for the lack of patient acceptance. Although this inquiry does not reveal the true frequency of neurological damage, a questionnaire such as this may exaggerate or suggest to the patient for the first time that symptoms present are related to anesthesia.

## Discussion

Anesthetic technics like surgical operations are acceptable only if of value and if complications do not outweigh the benefits. It is our opinion that anesthesia of the brachial plexus is an invaluable technic in many surgical circumstances. According to this survey neurological sequelae of brachial plexus block performed via the supraclavicular approach are not numerous considering the large number of blocks that have been performed. However the frequency of complications may be greater than we indicate for several reasons. The duration of hospitalization after brachial plexus block and operations on the arm is apt to be shorter than that following anesthesia for operations in other areas of the body. Brachial block is frequently performed as an out patient procedure. Consequently there is a lesser opportunity for the discovery of complications. This contention is strengthened by the fact that the majority of cases reported by us were discovered by surgeons during postoperative office visits. Moberg's report [12] with the greatest frequency of complications illustrates this point best since his interest lay in the results of surgery performed on the hand and his patients were examined minutely in the postoperative period. The situation is analogous to that in spinal anesthesia wherein the total of reported neurological sequelae is in direct proportion to the diligence of the follow up.[5] A second reason why complications may be missed is that they may be concealed in or confused with symptoms due to the injury or operation for which anesthesia was provided. We

know of no deliberate predetermined search for delayed complications of brachial plexus block. The retrospective study that we report is hardly adequate although a case (No. 5) was found that would otherwise have been missed. We did reaffirm the fact that local anesthesia is not an agreeable experience for some people and that the experience of a paresthesia is not pleasant.

The neurological sequelae that have been reported have not been severe or permanently incapacitating. In most instances complete recovery was a matter of not more than several weeks. The sequelae must be differentiated from those of the original injury or operation and those that might result from the misuse of a tourniquet for hemostasis. When brachial block is held responsible for neurological complications, the type of block performed and the expertness of performance or the local anesthetic solution injected must be considered in determining the cause.

A. *Approach to the brachial plexus and technic:* The supraclavicular approach to the brachial plexus with the deliberate elicitation of paresthesias has for a long time been the most popular technic because of the greatest incidence of successful blocks. Paravertebral, axillary and brachial approaches have been used very little even thought immediate and delayed complications may be less. Supraclavicular injection may produce pneumothorax, phrenic or recurrent nerve paralysis, Horner's syndrome, or hematoma from perforation of the subclavian vessels. Of these hematoma formation may have been responsible for the residual cervical tenderness and paresthesias reported by some of our patients. Persistent probing with a needle because of inexperience, failure to secure the necessary paresthesia in the ulnar nerve distribution and difficulties with a deep seated plexus in the thick necked patient increase the possibility of hematoma formation.

Deliberate elicitation of paresthesias and their enhancement on injection of the local anesthetic might be expected to produce dissolution, molecular damage, or ischemic changes in nerve. We have never understood why such complications were not more frequent with this technic. Permanent sequelae have been reported following injection of local anesthetics into peripheral nerves. The presence or absence of a definitive epineurium may be the determining factor in the production of pressure ischemia when a solution is injected into a nerve. On the other hand local anesthetic solutions thus administered have been shown to diffuse quickly along the length of a nerve through perineural spaces and may be found at a considerable distance from the site of injection.

B. *The local anesthetic agent:* Damage from the local anesthetic agent per se can be expected if the solution is unsterile, otherwise contaminated, or if the agent itself is neurolytic. These factors have been implicated in the development of postspinal anesthetic neurological sequelae and are probably just as important in any other type of nerve injection. For the safe performance of local anesthesia the anesthetic solutions should be autoclaved and stock solutions avoided whenever possible. Single dose ampules are best. The preparation for each nerve block of a fresh solution with sterile crystalline agent and solution is easily accomplished with procaine but has not been possible with some of the newer agents such as Xylocaine and Cyclaine. In Case 3 a newly snythesized anesthetic was employed. It had not been subjected to rigorous tests for neural toxicity. Subsequent studies with the rabbit anterior chamber technic [18] revealed it to be far more destructive to tissues than either procaine and Xylocaine. Nerve damage has followed the injection of Efocaine [16] and of anesthetic solutions in oil [6] when the neural toxic properties had not been recognized.

When a nerve is injured chemically the damage that ensues is characteristic in that the fibers of smallest diameter are in-

volved. Thus loss of sensation to pin prick, disturbances in sympathetic innervation, hyperalgesia, hypesthesia and spontaneous paresthesias may be found. These are important distinguishing characteristics from the type of damage that follows excess pressure to a nerve or the application of a tourniquet to an extremity.[13] Here destruction of large fibers leads to disturbances in motor power, touch, and proprioceptive sense. Paresthesias are lacking and severe pain and hyperalgesia are not common.

## Summary and Conclusions

Reports of five cases of neurological sequelae following brachial plexus nerve block, a brief retrospective study and a review of the literature comprise the subject matter of this paper. Brachial plexus nerve block performed via the supraclavicular approach is admittedly an invaluable method of anesthesia but immediate and delayed complications may ensue if a careful technic is not followed. Neurological sequelae of brachial block are not rare. The exact incidence of these complications is not known but might be higher than realized if careful studies were to be made. Such neurological sequelae are usually not severe nor permanently incapacitating. They must be differentiated from the sequelae that follow the injury to or operation on the arm and from the damage that may follow careless use of a tourniquet for the production of a bloodless operating field.

An atraumatic technic with the use of small gauge needles and avoidance of hematoma formation must be the goal in the performance of brachial plexus nerve block. Patients should be chosen for this type of anesthesia and carefully prepared with sedatives so that the experience of nerve injection is not disagreeable and recollection of the procedure not too vivid. Reputable local anesthetics should be used with careful attention to sterility. The concentration and volume of local anesthetic employed must be suitable for the surgical procedure planned to avoid inadequate anesthesia or anesthesia too brief for operation. In order to interpret the factors in the development of neurological sequelae a record should be kept in each case of the number and location of paresthesias, of the production of hematoma, and of the adequacy of anesthesia. Pre- and postoperative neurological examinations should be performed and postoperative notes kept. It may be prudent to avoid the use of brachial plexus nerve block in persons with prior cervical and shoulder afflictions or in individuals whose fingers and hands are exceedingly important for the performance of fine work. Musicians, artists, and certain types of technicians may fall into this category.

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