

Cause of Pain from a Pneumatic Tourniquet During Spinal Anesthesia

Lt. Comdr. L. D. Egbert, USN, MC, and Capt. T. C. Deas, USN, MC

"THE phenomenon of pain due to a tourniquet in an otherwise satisfactory spinal anesthesia remains to be completely explained. . . ." ¹ This severe ache occurs despite the careful administration of a dose of local anesthetic drug sufficient to anesthetize the patient from the fifth thoracic through the fifth sacral dermatomes. Since the pain disappears immediately when the orthopedic tourniquet is removed, we assume that the tourniquet is the cause of the pain. Cole ² described this pain but had no adequate explanation for its origin or transmission to the central nervous system. In the present study, we have administered spinal anesthesia using two different doses of tetracaine in order to evaluate the influence of the concentration of local anesthetic agent on the incidence of pain from the pneumatic tourniquet.

Method

All observations were made on patients undergoing orthopedic operations on the leg. The patients received a narcotic, a barbiturate and atropine as preanesthetic medication. Spinal anesthesia was induced following an intramuscular injection of 10 mg. of methoxamine. The patients received either 12 mg. or 16 mg. of tetracaine (1 per cent with an equal volume of 10 per cent dextrose) according to random order.³ The anesthetist re-

corded the level of anesthesia to pin prick and whether or not the patient could move his feet at the time the operation began. A wide band tourniquet was applied over Webril padding and then inflated to a pressure of approximately 550 mm. of mercury. If the patient complained of pain during the operation, we recorded a description of the pain, the level of analgesia to pin prick and whether or not the patient could move his feet. If the patient was free of pain throughout the operation, the same observations were made at the end of the operation, *i.e.*, when the tourniquet was removed.

Four groups resulted: those patients with pain and those without who had received 12 mg. of tetracaine, those patients with pain and those without who had had 16 mg. of tetracaine. Differences between these four groups were analyzed using Student's *t* test or Chi square.³

Results

The pain described by our patients was noted first as a dull ache referred to the thigh with the tourniquet. No patient reported radiation of the pain. In none of our patients did the pain spontaneously regress; within ten minutes they would complain bitterly of the severe ache. Although the average time of onset of the pain was about 65 minutes, the variation was great. Seven patients had a burning sensation when the operation began and which they referred to the site of the incision. We originally attributed this pain to the incision, but found on two occasions it was

Received from the U. S. Naval Hospital, Philadelphia, Pennsylvania, and accepted for publication January 10, 1962. Dr. Egbert's present address is Department of Anesthesia, Massachusetts General Hospital, Boston 14, Massachusetts.

TABLE 1. Comparison of Patients with Orthopedic Tourniquet

Number of Patients	Dose of Tetracaine Used for Spinal Anesthesia			
	12 mg. (55 Patients)		16 mg. (51 Patients)	
	With Pain 35 (63.6%)	Without Pain 20 (36.4%)	With Pain 17 (33.3%)	Without Pain 34 (66.7%)
Age (years)	28.4 ± 11.4**	29.0 ± 10.0	24.9 ± 7.5	29.7 ± 13.9
Height (inches)	69.8 ± 1.43	68.7 ± 3.32	70.2 ± 3.73	68.8 ± 4.07
Weight (pounds)	170.0 ± 24.4	166.0 ± 30.0	174.0 ± 23.8	162.0 ± 27.8
Maximum level analgesia†	5.00 ± 2.33	4.90 ± 1.83	4.65 ± 2.55	4.70 ± 1.89
Duration of‡ anesthesia (min- utes)	63.0 ± 28.8	72.6 ± 15.5	69.0 ± 28.3	76.2 ± 24.6
Level at end*†‡	5.88 ± 1.92	5.63 ± 1.80	5.76 ± 2.80	5.42 ± 1.99
Time tourniquet‡ inflated (min- utes)	34.8 ± 27.9	45.7 ± 17.5	39.3 ± 27.2	47.6 ± 19.4

* Mean ± standard deviation.

† Thoracic dermatome, tested by pin prick.

‡ The end of anesthesia is the time that the pain began or the time that the tourniquet was removed.

completely relieved by removing the tourniquet.

No statistically significant differences were found among the groups of patients in age, height or weight (table 1). The only statistical difference among the groups was the number of patients (table 1): 35 of the 55 patients (63.6 per cent) who received 12 mg. of tetracaine for spinal anesthesia had pain, while only 17 of the 51 patients (33.3 per cent) who received 16 mg. of tetracaine had pain. The likelihood of pain occurring during the operation in patients receiving only 12 mg. of tetracaine is significantly greater when compared with those receiving 16 mg. of tetracaine. (Chi square = 8.55, $P < .01$.) No significant difference was noted in: (1) the level of anesthesia to pin prick at the start of the operations, (2) the duration of anesthesia (*i.e.*, the time from the lumbar puncture to the onset of pain or the removal of the tourniquet), (3) the level of anesthesia at the time of onset of pain or the time at which the tourniquet was removed, or (4) the total time the tourniquet remained inflated without causing pain. Seven of the 52 patients who had pain could move their legs while only two of the 54 patients who were free of pain could move their legs. The levels of analgesia to pin prick were significantly lower ($P < .05$) at the end of the operation.

Discussion

We may conclude that a higher dose of tetracaine reduces the incidence of tourniquet pain. That this may be a result of the observers' bias must be considered since the drugs were not administered by a double blind technique as is recommended.³ We believe that the pain from an orthopedic tourniquet is severe enough to impress the observer adequately and reduce the effect of bias. The randomization of patient selection for each dose of tetracaine was carried out.

We believe that the sensation of pain from an orthopedic tourniquet is due to a concentration of tetracaine inadequate to block the large fibers transmitting pressure-pain to the central nervous system. Gasser and Erlanger⁴ showed that large nerve fibers continue to transmit impulses during local anesthesia sufficient to block smaller fibers. Greene, studying patients with spinal anesthesia,⁵ was able to demonstrate a block of cold sensation as much as six dermatomes higher than the block to pin prick sensation. Also, the studies of Heinbecker, Bishop and O'Leary⁶ and Arrowood and Sarnoff⁷ show that a graded block of different sensations occurs during spinal anesthesia. However, Heinbecker *et al.*⁶ believed the nerve fibers carrying pressure-pain sensations were smaller than those carrying pressure sensation. Our data support those of Arro-

wood and Sarnoff,⁷ who state that a spinal block, although sufficient to block the pain of a needle prick, may not block other types of pain. Presumably the pressure-pain of a tourniquet is carried to the spinal cord by nerve fibers larger than those transmitting pricking-pain.

Another paper tends to support this explanation of the pain. Denny-Brown and Brenner⁸ have shown that paralysis following prolonged pressure on a peripheral nerve affects large fiber activity more than that of small fibers. Motor weakness occurred while touch and pain sensibility remained. Large nerve fibers are more susceptible to pressure damage but less susceptible to local anesthetic drugs.⁴ Thus, if we assume the same process, pressure, is responsible for the pain during the operation and any injury to the nerve, we would then expect pain to occur more commonly when lower concentrations of local anesthetic drugs are used.

The data in table I suggest that the patients who had pain were taller than those who were free from pain. We have found that spinal anesthesia tends to wear off sooner in taller patients.⁹ Taller patients probably have spinal subarachnoid spaces with a larger volume resulting in greater dilution of the local anesthetic. Dilution of the tetracaine, however, is not even¹⁰⁻¹² but depends in part upon the distance from the site of injection¹⁰ and the natural curvature of the spinal column.⁶ If a patient lies horizontally during spinal anesthesia, the concentration of local anesthesia is lower at the third and fourth lumbar spaces than at the first sacral or first lumbar spaces because of the effect of gravity on the heavy dextrose solution.⁹ Some roots of the sciatic, femoral, and obturator nerves enter the subarachnoid space at this level and are consequently exposed to a lesser concentration of tetracaine than nerves originating from sacral and thoracic roots.

We do not believe that the pain is caused by ischemia as Cole² suggested. One of us applied an orthopedic tourniquet to his leg after forcing out venous blood with a rubber tape. The severe, well-localized, ache became unbearable in a few minutes; it did not resem-

ble the tingling, relatively mild and diffuse discomfort of arterial occlusion. Kuntz¹¹ has demonstrated that pain caused by stimulating blood vessels in the leg may be perceived despite transection of somatic nerve roots to the leg; he showed that transmission of this sensation was through small nerve fibers carried in the sympathetic pathway to the lower thoracic and upper lumbar regions. Since the average levels of analgesia to pin prick were approximately the same, fifth or sixth thoracic level, in the four groups of patients, we cannot assume that the difference in the incidence of pain from the tourniquet was due to sensation travelling around the anesthetized area up the sympathetic chain.²

All available data, therefore, point to the conclusion that the "otherwise satisfactory" spinal anesthetic may not be sufficient to block nerve fibers of large size. Our practical solution to prevent the occurrence of tourniquet pain during spinal anesthesia is to increase the dose of tetracaine. Treatment of tourniquet pain was unsatisfactory in our series. Although we attempted to cajole the patients into tolerating the pain or the surgeons into removing the tourniquet, 36 patients required treatment of the pain. Nineteen needed general anesthesia, 11 were sedated with secobarbital (three of these considered unsatisfactory) and six were treated with meperidine intravenously (one unsatisfactory). We did not lower and then reinflate the tourniquet because our surgeons considered this harmful in the middle of the operation; Cole² reported that this maneuver reduced the pain.

Summary

Spinal anesthesia was administered to 106 patients for orthopedic operations using a tourniquet. When 12 mg. of tetracaine was given for anesthesia, the incidence of pressure-pain resulting from the tourniquet was significantly greater than when 16 mg. of tetracaine was used. The patients with pain had approximately the same levels of analgesia to pin prick as those patients who were free of pain; the duration of tourniquet pressure was no longer for the patients who experienced pain than for those patients who had no pain.

We have concluded that, although spinal anesthesia may adequately block the sensation

* Egbert, L. D., and Deas, T. C.: unpublished data.

to pin prick carried by small nerve fibers, it may not produce a sufficiently high concentration of local anesthetic to block the large nerve fibers transmitting pressure-pain sensation.

The opinions expressed herein are those of the authors and do not necessarily represent the Navy Department.

References

1. Greene, N. M.: Physiology of Spinal Anesthesia. Baltimore, Williams & Wilkins, 1958.
2. Cole, F.: Tourniquet pain, *Anesth. Analg.* **31**: 63, 1952.
3. Mainland, D.: Elementary Medical Statistics. Philadelphia, W. B. Saunders Co., 1952.
4. Gasser, H. S., and Erlanger, J.: Role of fiber size in establishment of a nerve block by pressure or cocaine, *Amer. J. Physiol.* **88**: 581, 1929.
5. Greene, N. M.: Area of differential block in spinal anesthesia with hyperbaric tetracaine, *ANESTHESIOLOGY* **19**: 45, 1958.
6. Heinbecker, P., Bishop, G. H., and O'Leary, J.: Analysis of sensation in terms of the nerve impulse, *A. M. A. Arch. Neurol. Psychiat.* **31**: 34, 1934.
7. Arrowood, J. G., and Sarnoff, S. J.: Differential spinal block; use in investigation of pain following amputation, *ANESTHESIOLOGY* **9**: 614, 1948.
8. Denny-Brown, D., and Brenner, C.: Paralysis of nerve induced by direct pressure and by tourniquet, *A. M. A. Arch. Neurol. Psychiat.* **51**: 1, 1944.
9. Kuri, S., and Yoshida, J.: Spread of drugs used for spinal anesthesia, *ANESTHESIOLOGY* **17**: 205, 1956.
10. Helrich, M., Papper, E. M., Brodie, B. B., Fink, M., and Rovenstine, E. A.: Fate of intrathecal procaine and spinal fluid level required for surgical anesthesia, *J. Pharmacol. Exp. Ther.* **100**: 78, 1950.
11. Kuntz, A.: Afferent innervation of peripheral blood vessels through sympathetic trunks, *South. Med. J.* **44**: 673, 1951.

AXILLARY BLOCK Perivascular brachial plexus block for surgical operations on the arm was successful in 90 per cent of 250 cases and with supplementary single peripheral nerve blocks in 95 per cent. Transient neurologic sequelae occurred in 1.6 per cent; no permanent neurologic damage or evidence of serious vascular injury was noted. Total morbidity due to the perivascular brachial plexus block was 4.6 per cent. (*Bosomworth, P. P., and others: Block of the Brachial Plexus in the Axilla. Its Value and Complications, Ann. Surg.* **154**: 911 (Dec.) 1961.)

INTRAMEDULLARY ANESTHESIA Intramedullary anesthesia with 0.25 per cent solution of lidocaine was used on 102 patients with diseases or wounds of extremities. In 89.2 per cent of the cases anesthesia set in at the end of the injection and in the remaining 10.8 per cent of the cases at one to six minutes after injection. The tourniquet was kept on the limb for 27 minutes to two hours. No complications due to the use of a tourniquet appeared. A regular feature of the use of lidocaine is the considerable decrease of postoperative pains. (*Ovchinnikov, Y. I.: Use of Lignocaine (Lidocaine, Xylocaine) in Intramedullary Anesthesia, Vopr. Khir.* **12**: 96, 1960.)