Determination of Sensory and Motor Levels After Spinal Anesthesia with Tetracaine

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Sensory levels are usually determined after spinal anesthesia. There are, however, other anesthetic levels (example, sympathetic and motor). The former has been found to be about 1.5 dermatome levels above the sensory level. In this study, motor levels were measured by inserting needles in the intercostal muscles to determine the height of the paralysis. In a series of 33 patients, it was determined that the motor levels will generally be between 1.3 and 2.3 spinal segment below the sensory level.

IN DESIGNATING the level of spinal anesthesia, it is common to refer only to the sensory dermatome. However, since spinal nerves transmit several distinct types of impulses, sensory, motor, sympathetic, each may present a specific anesthetic level. More often than not, this will be at a spinal cord segment different from the level of sensory anesthesia.

Greene, in 1958,[1] compared the level of sympathetic paralysis to the sensory dermatome level. He was able to demonstrate a mean level of sympathetic block 1.91 segments above the sensory. In individual cases paralysis of sympathetic fibers occurred as high as 5 segments above the sensory level. He described this zone as the area of differential block.

In this study, motor and sensory components of the differential zone of block were investigated. The motor levels were determined by using an electromyophone to record presence or absence of activity in intercostal muscles.

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Material and Methods

Thirty-three patients who had operations performed under spinal anesthesia were included in the study. Preanesthetic medication was minimal and, in many cases, omitted entirely to insure the cooperation of the patient during testing.

With the patient in the lateral Trendelenburg position, spinal anesthesia was obtained by injecting a 0.5 per cent solution of hyperbaric tetracaine in dosage sufficient to obtain sensory anesthesia in the thoracic area. Testing of levels was begun 15 minutes following the administration of the anesthetic to allow time for spread of the drug (fig. 1).

Only one side of the thorax was tested because of the potential hazard of pneumothorax during motor determinations. By convention, this was the side uppermost during the time of injection of the drug. The 12 ribs were located and used as landmarks for the determination of levels. First thoracic level included the first rib and first intercostal space; second thoracic level the second rib and second intercostal space and so on. These levels corresponded in general to the accepted landmarks (nipple, fourth thoracic, and xyphoid, sixth thoracic).

The sensory level was obtained by touching the patient with a pin point in the area of anesthesia, and moving the pin cephalad. The end point was the first perception of touch.

Motor level was obtained by using a transistorized electromyophone suitable for use in the operating room. A 2.7 cm. Meditron monopolar needle insulated to within 0.5 mm. of the tip was used as a probing electrode in an intercostal space. A 1.4 cm. ground needle was placed subcutaneously in the same interspace, no more than 3 cm. from it. The needles were placed 3 cm. from the midline in

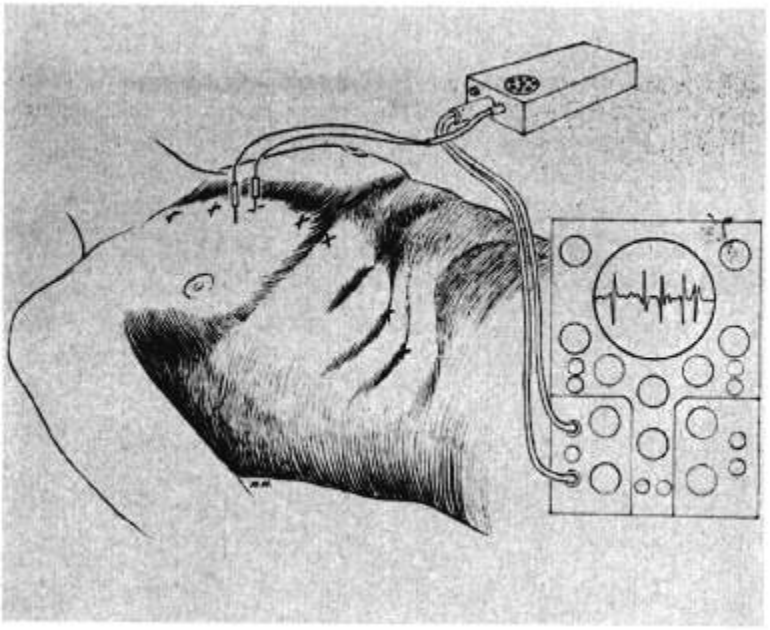

FIG. 1. Diagram demonstrating insertion of needles for testing motor activity.

the upper 5 intercostal spaces. In the lower spaces the needles were inserted 1 cm. laterally to the costochondral junction. In the eleventh and twelfth thoracic interspaces the needles were placed 1 cm. posterior to the ends of the floating ribs. The electrodes were connected to an electromyophone* (fig. 2). Upon elicitation of electrical potential within the muscle, the instrument emitted a crackling sound. By connecting the myophone to an oscilloscope, we identified these sounds as being produced by spike potentials, characteristic of those elicited during active contractions of skeletal muscle.

It was necessary to ascertain that activity heard on muscular contraction originated in

* Designed for our use by Halamore Electronic Corporation.

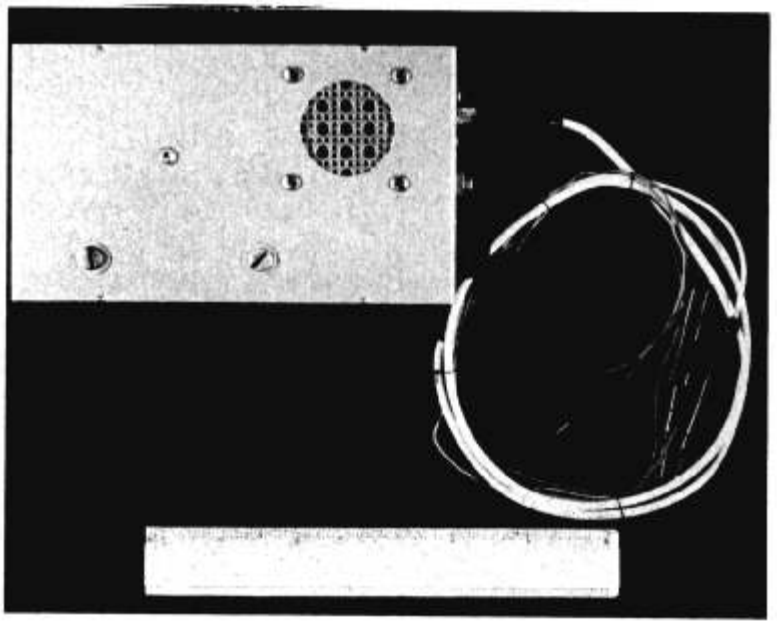

FIG. 2. Transistorized electromyophone used in study of motor levels.

TABLE 1. Levels of Anesthesia Produced by Tetracaine

Patient	Tetracaine Dose (mg.)	Sensory Level	Motor Level	Difference
1	18	T4	T5	1
2	15	T3	T5	2
3	18	T3	T4	1
4	20	T3	T5	2
5	18	T2	T3	1
6	20	T2	T6	4
7	20	T2	T2	0
8	15	T3	T3	0
9	10	T2	T3	1
10	15	T2	T1	−1
11	10	T9	T12+	3
12	15	T6	T12+	6
13	12	T6	T12+	6
14	15	T3	T4	1
15	15	T2	T2	0
16	15	T8	T8	0
17	15	T5	T5	0
18	15	T5	T7	2
19	15	T9	T12+	3
20	15	T10	T12+	2
21	15	T5	T5	0
22	15	T5	T7	2
23	10	T6	T9	3
24	12	T2	T5	3
25	12	T3	T5	2
26	8	T7	T10	3
27	15	T3	T3	0
28	12	T5	T6	1
29	7	T4	T6	2
30	15	T3	T4	1
31	15	T5	T8	3
32	12	T5	T6	1
33	8	T4	T7	3
	mean = 14.15 S.D. = ±3.33	mean = T4.4 S.D. = ±2.2	mean = T6.2 S.D. = ±3.2	mean = 1.8 S.D. = ±1.6

the intercostal muscle and not in overlying muscle groups. This could be done by having the patient perform certain voluntary acts. Thus, activity heard during adduction of the arm indicated that the electrode lay in the pectoralis major. Similarly, activity heard on depression of the shoulder indicated the needle point was in the pectoralis minor muscle. When the needle was properly placed, activity could be heard only on deep inspiration and expiration. It was not necessary to distinguish between placement in the external or internal intercostal muscle since both are innerverted from the same spinal cord segment. When the motor level was found in a lower intercostal space, it was necessary to distinguish intercostal activity from diaphragmatic contraction. This could be done by asking that the patient forcefully exhale. During this maneuver all diaphragmatic activity ceases abruptly.

Several intercostal muscles were tested adjacent to the sensory block. The end point was designated as the highest intercostal muscle silent on deep inspiration and forced expiration. It was not possible to determine motor levels accurately by testing muscles below the eleventh and twelfth thoracic intercostal space, since there is too much segmental overlapping in the innervation of the abdominal muscles. When activity was found to be present in the eleventh intercostal muscle, the end point was assigned as number 12. This liberty was taken in order to be able to compare more readily the difference in mean sensory and motor levels. In reality, the difference between these levels may be slightly greater than presented in the results.

Results

All data are presented in table 1. Sensory levels were found between the fifth and tenth thoracic dermatome. (The mean level was T-4.4 with a standard deviation of ±2.2 segments.)

Motor levels could be accurately determined on 28 patients. These levels were between first and eleventh thoracic. In 5 patients the motor level was below the eleventh and twelfth thoracic interspace. (The mean motor level was T-6.2 and the standard deviation ±3.2 segments.)

The mean difference in the motor and sensory levels was 1.8 spinal segments with 95 per cent confidence that the mean difference will be found in the interval 1.3 and 2.3 spinal segments.

On consideration of individual cases, the motor level was found to be equal to or below the sensory level in 32 cases. Only patient 10 had a level of muscular paralysis above the sensory dermatome. Patients 12 and 13 had differences between sensory and motor levels of 6+ spinal segments.

Discussion

Differing motor and sensory levels are best explained by the size of the fiber carrying each of these modalities. Erlanger and Gasser [2] demonstrated that stronger concentrations of local anesthetics are necessary to block fibers of larger diameter. In general, sympathetic fibers, smallest in diameter, are blocked by the most dilute concentrations, sensory by intermediate concentrations, and motor fibers by the strongest concentrations.

At the site of injection of the spinal anesthetic, the concentration of tetracaine used in the study, 0.5 per cent, was sufficient to block fibers carrying all nervous modalities. As the solution rises in the subarachnoid space and is diluted by spinal fluid, a point is reached at which the concentration is no longer sufficient to produce motor paralysis. The patient may yet have sensory and sympathetic paralysis. At a greater distance from the site of injection the concentration may be sufficient for sympathetic paralysis only. At still greater distance the solution will be too dilute to give objective evidence of any anesthesia. This study and that of Greene[1] suggest that the area of differential block is about 3.7 spinal segments. The distance between the sensory and motor levels is about equal to that between the sensory and sympathetic: that is, each is approximately 1.8 segments, but in individual cases it may be greater.

Summary

Sensory and motor levels were determined following administration of spinal anesthesia. The motor level was located from 1.3 to 2.3 spinal segments below the sensory dermatome level.

References

1. Greene, N. M.: Area of differential block in spinal anesthesia with hyperbaric tetracaine, ANESTHESIOLOGY **19**: 45, 1958.
2. Gasser, H. S., and Erlanger, J.: Role of fiber size in establishment of nerve block by pressure or cocaine, Amer. J. Physiol. **88**: 581, 1929.

PROCAINE CONVULSIONS Administration of procaine, 100 mg./kg. to dogs usually produces generalized convulsions. Electroencephalographic seizure discharges continue to occur if the convulsions are prevented by preliminary administration of succinylcholine. The administration of thiopental stops the convulsions and modifies the electroencephalograph tracings towards normal, eliminating the bursts of large amplitude spikes characteristic of convulsions. Maintenance of good artificial respiration is the major factor in recovery. (*Mark, L. C., Brand, L., and Goldensohn, E. S.: Recovery After Procaine-Induced Seizures in Dogs, Electroenceph. Clin. Neurophysiol. 16: 280 (March) 1964.*)

TOPICAL ANESTHESIA Rapidity of absorption of topically applied local anesthetic varies with the mucous surface involved. Peak levels are attained most quickly in the tracheobronchial tree, next the pharynx, and least quickly after gastric and esophageal instillation. Blood levels may rise quickly after instillation into the posterior urethra, particularly if the surface has been traumatized by instrumentation. Little significant absorption occurs from the bladder or unbroken skin. Vasoconstrictors, detergents, demulcents, and other nonanesthetic substances do not enhance or prolong the effects of topical anesthetics. The latent period is shortened as the maximum effective concentraiton is approached. Adverse reactions occur more frequently after topical application than after perineural injection. Two relatively safe topical anesthetics which do not cause systemic reactions are dyclonine (Dyclone) and ethyl aminobenzoate (Benzocaine). Neither causes convulsions or cardiovascular depression. Of more than forty drugs studied, cocaine, tetracaine (Pontocaine), and dibucaine (Nupercaine) were found to be the most effective and longest lasting. (*Adriani, J., and Zepernick, R.: Clinical Effectiveness of Drugs Used for Topical Anesthesia, J.A.M.A. 188: 711 (May 25) 1964.*)