AREA OF DIFFERENTIAL BLOCK IN SPINAL ANESTHESIA WITH HYPERBARIC TETRACAINE

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In 1929 Gasser and Erlanger (1), in work later confirmed by Heinbecker, Bishop, and O'Leary (2, 3), demonstrated that different types of nerve fibers are blocked by different concentrations of local anesthetic agents. Smaller nerve fibers were shown to be more sensitive to the action of local anesthetics than were larger fibers. Helrich et al. (4) and Kitahara et al. (5) showed that after a local anesthetic agent is injected into the subarachnoid space it is diluted by cerebrospinal fluid so that its concentration falls as the distance from the site of injection increases. This implies that although in the region of highest concentration all nerve fibers crossing the subarachnoid space may be blocked, a level is reached at which dilution has occurred to the extent that large somatic motor fibers are not blocked while smaller fibers transmitting pressure, touch, pain, and sympathetic impulses are still paralyzed. The concentration will finally be reduced until just sufficient to block the smallest fibers, namely sympathetic fibers and those transmitting temperature discrimination. The present report concerns the width of this area of differential block during spinal anesthesia under clinical conditions. Since the level of sensory anesthesia is most frequently determined clinically by use of a sharp instrument such as a needle or pin, but since the physiological effects of spinal anesthesia are primarily the result of preganglionic sympathetic block, attention was centered only upon the extent of the zone of differential block beyond the area made anesthetic to pin-prick. Although sympathetic block is difficult to determine on the trunk under operating room conditions, loss of temperature discrimination is easily determined. Since preganglionic sympathetic fibers are, if anything, more sensitive to the effects of local anesthetic agents than are temperature fibers, determination of the segmental level of anesthesia to temperature will indicate that sympathetic fibers are blocked at least to the same segmental level if not higher.

METHODS

Spinal anesthesia was induced in 50 male and female patients aged 16 to 83. Patients were unselected except for the elimination of those with language barriers and those with depressed mental status which would make evaluation of observations questionable. Surgery con-
sisted of a wide variety of procedures performed below the level of
the umbilicus. The majority of spinal taps were performed between
the third and fourth lumbar vertebrae, with a minority being done be-
tween the second and third or the fourth and fifth vertebrae. All pa-
tients received tetracaine as the anesthetic agent. All solutions were
made hyperbaric by the addition of 10 per cent glucose. The ratio
of volume of 1 per cent tetracaine to 10 per cent glucose ranged from
1:1.00 to 1:1.75. The rate of injection averaged approximately 1.0
cc. each five seconds. In 23 patients epinephrine (0.2 to 0.5 mg.) was
added to the tetracaine-glucose solution in order to prolong duration
of anesthesia. Five minutes after injection of the spinal anesthetic
(at a time when definite sensory blockade had appeared in all patients)
the highest segmental level at which anesthesia to pin-prick was pres-
ent was determined bilaterally in the anterior axillary line or on the
nipple line. Anesthesia to pin-prick was clearly defined in each case
as the area in which sharpness of the pin or needle could not be de-
tected by the patient. Each patient was told that the sensation of
touch was not being tested but only that of sharpness. Immediately
after the height of pin-prick anesthesia was determined and interpreted
in terms of spinal segments according to the data of Keegan (6), the
level of temperature anesthesia was determined bilaterally. This was
done by applying a sponge soaked in ether to the skin and determining
the level at which the sensation of cold was felt by the patient. Care
was again taken to make sure the patient did not confuse the sensation
of touch with that of cold. In all except 2 patients, the levels of pin-
prick and temperature were again determined ten to fifteen minutes
after the induction of spinal anesthesia. For the sake of brevity, those
observations made ten to fifteen minutes after induction of spinal an-
esthesia will be referred to as fifteen-minute observations.

The segmental levels made anesthetic to pin-prick and temperature
at five and at fifteen minutes were recorded on a special form together
with the patient's name, age, type of operation, the side upon which
the patient was lying at the time of injection, and the amounts of tetra-
caine, glucose, and epinephrine (if any) used. The blood pressure and
pulse at five and fifteen minutes were also recorded.

Because the study was designed to evaluate the extent of sympa-
thetic block and because the highest preganglionic sympathetic fiber
originates at the level of the first thoracic segment, no attempt was
made to determine the exact level of temperature block if it was found
to be above the first thoracic level.

Six patients were tested without spinal anesthesia to make sure
premedication or other factors did not alter the validity of the tests
used. All 6 patients could distinguish both pin-prick and temperature
on various parts of the trunk.
The results of the observations (it is to be noted that with few exceptions each patient represents 4 sets of observations) were analyzed by standard statistical methods (7) and are reported as the mean ± standard error of the mean.

Results

In 196 determinations, the mean difference between the highest level at which sensation of pin-prick was blocked and the highest level at which temperature discrimination was blocked was 1.91 ± 0.10 spinal segments. The difference ranged from 0 to 6 spinal segments. In 3 patients temperature discrimination in the hands was impaired. In one patient this occurred when the level of pin-prick anesthesia was at the second thoracic level, in another it occurred when pin-prick was blocked to the third thoracic level, but in the third patient temperature discrimination was blocked on the ulnar side of both hands at a time when the highest level made anesthetic to pin-prick was the seventh thoracic dermatome. In no instance was temperature discrimination blocked at a lower segmental level than was pin-prick.

Influence of Epinephrine.—In 106 observations made in patients who received tetracaine without epinephrine, the mean difference between the two levels of anesthesia was 2.09 ± 0.16 spinal segments. In 90 observations made in patients given tetracaine with epinephrine, the mean difference was 1.71 ± 0.12 segments. This difference is of borderline statistical significance. However, since the effect of time will be shown to be of significance, evaluation of the possible role of epinephrine must involve comparisons made at similar times. When this is done it is found that five minutes after injection of tetracaine without epinephrine the difference between the two levels was 1.63 ± 0.23 segments (52 observations), while five minutes after injection of tetracaine with epinephrine the difference was 1.54 ± 0.12 segments (46 observations). Comparison between these two groups of observations shows no statistically significant difference. However, fifteen minutes after injection, comparable figures for tetracaine without epinephrine were 2.52 ± 0.21 (54 observations), for tetracaine with epinephrine 1.89 ± 0.19 (44 observations). This difference is significant (P less than 0.01), indicating that although epinephrine does not reduce the width of the zone of differential block at five minutes it does so at fifteen minutes.

Influence of Time.—As suggested in the preceding paragraph, the time at which the observations were made following injection of the spinal anesthetic was important in determining the width of the zone of differential block. Without epinephrine this zone was 1.63 ± 0.23 segments wide at five minutes, and 2.52 ± 0.21 segments at fifteen minutes. This difference is statistically significant (P less than 0.01).
Similarly, comparison of the width of the zone after tetracaine with epinephrine at five minutes (1.54 ± 0.12) and at fifteen minutes (1.89 ± 0.19) shows a significant (P less than 0.01) difference. Thus with increased time, at least up to fifteen minutes, there was an increase in the width of the area of differential block.

*Influence of Position at the Time of Injection.*—The side upon which the patient was lying at the time the spinal anesthetic was injected ("down" side) did not show any significant difference in the width of the zone of differential block at either five minutes or fifteen minutes when compared to the contralateral side ("up" side). Excluding 4 patients in whom the injection was made in the sitting or prone position, the following results were obtained. Five minutes after the injection of tetracaine without epinephrine the area of differential block was 1.56 ± 0.40 segments wide on the "down" side and 1.60 ± 0.25 on the "up" side. Fifteen minutes after the injection, corresponding figures were 2.50 ± 0.32 on the "down" side and 2.35 ± 0.27 on the "up" side. Five minutes after the injection of tetracaine with epinephrine, the area was 1.65 ± 0.28 segments wide on the dependent side and 1.52 ± 0.70 on the contralateral side, while at fifteen minutes the results were 1.90 ± 0.27 and 1.95 ± 0.34 respectively. Although these average figures indicate the area of differential block was not significantly different on the "up" side as compared to the "down" side, in individual patients the difference in the width of the zone on the two sides of the body varied from 0 to 4 spinal segments.

*Effect of Dosage.*—The possible role that the dosage of tetracaine played in determining the width of the differential zone was analyzed after taking into account the part played by both time and epinephrine. Five minutes after the injection of 6.0 to 8.9 mg. of tetracaine without epinephrine the width of the zone of differential block was 2.28 ± 0.52 (18 observations), while five minutes after 9.0 to 11.9 mg. it was 1.54 ± 0.14 (26 observations). Comparable figures fifteen minutes after injection were 3.05 ± 0.39 and 2.23 ± 0.17 respectively. Comparison of these two dosage ranges shows no significant effect on the width of the area of differential block. Comparisons involving other dosages of tetracaine without epinephrine were not undertaken because of the small number of observations involved. When epinephrine was added to the anesthetic agent, the zone of differential block was 1.50 ± 0.16 segments wide five minutes after 9.0 to 11.9 mg. of tetracaine (18 observations) and 1.61 ± 0.27 segments wide after 12.0 or more milligrams of tetracaine (26 observations). Fifteen minutes after these dosages of tetracaine with epinephrine the results were 1.88 ± 0.23 and 1.88 ± 0.29 respectively, again indicating that for the dose ranges studied dosage has no effect on the width of the area of differential block. As in the case of tetracaine without epinephrine, comparisons involving other dosage levels of tetracaine with epinephrine were not attempted because of the inadequate numbers involved.
The influence of other factors such as the height of the anesthesia on the width of the area of differential block was not determined because the number of cases was inadequate to provide reliable statistical data. The type of surgical procedure did not appear to bear any relation to this zone of differential block. It was interesting to note that in 4 patients having cesarean sections there was not any obviously greater width in the area of differential block, thus eliminating this as a possible explanation for the profound hypotension such patients may experience during spinal anesthesia.

**Discussion**

Paralysis of sensory and somatic motor fibers is clinically the most conspicuous result of injection of local anesthetic agents into the subarachnoid space. However, the concurrent block of preganglionic sympathetic fibers, although not obvious, is physiologically the most important result of such a technique. Since fibers transmitting the sense of temperature are blocked approximately two spinal segments higher than are fibers conveying the sense of pin-prick, sympathetic fibers are also blocked approximately two segments above the level made anesthetic to pin-prick. Sympathetic fibers may possibly be blocked even above the area made anesthetic to cold. In view of this and because in individual patients this area of differential anesthesia may amount to six spinal segments, any attempt to relate physiological changes produced by spinal anesthesia to the height of the spinal block as determined by pin-prick is bound to contain inaccuracies. This will be especially true if the blood pressure, pulse, or cardiac output are being measured. The area of differential block during spinal anesthesia not only assumes importance in investigative studies on spinal anesthesia but may also constitute the explanation of profound cardiovascular changes in the presence of low levels of sensory anesthesia.

Current hypotheses concerning the action of epinephrine in the subarachnoid space are inadequate to explain fully the decreased width of the area of differential block following its use.

**Summary**

In 196 observations made in 50 patients during spinal anesthesia with hyperbaric tetracaine the level of anesthesia to temperature discrimination was found to be an average of about two spinal segments higher than the level made anesthetic to pin-prick. The width of this area of differential block is greater at fifteen minutes than at five minutes and is decreased when epinephrine is injected with the spinal anesthetic agent. The physiological significance of this area of differential anesthesia is discussed.
REFERENCES