

## SPINAL HEMIANALGESIA: AN EVALUATION OF A METHOD, ITS APPLICABILITY, AND INFLUENCE ON THE INCIDENCE OF HYPOTENSION

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THE use of localized spinal analgesia was described as early as 1909 by Jonnesco.<sup>1</sup> Since that time various techniques have been described,<sup>2-6</sup> each attempting to restrict the extent of somatic and sympathetic paralysis to the operative site. All the techniques are concerned in part with decreasing the incidence of hypotension and other complications associated with spinal analgesia. Among such techniques are: *fractional segmental spinal analgesia*<sup>7-10</sup> where localization is achieved by intermittent injection of small amounts of agents into the subarachnoid space via an indwelling catheter or needle, and "*unilateral*" spinal analgesia<sup>11-14</sup> where anesthesia is confined to one side of the body by the subarachnoid administration of hyper- or hypobaric solutions to the patient placed in the lateral position. The use of fractional spinal analgesia in routine clinical practice has declined recently, and the only technique of localization currently employed is "*unilateral*" spinal analgesia. With this method, a paralysis of somatic and sympathetic nerves of one side of the body is sought. While clinicians describing this technique allude to an associated decrease in morbidity, controlled clinical studies have not been reported where the incidence of hypotension with unilateral spinal analgesia is compared to that of conventional bilateral techniques. Further, since the criteria of unilaterality were clinical, and since objective methods of measuring sympathetic activity were not utilized in the evaluation of these techniques, there are no data to indicate how frequently true sympathetic lateralization was obtained in the series reported.<sup>11-14</sup>

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Accordingly, we undertook a study of one-sided spinal analgesia. This study was concerned primarily with evaluating one method of spinal hemianalgesia.\* We were concerned with providing answers to the following questions:

- (1) Is it possible to administer a hemianalgesic spinal anesthetic so that the loss of sensory, motor and sympathetic function is confined to one side of the body?
- (2) Does the use of hemianalgesia decrease the incidence of hypotension, and is this technique therefore clinically advantageous?

### MATERIAL AND METHODS

**SELECTION OF PATIENTS:** Studies were undertaken in 90 patients requiring spinal analgesia for surgery, and in 2 patients to whom spinal analgesia was administered for diagnostic purposes. Two groups were studied: 50 patients with conventional bilateral spinal anesthesia, and 42 patients under attempted hemispinal analgesia. The former control series will be referred to as group I and the hemispinal series as group II.

Operations in group I consisted of urological, lower abdominal and bilateral lower extremity procedures, while operations in group II were performed on the inguinal, hip or lower limb region of one side.

All patients were seen preoperatively by one author. At that time the patient's physical status was evaluated and they were classified according to the criteria of the American Society of Anesthesiologists.<sup>15</sup>

**PREMEDICATION:** Preoperative sedatives administered within two hours of operation consisted of secobarbital or chloral hydrate; meperidine was administered for preoperative

\* The term spinal hemianalgesia describes a spinal block where sensory, motor and sympathetic effects of the anesthetic are confined to one side of the body.

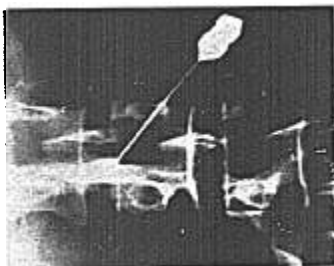
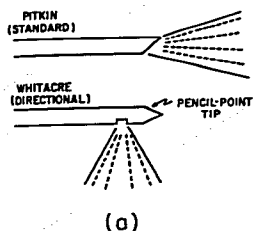


FIG. 1. (a) Spinal needles used in study. (b) Roentgenogram of the lumbar spine (cadaver) showing the directional needle in position for injection. The paramedian approach places the point of the needle near the dependent side of the spinal canal. One milliliter 76 per cent Renograffin has been injected slowly to illustrate one-sided distribution. (The specific gravity of this solution is much higher than 1.022 but no visualization could be obtained after dilution of the dye.)

relief of pain when this was present. Sedation was light in all cases. Belladonna drugs were omitted except in 16 group I patients who received atropine. (Subsequent analysis of our data failed to indicate any influence of this alkaloid on the results.)

An intravenous infusion of 5 per cent dextrose in distilled water was started on all patients when they arrived in the study room. The intravenous fluids were administered throughout the preanesthetic and study periods and during the subsequent operation.

**TECHNIQUES OF SPINAL ANESTHESIA: Group I (Controls).** These spinal anesthetics were administered by anesthesiology residents or by one of us. All punctures were made in the third or fourth lumbar interspace with the patient either sitting or in the lateral position. The patient was placed in the supine position promptly after the subarachnoid injection and the desired level of analgesia as determined by pin prick was obtained by adjusting the tilt of the table. Tetracaine was used in 39 patients while 11 patients received procaine. Twenty milligrams of powdered tetracaine were dissolved in 2.0 cc. of 10 per cent dextrose in water; the desired dose was withdrawn; 2 to 3 mg. of phenylephrine solution (10 per cent) was added and the mixture was diluted with an equal volume of cerebrospinal fluid to give a 0.5 per cent concentration of tetracaine in 5 per cent dextrose.

The volume of solution injected was approximately 2.0 cc. The mean dose of tetracaine was 9 mg. (range 6-14 mg.), with phenylephrine 2.5 mg. When procaine was employed, crystals were dissolved similarly in 10 per cent dextrose, phenylephrine was added and the mixture diluted with cerebrospinal fluid to yield 5 per cent procaine in 5 per cent dextrose solution. The mean dose of procaine was 104 mg. (range 75-130 mg.). Thus a hyperbaric solution was used in all patients in this group.

**Group II (Attempted Hemispinals).** All spinal anesthetics in this group were administered by the senior author. A 20 or 22 gauge Pitkin needle was utilized in 33 patients, and a 20 gauge directional Whitacre needle (fig. 1a), with a Sise introducer, was used in 9 patients.

Two patients received hypobaric 0.1 per cent tetracaine in distilled water and hence were positioned laterally so that the side to be blocked was uppermost. The other 40 patients received a hyperbaric tetracaine solution which was prepared in the same manner as that employed in the control patients. The mean dose of tetracaine was 4.4 mg. (range 2-7 mg.) with phenylephrine 2.3 mg. The volume of solution injected was not more than 1.2 cc. The specific gravity of this solution was found to be 1.022 at 37 C. These patients

were placed in the lateral position so that the side to be blocked was dependent.

The table was arranged so that the spine was horizontal at all times. The spine was flexed in the usual manner with the head resting on a small pillow. The patient was asked to cough and clear the throat and then to relax, breathe quietly, and not to lift his head or strain. Each step of the procedure was explained carefully to the patient.

For patients receiving the hyperbaric tetracaine an upper paramedian approach was made through the third or fourth lumbar interspace, and the spinal needle guided so that the tip lay in the dependent portion of the spinal canal (fig. 1b). After a free flow of fluid had been obtained in all quadrants the bevel of the needle was rotated toward the dependent side and the solution slowly and steadily injected. The time required for injection was never less than two minutes. The needle was usually withdrawn immediately after injection. However, on occasion, the needle was left in place for several minutes so that additional solution might be added if needed to achieve the necessary height of analgesia. The lateral position was maintained for 30 minutes after which time the patient was turned supine. Movement by the patient was discouraged during maintenance of the lateral position.

Recordings of skin temperatures or skin resistances (see below) were made prior to injection and were continued for at least 15 minutes after the supine position had been assumed. The approximate study time prior to operation was 50 minutes.

**MEASUREMENTS:** Pulse and blood pressure data were recorded several times before the spinal was administered. After injection of the anesthetic they were recorded every three minutes for 30 minutes and every five minutes thereafter. Blood pressure readings were auscultatory using a 12 cm. cuff on the upper arm; auscultatory criteria were those of the American Heart Association.<sup>18</sup>

The level of sensory loss was determined by pin prick 30 minutes after administration of the agent and, in group II, redetermined 10 minutes after turning the patient supine. Dermatomal levels were those of Keegan.<sup>17</sup>

Paralysis of muscle groups was utilized as an index of motor function loss.

Sympathetic nerve function was studied in all individuals in group II and in a few selected patients in group I. Two established methods were used in assessing sympathetic activity; *skin resistance* and *skin temperature* determinations.

On 11 patients skin resistance measurements were made using the technique of Richter.<sup>18</sup> For this purpose a microammeter (dermometer) with a voltage range of 2 to 8 volts, a variable resistance range to 2000 ohms, with lead electrodes was utilized. † The patient was placed in a tent at 46-48 C. for approximately 20 minutes to evoke active perspiration. Measurements were made before and 30 minutes after administration of the spinal anesthetic. The data obtained were charted to outline the area of the body showing loss of sudomotor activity. This has been shown to correspond to the loss of sympathetic nerve function.<sup>18, 19</sup>

On 31 patients skin temperature changes were measured.<sup>20-23</sup> A Speedomax (Leeds Northrop) recorder (115 volts, 50-60 cycles per sec.) with 6 iron-constantan thermocouples as leads was used. The leads were attached to the plantar surface of the first and fourth toes of each foot, the finger of one hand, and the sixth lead was left free to record room temperature. Readings were automatically and sequentially recorded in degrees centigrade at 30 second intervals. The studies of skin temperature were carried out in an induction room where the environmental temperature remained constant within 0.5 degree centigrade during any one study. The room temperature was never less than 20 C. or more than 24 C. and the relative humidity ranged between 50 and 60 per cent. While constancy of temperature and humidity did not approach that found in a constant temperature room, the environmental conditions were adequate for our purposes. The patient, with only the abdomen and chest covered by a single cotton sheet rested in the induction room approximately one hour before the anesthetic was given.

† We wish to express appreciation to E. Baaken, B.E.E., Medtronic Laboratories, Minneapolis, Minnesota, for his assistance in constructing the instrument.

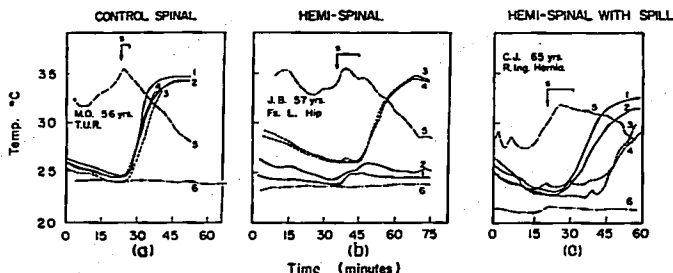


FIG. 2. Skin temperature changes following spinal anesthesia. Leads 1 and 2 sense skin temperature of right foot; leads 3 and 4 sense skin temperature of left foot; lead 5 senses skin temperature of hand; lead 6 measures room temperature. (a) Control: The temperatures in both feet rise rapidly 4 minutes following the spinal injection, to a maximum of 34 C. The hand temperature (lead 5) falls during this time probably as a result of compensatory vasoconstriction. (b) Hemispinal: The temperatures in the left foot rise 9 minutes following the spinal injection to reach 34 C., while the right foot remains at equilibration temperature over a 40 minute observation period. The hand temperature again decreases following the spinal anesthetic. (c) Hemispinal with Spill: The temperatures in the right foot rise 10 minutes following the spinal injection. The temperatures of the left foot show a similar rise occurring 15 minutes after the temperature changes on the right side. The hand temperature once more falls as the temperature of the lower limbs rises.

The skin of the exposed arms and legs thus came close to equilibrium with the room temperature before the anesthetic was administered.

Among the 31 patients (group II) studied by the skin temperature method, 6 failed to show temperature changes following the anesthetic probably as a consequence of obliterative vascular disease. These 6 patients showed motor or sensory evidence of contralateral spread and were therefore classified as unsuccessful hemispinal anesthetics. One patient who had been sympathectomized on the dependent side 4 years previously failed to show a temperature rise on this side following the spinal anesthetic. Since a temperature change or sensory loss was not observed on the non-sympathectomized side this patient was considered to have experienced a true hemispinal.

**ANESTHETIC COURSE AND MANAGEMENT:** Hypotension was considered a be a consequence of the spinal anesthetic when it occurred within 60 minutes of the administration of the anesthetic. A decrease in systolic pressure of 25 per cent or greater occurring within this time period was considered significant. These criteria have been utilized by others.<sup>24, 25</sup>

Treatment of the hypotension consisted of the intravenous injection of atropine and graded doses of metaraminol or methoxamine until the blood pressure was restored. In addition, a modified Trendelenberg position and oxygen by mask were used as necessary.

Supplements required for inadequate analgesia during the operation were noted. These usually consisted of infiltration of local anesthetics, intravenous injections of meperidine or nitrous oxide-oxygen administered by mask.

Recovery time was arbitrarily defined as the time movement returned to the foot, knee and hip of the paralyzed limb(s). Sensory block usually persisted for a longer period.

Statistical evaluation of the data was made by the chi-square method. A test for the significance of proportions was also carried out on the data in table 3. All *P* values less than 0.05 were considered significant.

#### OBSERVATIONS AND RESULTS

Specimen skin temperature plots and skin resistance changes are seen in figures 2 and 3. The data are summarized in tables 1-5.

Table 1 outlines the incidence of success in obtaining true hemispinal analgesia in group II. In 33 attempts with the Pitkin needle, 10

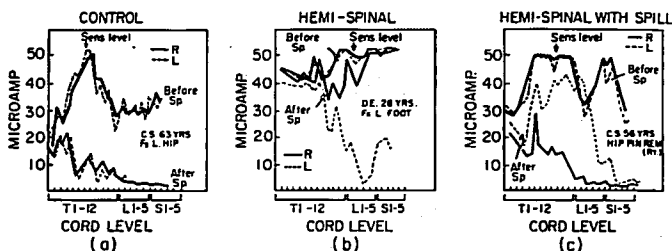


FIG. 3. Skin resistance before and following spinal anesthesia (heat stimulus used). Arrow indicates sensory level of spinal anesthesia as determined by pin-prick. Right side—solid line, left side—broken line. (a) Control: The sensory level is at T8, and diminished current flows (increased resistances) are seen at all levels below T3 bilaterally. (b) Hemispinal: The sensory level is at L1. Following spinal anesthesia the current flows on the right are similar to the pre-spinal values while on the left side (below T11) they are decreased (resistances increased) after the spinal. (c) Hemispinal with Spill: The sensory level is at T8. Between T8 and L2 the current flows diverge while below L2 they once more converge. Spill has occurred on the left below L2, so that current flows are bilaterally reduced (resistances increased) below this level.

were successful clinically and by skin temperature measurement or skin resistance recordings. There was thus a 30 per cent incidence of success with the conventional needle. Attempts using the directional needle resulted in 6 successful hemispinal anesthetics in 9 patients, or 67 per cent success. For both needles the over-all success was 38 per cent. Statistically the directional needle was associated with a significantly greater degree of success ( $P < 0.03$ ).

Table 2 shows the over-all incidence of hypotension in groups I and II. The incidence was greater in the control group (34 per cent) than in the hemispinal group (19 per cent).

TABLE 1  
INCIDENCE OF SUCCESSFUL UNILATERAL SPINALS

Needle and Method of Evaluation	Hemispinals		
	No. Attempts	No. of Successes	Success Per Cent
Pitkin (skin temperature)	33	10	30*
Pitkin (skin resistance)	22	7	32
Whitacre (skin temperature)	11	3	27
Total	42	16	38

\*  $P < 0.03$ .

TABLE 2  
OVER-ALL INCIDENCE OF HYPOTENSION\*

Group	No. Patients	Mean Age (Years)	Incidence of Hypertension	
			Number	Per Cent
I	50	64	17	34
II	42	63	8	19
True Hemisp.	16	55	1	6
Spills	26	66	7	27

\* No statistical analysis (see text).

In the latter group the incidence was greater in hemispinal anesthetics with spill † (27 per cent) than in those where successful lateralization occurred (8 per cent). However, since age, physical status and level of anesthesia also influence the frequency of hypotension, these must be considered before a statistical analysis of the data can be attempted.

Table 3 shows the relationship of height of analgesia to the incidence of hypotension in both groups. Fifty-eight per cent of control patients (group I) with sensory levels at the seventh thoracic dermatome or higher, experienced hypotensive episodes while in the same

† An unsuccessful hemispinal anesthetic showing at least sympathetic involvement of the contralateral side.

group 26 per cent developed hypotension when the sensory level was *below* the seventh thoracic dermatome. In the hemispinal series (group II) 57 per cent of patients had hypotension when the sensory level was at the seventh thoracic dermatome or higher, while *below* this level the incidence was 11.4 per cent. Although there were some age differences in the subgroups the hemispinal technique appeared to influence the incidence of hypotension *only* when the sensory level was *below* the seventh thoracic dermatome.

In table 4 the data for physical status class 2 and class 3 patients are tabulated separately. There were 42 class 2 patients and 32 class 3 patients. The mean age difference between the two classes was 6 years. When the sensory level was *below* the seventh thoracic dermatome class 2 patients of the control group had a 13 per cent incidence of hypotension while class 3 patients of the same group had a 50 per cent incidence of blood pressure fall. This is a significantly higher morbidity ( $P < 0.04$ ), and suggests that pre-operative physical status contributed to hypotension associated with spinal analgesia. Consideration of the class 2 patients showed that spinal analgesia extending *above* the seventh thoracic dermatome was associated with a high incidence of hypotension in both groups I and II. (This is not unexpected since we were unable to produce a true hemispinal analgesia at these higher levels.) In the class 2 patients, with levels of analgesia *below* the seventh thoracic dermatome the incidence

TABLE 3

INFLUENCE OF HEIGHT OF ANALGESIA ON INCIDENCE OF HYPOTENSION

Group	Height (Sensory)	Patients Number	Mean Age (Years)	Incidence of Hypotension	
				Number	Per Cent
I	T7 and above	12	58	7	58
	Below T7	38	66	10	26*
II	T7 and above	7	70	4	57
	Below T7	35	60	4	11.4*
Total		92		25	

\* Chi-square  $0.05 < P < 0.10$ .

\* Proportions test  $P < 0.05$ .

TABLE 4

A.S.A. CLASS, HEIGHT OF SPINAL, AGE, AND INCIDENCE OF HYPOTENSION

Group	Height of Spinal	No. Patients	Mean Age (Years)	Incidence of Hypotension	
				Number	Per Cent
Class 2	I T7 and above	6	65	4	67
	II T7 and above	5	73	4	80
Class 3	I Below T7	15	65	2	13†
	II Below T7	16	59	2	12
Class 3	I T7 and above	2	73	2	100
	II T7 and above	1	(62)	—	—
Class 3	I Below T7	18	72	9	50†*
	II Below T7	11	71	2	18*

\*  $P < 0.03$ .

†  $P < 0.04$ .

of hypotension was almost identical in both groups (13 per cent and 12 per cent). Class 3 patients of both groups were of comparable age. *Below* the seventh thoracic dermatome the control patients showed a 50 per cent incidence of hypotension while the hemispinal patients had an 18 per cent incidence of hypotension. This difference is significant ( $P < 0.03$ ). It appeared that where factors of age and sensory level of analgesia were approximately the same, hemispinal analgesia was associated with a significantly decreased incidence of hypotension in the poorer risk patients. With the hemispinal technique the incidence of hypotension in class 3 patients (18 per cent) was comparable to that observed among the better risk class 2 patients (12 per cent).

Table 5 contains the data on all the patients where the sensory level was *below* the seventh thoracic segment. None of the class 1 patients of either group had hypotension. In class 2 patients hypotension occurred in 13 per cent of the controls, in 10 per cent of the patients with true hemispinal analgesia and in 17 per cent of the patients who exhibited hemispinal analgesia with spill. Statistically the differences were not significant. In class 3 patients (group II), however, where only 2 hemispinal analgesias were successful and 9 were spills, the incidence of hypotension remained significantly reduced ( $P < 0.04$ ) even with the

TABLE 5

GROUP I AND II PATIENTS WITH SENSORY LEVELS BELOW T7 AND INCIDENCE OF HYPOTENSION

	Class 1		Class 2		Class 3	
	No. Patients	Mean Age (Years)	No. Patients	Mean Age (Years)	No. Patients	Mean Age (Years)
True Hemispinals Hypotension	4 0	37	10 1 (10%)	57	2 0	60
Hemispinal spills Hypotension	4 0	51	6 1 (17%)	63	9 2 (22%)*	73
Controls Hypotension	6 0	49	15 2 (13%)†	66	18 9 (50%)*†	72

† \*  $P < 0.04$ .

true hemispinal analgesias excluded from the analysis.

Hypotension occurred earlier in the control group than in the hemispinal analgesia group (fig. 4). In the 17 control patients who developed hypotension it occurred at a mean time of 23 minutes (S.D. = 11.9) after the injection of the spinal anesthetic. In the 8 patients with hemispinal analgesia who developed hypotension it occurred at a mean time of 38 minutes (S.D. = 12.1) after administration. This 15-minute difference in mean time of onset of hypotension was significant ( $P < 0.03$ ). The interval of 15 minutes was approximately of the same magnitude as the mean time when spill occurred to the contralateral leg (11.4 minutes) and suggested that hypotension in the patient with hemispinal analgesia occurred

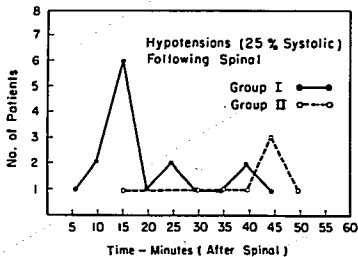


FIG. 4. Chart showing the number of hypotensive episodes in groups I and II, and their time of onset following the administration of spinal analgesia.

after the local anesthetic agent had diffused to block the sympathetic nerves to both limbs.

The incidence of hypotension appeared to be correlated with age. However, the highest frequency of hypotension was observed in the eighth decade. This decade had proportionately more class 3 patients (20 out of 32 class 3 patients), and it is possible that the high incidence of hypotension is related more to physical status than age.

Patients were classified as normotensive or hypertensive according to the criteria of Master *et al.*<sup>28</sup> Preoperative hypertension was found in 13 of the 92 patients studied. Based on percentage of decrease of the incidence of hypotension was not significantly greater in patients with pre-existing hypertension. In this series hypertension *per se* did not appear to predispose to hypotension following spinal analgesia. This has also been observed by Pugh and Wyndham.<sup>29</sup>

Patients demonstrating hemispinal spill showed an earlier recovery of sympathetic function on the spill side. An example of this is shown in the skin temperature chart of one patient (fig. 5).

The average duration of analgesia in group II was 3 hours and 30 minutes while in group I the average duration observed was 3 hours and 50 minutes. The dosage of tetracaine administered to patients in group II was approximately one-half of that used in group I patients.

Analgesia in the patients in the hemispinal series was satisfactory in 35 of 42 cases (83

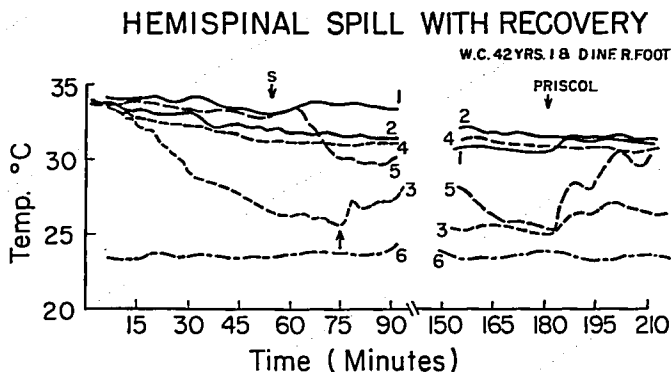


FIG. 5. Temperature changes after hemispinal for drainage of an infected right heel in a diabetic patient. Leads 1 and 2 (right foot) indicate a maximal inflammatory dilatation and no change is observed following the spinal anesthetic. Lead 3 (left foot) shows a rise in temperature due to spill (lower arrow), 22 minutes after administration of the hemispinal. After one hour in surgery the temperature in lead 3 has returned to basal level. A rise in temperature is observed in this lead after intravenous administration of 25 mg. Priscoline as well as an accompanying dilatation in the hand (lead 5). Lead 4 (left foot) shows dilatation throughout the whole study period, presumably due to local inflammation in this toe.

per cent). Failures were due to initial inadequate sensory level or insufficient duration of anesthesia. Since the study period was approximately one hour in duration the time available for operation was shortened. The percentage of satisfactory hemispinal analgesia was similar to that seen when the conventional bilateral techniques were utilized. There was no mortality among the group II (hemispinal) patients. One death occurred in the control group. A 75 year old man underwent a transurethral prostatic resection under spinal anesthesia. Analgesia was obtained to the ninth thoracic dermatome. The systolic blood pressure fell from 150 to 90 mm. of mercury 15 minutes after the spinal was administered. He was treated with oxygen by mask, atropine (0.6 mg.) and methoxamine (2 mg.) intravenously, and responded satisfactorily. No further incident occurred during the operation but twelve hours afterward he developed shock and died after two hours. At autopsy a massive acute infarction of the left ventricle was found as well as scars of an old infarction.

#### DISCUSSION

The problem of hypotension in spinal analgesia has been extensively investigated and has been reviewed recently by Greene.<sup>20</sup> There is general agreement that its incidence is closely related to the extent of sympathetic paralysis. Spinal anesthetics with a sensory level higher than the fifth thoracic dermatome are associated with a 70-80 per cent incidence of hypotension whereas those between the fifth and tenth thoracic dermatomes have a 60-70 per cent incidence of hypotension; those below the tenth thoracic segment have a 25-40 per cent incidence of blood pressure fall.<sup>6, 21, 21-24</sup> The incidence of hypotension in our control group corresponded well with the foregoing data. A 58 per cent incidence of hypotension was observed when the sensory level was at or above the seventh thoracic dermatome and a 26 per cent incidence occurred below this level. It is apparent that even low spinal anesthetics have a considerable incidence of hypotension.

Numerous reports indicate that hypotension in aged patients results in greater morbidity



and mortality. Beecher and Todd<sup>23</sup> reported 19 deaths associated with spinal anesthetics in senile, previously hypertensive, hypovolemic patients. Others<sup>24, 25, 26</sup> have described refractory hypotension in similar patients. Cerebral and coronary blood flow is decreased<sup>27, 28</sup> and there is an increased danger of pulmonary embolism and thrombosis.<sup>29, 30</sup> Several authors<sup>40-42</sup> reporting on the incidence of myocardial infarction during operation emphasize the association of hypotension with this complication. In the single death in the control group (see results), we assumed that the hypotensive episode contributed to, if it did not actually cause the acute infarction. While the nature of the operation in this instance precluded the use of hemispinal analgesia, the incident illustrates the hazards of hypotension in elderly patients.

Owens and Smith<sup>39</sup> state that "bilateral sympathetic blocks, or their equivalent, should not be done on the aged, sclerotic patients." Since a conventional spinal anesthetic results in a bilateral sympathetic blockade any modification which would effectively reduce this bilaterality seems desirable.

Our data suggest the following: if the sensory level of spinal analgesia is high (above the seventh thoracic segment) the incidence of hypotension is high and is not particularly dependent on the pre-existing physical state of the patient (that state, however, may determine the nature and gravity of sequelae of the hypotensive episode). Below this level the incidence of hypotension appears to be a function of the preanesthetic physical state. Thus, when the sensory level was below the seventh thoracic dermatome none of the physical status class 1 patients of either group experienced hypotension; an equal incidence of hypotension occurred in class 2 patients of both groups, while in class 3 patients the incidence was greater in both groups. In this latter class, the hemispinal technique significantly reduced the incidence of hypotension ( $P < 0.03$ ). Even a spill hemispinal anesthetic appeared to provide some protection in the class 3, poor risk patients ( $P < 0.04$ ). In effect the use of the hemispinal technique in this class of patients resulted in an incidence of hypotension not unlike that seen in class 2 patients (tables 4 and 5). This effect is perhaps related to the

later time of onset of hypotension in group II since the hypotension in this group occurred significantly ( $P < 0.03$ ) later than that in the control group. With a spill more time is available for compensatory vascular adjustments to take place, thus helping to maintain circulatory homeostasis.

With the hemianalgesic technique the dose of tetracaine is reduced to approximately one-half of that in the controls for a comparable duration of analgesia. Such small doses of agent are obligatory when attempting to confine the anesthetic to one side. In this regard it might be noted that unilateral techniques which have been described<sup>11, 12, 14</sup> previously probably were not associated with complete lateralization. The relatively high doses of agents used by these authors<sup>11, 12, 14</sup> makes it doubtful that one-sided sympathetic localization was obtained. It has been our experience that unless the dose of agent is small and the spine of the patient is horizontal during the administration and "fixation" period, a spill will occur.

A 30-minute interval appeared essential for "fixation" of tetracaine. If the patient was turned supine before this period both contralateral and cephalad spread occurred. This was evident after several trials of turning the patient supine 10 and 20 minutes after the injection. Harris<sup>44</sup> has similarly observed that 30 minutes is required for "fixation" of hyperbaric solutions.

The initial placement of the heavy solution is important. A directional  $\frac{1}{2}$  needle facilitates deposition of the agents at the site desired and in our series was twice as successful as conventional spinal needle.

The method is technically simple and easy to perform. There is no deviation from the usual site of spinal puncture; the standard mixture of hyperbaric tetracaine solution is employed. It should be emphasized that this is a technique primarily for low spinal analgesia. The mean sensory level obtained in the 42 cases described was the ninth thoracic dermatome. Attempts to raise this level usually resulted in a spill. Volume of solution

§ Since completion of this study we have been using a 22 gauge Rovenstine directional needle. This directional needle has a cutting edge tip and can be passed without the aid of an introducer. It is thus currently preferred to the pencil point directional needle used in this study.

rate of injection and horizontal positioning of the patient must be meticulously observed, and good patient cooperation is essential. When diffusion to the other side occurs it may be manifested only as a subjective numbness; however, this is adequate to produce sympathetic nerve paralysis to the contralateral limb.

The major disadvantage of the technique is the 30-minute post-injection waiting period with the patient in the lateral position. In addition, spills may occur despite attention to the details previously described. Of the three spills which occurred when the directional needle was used, two were a consequence of the needle being placed in the upper side of the spinal canal. Lumbar puncture was difficult in these two patients and when entry was made into the spinal canal radicular pain was experienced in the upper leg. Although the pain did not recur upon injection of the solution, the skin temperature reading showed evidence of spill within 4 minutes of injection, and it is presumed that during injection the solution bathed the nerve roots to the upper leg. The third spill occurred in a patient with marked scoliosis of the lumbar spine. There is also some anatomical evidence which suggests unilateral deposition in the subarachnoid space may occasionally be difficult. Dogliotti<sup>2</sup> described how the long nerve roots of the cauda equina sink to the dependent side when the body is in the lateral position. This would make it difficult to deposit the anesthetic solution around the nerve roots of only one side and may be a factor in the production of spills.

#### SUMMARY AND CONCLUSIONS

In order to determine the feasibility and applicability of hemispinal analgesia studies were undertaken in 42 patients submitted to this form of anesthesia; parallel studies were conducted in 50 control patients undergoing conventional bilateral spinal anesthesia. In the hemispinal group activity of the sympathetic nervous system was assessed by skin temperature or skin resistance measurements; preservation of this activity on the contralateral side was utilized to demonstrate actual lateralization of the anesthetic. Directional and non-directional spinal needles were used in the hemispinal group in order to assess their influence upon ease of lateralization. The inci-

dence and time of onset of hypotension was compared in the control and hemispinal groups. Incidence of hypotension was also correlated with the preoperative physical state, age of the patient and the spinal anesthetic sensory level attained.

True spinal hemianalgesia was obtained in 30 per cent of patients when a standard (Pitkin) needle was used and in 67 per cent of patients when a directional (Whitacre) needle was used. The hemianalgesic technique appeared to influence the incidence of hypotension only when the level of sensory analgesia was below the seventh thoracic dermatome. Spinal hemianalgesia was associated with a statistically significant decrease in the incidence of hypotension in patients of poor physical status (A.S.A., Class 3) even when complete lateralization was not maintained. The onset of hypotension after the administration of the hemispinal anesthetic occurred significantly later in time when compared to the onset after the conventional spinal anesthetic.

Spinal hemianalgesia provided satisfactory anesthesia in over 80 per cent of the operations performed with this technique. In poor risk patients this method appears preferable to the conventional spinal technique for surgery of the hip, inguinal or lower extremity regions.

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#### REFERENCES

1. Jonnesco, T.: Remarks on general spinal analgesia, *Brit. Med. J.* 2: 1935, 1909.
2. Borica, J. J.: Management of Pain. Philadelphia, Lea & Febiger, 1953, Ch. 11.
3. Dogliotti, A. M.: Anesthesia, Narcosis, Local, Regional, Spinal. Chicago, S. B. Debour, 1939, Ch. 10.
4. Kirschner, M.: Experiments in securing girdle-formed spinal anesthesia, *Surg. Gynec. Obstet.* 55: 317, 1932.
5. Pitkin, G. R.: Controllable spinal anesthesia, *J. Med. Soc. New Jersey* 24: 425, 1927.
6. Pitkin, G. R. P.: Conduction Anesthesia, ed. 2. Philadelphia, J. B. Lippincott Co., 1953, Ch. 18.
7. Brown, S.: Fractional segmental spinal anesthesia in poor risk surgical patients; report of 600 cases, *ANESTHESIOLOGY* 13: 416, 1952.

8. Hubbard, S. T., Jr., Schneider, G. F., and Kenney, L. J.: High segmental spinal anesthesia, *J. Thor. Surg.* 20: 43, 1950.
9. Saklad, M., Dwyer, C. S., Kronenberg, S., Neves, E., and Sorkin, M.: Intraspinal segmental anesthesia; preliminary report, *ANESTHESIOLOGY* 8: 270, 1947.
10. Tuohy, E. B.: Continuous spinal anesthesia, *ANESTHESIOLOGY* 5: 142, 1944.
11. Hander, H. T.: Unilaterale lumbale spinale Anesthetie mit hyperbarer Lösung, *Anaesthetist* 5: 145, 1959.
12. Lund, P. C., and Rumball, A. C.: Hypobaric pontocaine, new technic in spinal anesthesia, *ANESTHESIOLOGY* 8: 181, 1947.
13. Smith, S. M., and Rees, V. L.: Use of prolonged continuous spinal anesthesia to relieve vasospasm and pain in peripheral embolism, *ANESTHESIOLOGY* 9: 229, 1948.
14. Snyder, J. J.: Hypobaric spinal anesthesia: review of literature and some clinical observations, *ANESTHESIOLOGY* 12: 301, 1951.
15. Saklad, M., and Sellman, P.: Statistical systems in anesthesiology, *ANESTHESIOLOGY* 7: 146, 1946.
16. Barker, M. H., and others: Report by the committee for standards of blood pressure recording of the American Heart Association, *J. A. M. A.* 113: 294, 1939.
17. Keegan, J. J.: Segmental distribution of cutaneous nerves in limbs of man, *Anat. Rec.* 102: 409, 1948.
18. Richter, C. P.: Nervous control of electrical resistance of the skin, *Amer. J. Physiol.* 88: 592, 1929.
19. Tower, S. S., and Richter, C. P.: Injury and repair in sympathetic nervous system, *Arch. Neurol. & Psychiat.* 28: 485; 1139, 1931 and 1932.
20. Morton, J. J., and Scott, W. J. M.: Methods of estimating degree of sympathetic vasoconstriction in peripheral vascular disease, *New Engl. J. Med.* 204: 955, 1931.
21. Cranley, J. J., Jr., Buchanan, J. L., Simeone, F. A., and Linton, R. R.: Critique of laboratory methods in peripheral vascular disease, *Surgery* 31: 74, 1952.
22. Burton, A. C.: *Methods of Medical Research*, vol. 1. Chicago, Year Book Publishers, 1948, Section II.
23. Brill, S., and Lawrence, L. B.: Changes in temperature of lower extremities following induction of spinal anesthesia, *Proc. Soc. Exp. Biol. Med.* 27: 728, 1930.
24. Dripps, R. D., and Deming, M.: Evaluation of certain drugs used to maintain blood pressure during anesthesia, *Surg. Gynec. Obstet.* 83: 312, 1946.
25. Dripps, R. D., Eckenhoff, J. E., and Vandam, L. D.: *Introduction to Anesthesia*. Philadelphia, W. B. Saunders Co., 1957, Ch. 20.
26. DeBakey, M. E., Burch, C., Ray, T., and Ochsner, A.: Borrowing-lending hemodynamic phenomenon and its therapeutic application to peripheral vascular disturbances, *Ann. Surg.* 126: 850, 1947.
27. Neumann, C., Foster, A. N., Jr., and Roventine, E. A.: Importance of compensating vasoconstriction in unanesthetized areas in maintenance of blood pressure during spinal anesthesia, *J. Clin. Invest.* 24: 345, 1945.
28. Master, A. M., Garfield, C. I., and Walters, M. B.: Normal Blood Pressure and Hypertension. Philadelphia, Lea & Febiger, 1953.
29. Pugh, L. G. C., and Wyndham, C. L.: Circulatory effects of high spinal anesthesia in hypertensive and control patients, *Clin. Sci.* 9: 189, 1950.
30. Greene, N. M.: *Physiology of Spinal Anesthesia*. Baltimore, Williams & Wilkins Co., 1958, Ch. 2.
31. Andros, G. J., and Priddle, H. D.: Saddle block anesthesia at Chicago Lying-In Hospital, *Anesth. Analg.* 29: 330, 1950.
32. Papper, E. M., Bradley, S. E., and Roventine, E. A.: Circulatory adjustments during high spinal anesthesia, *J. A. M. A.* 121: 27, 1943.
33. Sancetta, S. M., Lynn, R. B., Simeone, F. A., and Scott, R. W.: Studies of hemodynamic changes in humans following induction of low and high spinal anesthesia, *Circulation* 6: 559, 1952.
34. Smith, H. W., Roventine, E. A., Goldring, W., Chasis, H., and Ranges, H. A.: Effects of spinal anesthesia on circulation in normal unoperated man with reference to the autonomy of arterioles, and especially those of the renal circulation, *J. Clin. Invest.* 18: 319, 1939.
35. Beecher, H. K., and Todd, D. P.: Study of deaths associated with anesthesia and surgery, *Ann. Surg.* 140: 2, 1954.
36. Soffer, A., and Sweet, R.: Effect of position changes of lower extremities during vaso-motor block, *J. A. M. A.* 151: 1191, 1953.
37. Loman, J., Dameshek, W., Myerson, A., and Goldman, D.: Effect of alterations of posture on intra-arterial blood pressure in man, *Arch. Neurol. Psychiat.* 35: 1216, 1936.
38. VanBergen, F. H., Buckley, J. J., French, L. A., Dobkin, A. B., and Brown, I. A.: Physiologic alterations associated with hexamethonium-induced hypotension, *ANESTHESIOLOGY* 15: 507, 1954.
39. Owens, J. C., and Smith, A. J.: Fatal pulmonary embolism following regional anesthesia, *Angiology* 4: 23, 1953.
40. Feruglio, G., Bellet, S., and Stone, H.: Post-operative myocardial infarction: 35 cases, *A. M. A. Arch. Int. Med.* 102: 345, 1958.
41. Wasserman, F., Bellet, A., and Saichek, R. P.: Post-operative myocardial infarction: 25 cases, *New Engl. J. Med.* 252: 967, 1955.

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42. Hayward, G. W.: Anesthesia and cardiac patient, *Anesthesia* 7: 67, 1952.
43. Little, D. M., Jr.: Controlled Hypotension in Anesthesia and Surgery. Springfield, Illinois, Charles C Thomas, Publishers, 1958, Ch. 11.
44. Harris, T. A. B.: Mode of Action of Anesthetics. Edinburgh, E. & S. Livingstone, Ltd., 1951, Ch. 18.
45. Sarnoff, S. J., and Rovenstine, E. A.: Utility of directional needle in spinal anesthesia, *New York J. Med.* 45: 286, 1945.

**PHENOL NERVE BLOCK** Phenol may cause a completely reversible or an irreversible block of nervous conduction in myelinated and unmyelinated nerve fibers depending upon its concentration, length of time for which it acts, and the solvent in which it is dissolved. The order in which the fiber groups are blocked is the same as that for local anesthetics, small fibers before large fibers. The action of phenol is the same whether it is dissolved in water, iodophenylundecylate (Myodil) or glycerol. Since dilute solutions of aqueous phenol are as active as concentrated solutions in Myodil or glycerol, and as the solvents themselves have no effect on conduction, one must assume that to affect conduction the phenol surrounding the nerve fibers must be in aqueous solution. The effect of the solvent is probably to determine the rate of liberation of phenol. It is fortunate that phenol has both temporary and permanent blocking effects for this permits it to destroy nerve fibers, having blocked their conduction; thus it achieves their destruction without causing pain. (Nathan, P. W., and Sears, T. A.: *Effects of Phenol on Nervous Conduction*, *J. Physiol.* 150: 565 (March) 1960.)

**EPIDURAL ANESTHESIA** Beginning in 1956 epidural anesthesia has been used increasingly both for vaginal deliveries and Caesarian sections at the new Mt. Sinai Hospital, Toronto, Ontario. In 9,000 obstetric cases there were no mortalities; total spinal

anesthesia occurred three times without complications. Convulsions occurred three times and were easily controlled. The over-all fetal loss fell from 2.8 per cent to 2.4 per cent. The technique has been extended to many gynecological procedures. Both types of cases receive 18 cc. of 2 per cent xylocaine by single shot technique. The continuous catheter technique is used for longer cases. Obstetric and anesthetic staffs are extremely enthusiastic about this technique. (Norris, S., Harris, L. J., and Eisen, S. M.: *Epidural Anesthesia in Obstetrics and Gynecology*, *Obst. & Gynec.* 16: 15 (July) 1960.)

**POSTSPINAL HEADACHE** During a two-year study period 235 spinal anesthetics were administered (usually with a 20 gauge needle), with a 17 per cent incidence of headaches. Patients receiving an intravenous infusion following delivery had approximately two and one half times fewer headaches than those not receiving the infusion. Patients with headaches who were treated with the "Pitressin Regimen" obtained relief from their headaches. The authors believe that Pitressin causes an antidiuresis which results in a compartmental shift of fluid from the vascular space to the cerebral spinal fluid space. The only adverse reaction seen on this regimen was the transient hypertension significant in only four of the patients. (Zuspan, F. P.: *Treatment of Postpartum Postspinal Headache*, *Obst. & Gynec.* 16: 21 (July) 1960.)