

HYPOBARIC SPINAL ANESTHESIA: A REVIEW OF THE LITERATURE AND SOME CLINICAL OBSERVATIONS *

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HYPOBARIC solutions for spinal anesthesia were apparently first used by Babcock in 1904 (1). It was not until 1927, however, when Pitkin introduced "spinocaine," a hypobaric procaine solution, that this type of anesthesia received attention. At that time he claimed a new degree of controllability and increased safety with this method of spinal anesthesia (2, 3).

The two most important factors affecting the spread of an anesthetic solution within the subarachnoid space are barbotage and convection by gravity. Diffusion and cerebrospinal circulation are both so slow or sluggish as to have no appreciable effect. In fact Adriani said that there is no circulation of the cerebrospinal fluid (4). Barbotage itself is difficult if not impossible to control and is mentioned only to be condemned. Convection by gravity, on the other hand, which is governed by difference in gravity between the injected solution and that of the spinal fluid and also the position of the spinal canal, can be accurately controlled and for this reason is the safest and most scientific method at the present time of controlling the height and spread of spinal anesthesia.

Hyperbaric solutions have been used extensively, but several advantages of the hypobaric technic make it desirable in certain instances. The need for changing the position of the patient is eliminated or minimized in certain types of surgical procedures. Also, considerable time can be saved when patients require operations on the dorsal aspects of the body. It is to be remembered that with heavy solutions the posterior sensory nerves must first be fixed by the anesthetic agent before the patient can be placed in the prone position. It is believed that the need for analeptics is less when hypobaric technics are used. Nausea and vomiting attributable to the anesthesia occur infrequently if at all. My observations tend to bear out these findings. The respiratory excursions are only slightly decreased probably because sensory analgesia extends two to four segments higher than the motor

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block, a factor that decreases the risk of high spinal anesthesia. Complete block of all sensory nerve roots produces no immediate alarming constitutional effects so far as is known (5). It has been said that, with the hypobaric technic, smaller doses of pontocaine can be used than when the drug is employed alone or with hyperbaric solutions. It has been my practice, however, to employ comparable amounts of the agent, and satisfactory results have been obtained. It is also reported that anesthesia is induced much more rapidly, requiring only two to three minutes. This is attributed to warming the anesthetic solution before injection. I have not found this to be uniformly true. In many instances there appeared to have been a greater interval than that usually anticipated between the time of administering the drug and the onset of analgesia.

Nupercaine, a synthetic quinoline derivative, was introduced for spinal anesthesia by Howard Jones in 1930 (6, 7) and again reported in 1934 (8). It is the most potent of all spinal anesthetic agents. When using hypobaric solutions Jones recommended that the patient be placed in the ventral decubitus position so that the anesthetic agent comes into contact with the posterior or sensory nerve roots. It was found that if this were not done sensory anesthesia was often incomplete. To use the technic introduced by Howard Jones, the patient is placed in the lateral position with the affected side uppermost, the incline of the table depending on the desired height of anesthesia. With this method the height of anesthesia can be accurately controlled and smaller doses of the anesthetic drug seem to be sufficient. Absolute unilateral anesthesia does not result, but is more closely approached than with other technics. The necessity of turning the patient is eliminated in many instances. In his original descriptions Jones recommended that the bevel of the needle be turned in the direction anesthesia was desired. It is questionable whether this device plays an important role in this respect.

Etherington-Wilson (9), in a "mock spinal anesthesia," used glass tubes of different calibers and curves filled with a solution of the same specific gravity as spinal fluid, which was regarded at that time as 1.007 (10). Later studies, however, indicate that cerebrospinal fluid has a constant specific gravity of 1.003 to 1.004 at body temperature (11). Such a simulacrum was held in the upright position and an injection of nupercaine solution, specific gravity 1.003, colored with methylene blue, was made through a side opening in the glass tube, both fluids being of the same temperature. The rise of the lighter fluid was timed and found to be constant. The lighter fluid mixes most evenly in the canal during its ascent when the canal is vertical. It rises steadily and slowly, getting more sluggish in the higher reaches because "it is mixing every centimeter of the way" with the heavier fluid. When the tube is at an angle, ascent of the lighter fluid is much more rapid than when it is vertical, and the drug concentrates along

the upper longitudinal parts of the canal. From careful measurements it was found that three main zones of analgesia could be obtained. The dose of nupercaine and times suitable for these zones of analgesia are shown in table 1.

In 1936 (12) and again in 1942 (13) Bourne et al., reported the use of the Etherington-Wilson technic (14) of spinal anesthesia in the performance of extrapleural thoracoplasty. This method was first employed when it was noticed that analgesia extended well up on the chest in abdominal operations and so was used first in third stage thoracoplasty, then second stage thoracoplasty and finally even in first stage thoracoplasty. Following a death that occurred in the series it was postulated that the specific gravity of the spinal fluid may have been increased which would have allowed the anesthetic fluid to rise more rapidly. This possibility is admittedly a weakness in the method, and it was thought that the specific gravity of the spinal fluid should be measured before the nupercaine solution was injected. In 1938 Gurd et al. (15) first reported their experiences and again in 1939

TABLE 1
Doses of Nupercaine and Time Required for Analgesia

Dose of Nupercaine in mg.	Time in Seconds in Upright Posture	Area At or Below Which Operation May be Performed
8-10	20-25	Poupard's ligament
10-12	30-35	Umbilicus
12-15	40-45	Nipple
12-15	45-60	Chest

(16) with the use of spinal anesthesia for thoracoplasty. They employed the Etherington-Wilson technic and recommended the injection of 12 or 13 cc. of 1:1500 nupercaine solution, allowing it to rise for fifty to fifty-five seconds. In their latter paper they, too, proposed determining the specific gravity of the spinal fluid and suggested the Barbour's falling-drop method (17) for this purpose.

Lund and Cameron (18) have employed the Etherington-Wilson technic using a 0.1 per cent warmed pontocaine (niphanoïd) solution which has a specific gravity of 1.001 at 45° C. With the patient sitting the back is straightened to the vertical position after the spinal needle is in place and the injection is made in this position. Stechishin (19), using nupercaine, extended this type of technic with some modifications for use in upper abdominal surgical procedures of long duration. A combined method was used which was first reported by Jones in 1934 for prostatectomy (8) in which an isobaric solution was given, followed after a two or three minute interval by administration of a hypobaric solution. Later Noseworthy (20) used a similar technic for lower abdominal operations. Stechishin found that if the anesthetic agent was warmed to 104° F. a steadier and more rapid rise in the spinal

canal took place. A cold solution rose more slowly and because of poor mixing produced a patchy, unpredictable ascent. After the spinal puncture, 2 cc. of nupercaine 1:200 (isobaric solution) was introduced, followed by 15 cc. of nupercaine 1:1500 at the rate of 1 cc. per second.

Gifford and Wilkerson (21, 22) have also reported a combined method with nupercaine using a hyperbaric and hypobaric technic for abdominoperineal resection of the rectum. This procedure also makes use of the sitting-up technic of Etherington-Wilson and affords a powerful, long-lasting anesthesia. Maximal doses of 20 cc. of 1:1500 nupercaine were used in these studies (21), the volume being calculated according to the length of the back as measured from the spinous process of the seventh cervical vertebra to the interiliac line with the back in flexion. Normal lengths were found to vary from 16 to 22 inches. The dose of the agent was dependent upon the length of the back, the sitting-up time in seconds being about three times the dose in cubic centimeters.

In 1946 Kieley (23) reported enthusiastically on the use of hypobaric percaine (nupercaine) spinal anesthesia. With his technic the patient sits with the back arched backward during the injection and immediately afterward is placed in a prone position in order to saturate the posterior roots. For higher abdominal operations an analgesia level to the fourth dorsal vertebra is recommended. It was observed that the analgesia did not last as long when there was a poor flow of cerebrospinal fluid.

Lund and Rumball (24) have published an extensive report on hypobaric spinal anesthesia with 0.1 per cent pontocaine solution, describing its application to various types of operations. They have used a prone technic for performing spinal anesthesia for surgical procedures on the vertebral column or posterior aspect of the body. With this method there should be maximal sensory analgesia with minimal block of the anterior motor roots. Clinically this has been found to be the case and many patients are able to move the lower extremities after operation. This technic was also used in operations for extruded nucleus pulposus and was found to be safe and satisfactory (25). It is well to emphasize that with this approach it is generally necessary to aspirate cerebrospinal fluid to determine whether the spinal needle is correctly located before the anesthetic solution is injected. Spinal fluid will rarely flow upward of its own accord through a 20 or 22 gauge spinal needle. With this approach the anesthetic solution should be injected very slowly to prevent undue mixing with the spinal fluid and also to induce the solution to float along the posterior aspect of the cord. I have used the prone technic extensively for hemorrhoidectomy performed in the Buie position because of the advantage of not having to reposition the patient after administering the anesthetic agent. In a considerable number of these patients, however, marked difficulty in voiding developed which persisted for several days. Consequently this

method has been abandoned in favor of a lateral technic which I believe to be the procedure of choice for this type of surgical procedure. Dye and Vaughan (26), on the other hand, reported a series of 60 cases in which hypobaric spinal anesthetic was administered with the patient in the prone position for proctologic surgical procedures and only one patient was unable to void after operation.

When hypobaric spinal anesthesia is employed for orthopedic procedures on the lower extremities, using the tourniquet, many patients complain of pain at the site of the tourniquet. This discomfort is explained as being the result of stimulation of sympathetic pain pathways despite adequate segmental anesthesia (24). I have also found this to be true and consequently prefer a hyperbaric technic.

Lund and Rumball (24) described their method for inducing hypobaric pontocaine spinal anesthesia for nephrectomy. The table is inclined 20 to 30 degrees from the horizontal for this procedure, the head of the table being elevated until the desired level of analgesia is obtained. They found that considerable difference in segmental sensory anesthetic level on the two sides could be obtained. This increased the margin of safety since there was vasodilatation of a smaller proportion of the vascular bed, a larger proportion being left intact with its inherent ability to undergo compensatory vasoconstriction to aid in maintaining cardiovascular equilibrium. I have used this technic extensively for surgical procedures involving a flank approach and have obtained uniformly excellent results. In my opinion it is the most valuable application of the hypobaric technic.

In an unpublished paper Slater and Stephen (27) described their experiences with hypobaric spinal anesthesia in children from 2 to 17 years of age. Pontocaine solution, 0.1 per cent, was used in a dosage of 0.5 mg. for each year of age and a sensory anesthetic level was produced to the fourth, fifth or sixth thoracic segment. The injection was performed over a period of 20 seconds and with the patient in the sitting position, the total sitting-up time being obtained by multiplying the length, in inches, of the patient's back from the seventh cervical to the third lumbar vertebra by 2.5 seconds.

Dodd and Hunter (28), in an effort to decrease the toxicity of nupercaine, used 1:2000 solutions, but they failed to notice a lessening in the incidence of circulatory depression. Fisher and Whitacre (29), using dilutions up to 1:10,000 were of the same impression and also found that the concentration of the drug did not appreciably alter the degree or duration of sensory anesthesia or motor block. On the other hand, Fairlie (30), using 1:2000 and 1:2500 dilutions, thought there was less danger when the more dilute solutions were used. Hunter (31) used a light 1:1500 nupercaine for laminectomy, but the quality of anesthesia obtained was variable. Results were more satisfactory with a heavy solution of nupercaine, 1:1000.

Cull and Schotz (32) attempted a hypobaric technic with the piperi-

dine derivative lucaine, dissolving 10 mg. of the drug in 5 cc. of distilled water. After the injection the patient was placed in the prone position and the table jackknifed. Even though there was good relaxation of the sphincter, analgesia was incomplete.

A few factors are pertinent to the success of the hypobaric technic. In premedicating the patient, marked drowsiness and amnesia are desired. As to timing, each anesthesiologist should develop his own standards although formulas for the various procedures have been worked out. Ruben and Kistler (33), however, in their evaluation of hypobaric spinal anesthesia, cautioned that this technic should be employed only by the anesthesiologist and not by those who use spinal anesthesia only occasionally or when the anesthetist is not equipped to perform endotracheal intubation.

SUMMARY

Although the usefulness of hypobaric spinal anesthesia probably is unlimited, this technic is particularly indicated for surgical procedures involving a flank approach and also for proctologic operations performed with the patient in the Buie position. A review of the literature and some clinical observations are presented.

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JUNE 11-15, 1951

The meetings of the Section on Anesthesiology, of which Doctor H. Boyd Stewart is Chairman, will be held on Wednesday, Thursday, and Friday mornings in the St. Dennis Room of the Dennis Hotel. The program follows:

WEDNESDAY

Business Meeting for Presentation of Resolutions.

The Hazards of Lumbar Puncture.

Robert D. Dripps, M.D., and Leroy D. Vandam, M.D., Philadelphia, Pa.

Symposium on Plasma Volume Expanders in the Treatment of Shock.

Volemic Substances for the Maintenance of Plasma Volumes After Blood Loss.

Jesse L. Bollman, M.D., Rochester, Minn.

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