THE TECHNICS OF SPINAL ANESTHESIA *

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SPINAL anesthesia is employed at the Lahey Clinic for almost all operations below the diaphragm, other methods being used occasionally when spinal anesthesia is for some reason contraindicated. In this discussion will be considered the indications, contraindications, criteria for the selection of agents and methods, supportive drugs, apparatus and technics now employed in spinal anesthesia at this clinic.

Indications and contraindications rarely are absolute in anesthesia. Disease of the central nervous system is usually considered a contraindication to spinal anesthesia, assuming that resistance to the disease may be diminished by the anesthesia, but more because any new symptoms may be attributed by the patient to the anesthesia. For similar reasons one may hesitate to use spinal anesthesia in a patient who has been led to fear postanesthetic sequelae.

With increased experience in using technics for spinal anesthesia which afford better control of the height and duration of the anesthesia, many conditions which were formerly considered contraindications are not now viewed as such. By carefully watching the patient and by immediate institution of measures to support depressed respiratory and circulatory mechanisms, many patients to whom spinal anesthesia was formerly denied because it was thought the risk too great may now be safely managed under this form of anesthesia.

The presence of severe hemorrhage, anemia, shock, cardiac decompensation and coronary disease was formerly considered a distinct contraindication to spinal anesthesia. With the use of fluids preoperatively and transfusions for the first three mentioned conditions, and adequate preoperative medical control for the latter two, combined with the supportive measures mentioned above, the hazards presented by these conditions are lessened.

Furthermore, there are certain conditions, notably intestinal obstruction with shock, in which the improved operating conditions afforded by spinal anesthesia overbalance any increased hazard presented by it. In addition, spinal anesthesia may be beneficial to early shock thought to be produced by reflex action.

Spinal anesthesia is particularly indicated in the presence of disease of the respiratory tract because it causes no further irritation to the respiratory epithelium and does not alter the proportion of oxygen and carbon

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dioxide in the inhaled atmosphere. If absorption of oxygen into the blood is insufficient, due either to the pulmonary disease, to the effect of hypnotics or high spinal anesthesia, additional oxygen may be given by pharyngeal insufflation or by inhalation from the mask of a gas machine.

Another special indication is the presence of disease of the liver or kidneys. Similarly, metabolic diseases such as diabetes constitute an indication for spinal anesthesia because it causes less disturbance of the level of blood sugar, the reaction of body fluids and other metabolic processes, than do general anesthetics.

The most frequent indication for spinal anesthesia is the need for muscular relaxation in operations in the abdomen.

In selecting the agent and method of spinal anesthesia for a given case, many factors must be considered. Probably the first consideration, after spinal anesthesia has been selected, is the estimated time required for the operation, as different drugs and technics produce anesthesia for varying periods of time. The position in which the patient is to be on the operating table also influences the selection. The site of operation influences both choice of agent and method as the anesthesia for a hemorrhoidectomy will not suffice for a gastric resection or cholecystectomy.

The age and physical state of the individual influence the choice of agent and method, the aged and debilitated patient requiring much less of any agent to produce comparable anesthesia than does the vigorous, husky youth.

Three agents are now routinely used for spinal anesthesia at this clinic. Pontocaine, 1 per cent in saline solution, in combination with 10 per cent glucose solution, is the agent of choice for the routine operations in which anesthesia up to two hours is desired and in which steep Trendelenburg position is not required for twenty to thirty minutes after induction.

Nupercaine, 1 : 1500 dilution, in 0.5 per cent saline solution, is used when an anesthesia of longer duration than obtainable with pontocaine is desired or when steep Trendelenburg position is to be employed immediately after induction.

The third agent employed is procaine, which formerly was used exclusively in from 2.5 to 10 per cent solution in normal saline when fractional spinal anesthesia was selected. For some time pontocaine in combination with 10 per cent glucose has also been employed in this extremely useful method of producing spinal anesthesia of any desired duration. Either drug is satisfactory, the choice being entirely up to the individual anesthetist.

The tables set up by the operating room staff for pontocaine-glucose anesthesia after the method of Sise (1) contain one 5 cc. syringe, one 2 cc. syringe with two 24 or 25 gage needles 1¼ inches long, one long and one short Sise introducer,* two gold spinal needles 21 gage, one ampule of ephedrine sulfate 50 mg., one ampule of 10 per cent glucose containing

* Manufactured by the MacGregor Instrument Company, Needham, Massachusetts.

3 cc., one ampule of 1 per cent pontocaine in saline, containing 2 cc. (20 mg.), one ampule file, cups for normal saline, alcohol and antiseptic, sterile towels, gauze and gloves.

For nupercaine the table in addition has one 20 cc. syringe and a cup containing warm sterile water in which to warm the nupercaine solution and 20 cc. syringe, and one ampule of nupercaine, 1 : 1500, 20 cc. (12.66 mg.) instead of the pontocaine and glucose.

For fractional spinal anesthesia the table has one long Sise introducer, one Moore (2) introducer,* one 18 and one 19 gage German silver needle with a hole bored through the bevel to facilitate aspiration of spinal fluid (figs. 1 and 2), one 2 cc. syringe with two needles, 24 gage, 1½ inches long,

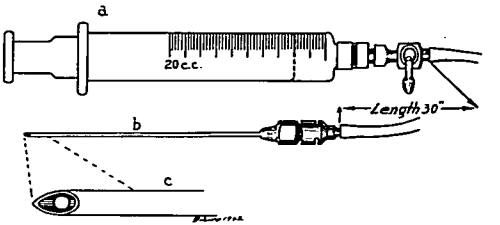

FIG. 1. Syringe, needle and tubing for induction and maintenance of fractional spinal anesthesia. Note hole opposite bevel of German silver needle to facilitate aspiration of spinal fluid.

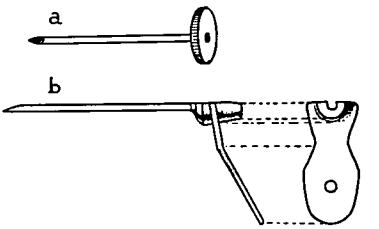

FIG. 2. *a*, Sise introducer. *b*, Moore introducer designed to permit withdrawal of introducer after spinal needle is in place.

one 10 cc. Luer-lok syringe, one piece of fine rubber tubing 30 inches long provided with Luer-lok connections at both ends, one ampule of ephedrine sulfate 50 mg., and the ampules of anesthetic solution (procaine or pontocaine and glucose), sterile towels, cups, gloves and antiseptics as above.

The technic for spinal anesthesia with pontocaine-glucose has been published before (1, 3), but its usefulness is so great that repetition in brief is justified. The specific gravity of 1 per cent pontocaine in saline

* Manufactured by the MacGregor Instrument Company, Needham, Massachusetts.

as supplied by the manufacturer is 1.007, which is just about the same as the average for spinal fluid which ranges from 1.001 to 1.009. By adding 10 per cent glucose to the anesthetic solution the specific gravity of the mixture is made greater than spinal fluid (one part pontocaine to 1½ parts 10 per cent glucose gives a specific gravity of 1.013), and by making the injection with the patient in various positions, Trendelenburg, level or Fowler, the height to which the solution flows in the spinal canal can be controlled. This is a powerful and rapidly acting anesthetic solution and those who use it for the first time are therefore cautioned to do so with considerable care, testing the level of anesthesia frequently during the early stages.

For operations in the upper abdomen, for instance cholecystectomy, where anesthesia is desired to the fourth or fifth thoracic segment, the technic is as follows: the patient is placed on the operating table and a blood pressure apparatus strapped on one arm so that readings may be

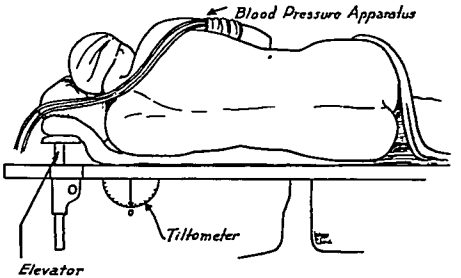

FIG. 3. Patient in position for spinal puncture when pontocaine-glucose mixture is to be used.

taken throughout the operative procedure. After the preoperative blood pressure is noted, the patient is turned to the lateral decubitus position, with the padded, adjustable goiter bar under the head (fig. 3). This bar enables the anesthetist to raise or lower the head as desired, and also catches the lower shoulder of the patient to prevent him from sliding toward the head of the table when it is lowered. If such a bar is not obtainable, the head may be placed on a hard pillow or sandbag, and shoulder braces used to keep the patient from sliding when the table is tilted. The skin over the lumbar region is prepared with ether, and an antiseptic is applied.

The previously estimated dose of pontocaine is drawn into the 5 cc. syringe to which is added 10 per cent glucose in volume equivalent to one and one-half times that of pontocaine. This solution is then thoroughly mixed. Next, the 50 mg. of ephedrine sulfate is drawn into the 2 cc. syringe, to which is added enough of the pontocaine remaining in the ampule to make this mixture serve as a local anesthetic for the spinal

puncture. A wheal is made in the skin over the third lumbar interspace. The needle is then introduced deeper, injecting ahead of the needle, anesthetizing the interspinous ligaments. The needle is then withdrawn and any remainder deposited intramuscularly through the wheal.

The Sise introducer is then introduced through the wheal and into the interspinous ligaments. The 21 gage gold needle is then passed through the introducer into the dural sac. The patient is placed in 10 degree Trendelenburg position (fig. 4), head elevated, and the 5 cc. syringe

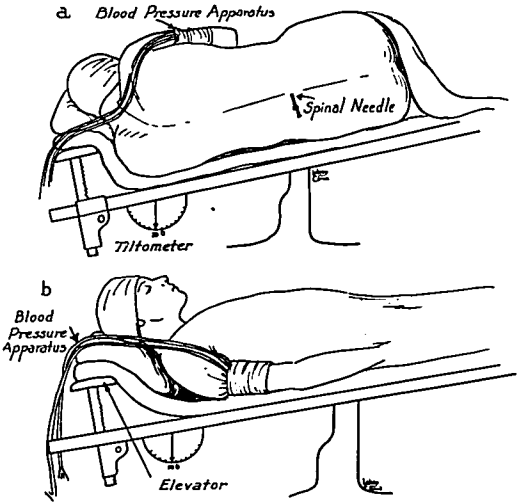

FIG. 4. *a*, Patient in position for injection of pontocaine-glucose mixture for spinal anesthesia. *b*, Position for obtaining height of anesthesia.

containing the anesthetic mixture connected to the needle. The plunger is withdrawn slightly to make certain the point of the needle is in the dural sac. The injection is slowly made, that is, about 0.25 cc. per second, after which the patient is turned supine and the level of anesthesia immediately checked. Notice of the time is made when the injection is started, since under no circumstances should the patient be left in the head down position longer than one minute from the start of injection without the height of anesthesia being tested. At the end of one minute the anesthetic level will usually be to the sixth or seventh thoracic segment and will proceed up to the fourth or fifth segment in another one or two minutes. Should this not be the case, the position may again be changed to a 10 degree Trendelenburg position until the desired height is obtained.

Careful attention must be paid to the cephalad progress of anesthesia; an undesirable height may occasionally be obtained in even a shorter time than mentioned. Should this happen, the table is immediately tilted to a 5 degree Fowler's position to prevent further cephalad flow of the anesthetic mixture. While this will not immediately lower the height of anesthesia, it will lessen its intensity and shorten its duration along its upper border. Also, the respiration and blood pressure of the patient should be closely watched in order that the anesthetist may be forewarned of any untoward reaction. During all these procedures care should be taken to see that the head is well elevated, as a marked upward slant of the cervical and upper thoracic regions forms a protection against too high extension of the anesthesia.

For operations in which steep Trendelenburg is desired immediately, the above technic is modified as follows: after one minute in 10 degree Trendelenburg position, the table is turned into 5 degree Fowler position for at least two minutes. Following this maneuver the patient may be immediately placed in Trendelenburg position; however, careful watch should be maintained for any intercostal paralysis.

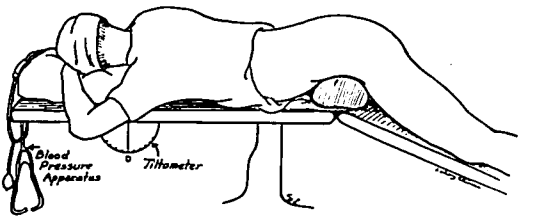

FIG. 5. Patient in Buie position for rectal operation after the spinal anesthetic has been given.

For lumbar operations such as nephrectomy or nephrostomy, the side to be operated on is placed down when the injection is made, the rationale being that the stronger anesthesia will be on the dependent side.

For inguinal operations such as herniorrhaphy, the injection may be made with the patient level, or in only slight Trendelenburg position for one minute, anesthesia developing promptly to a satisfactory level.

For operations on the lower extremity, perineum, rectum, prostate or bladder, the injection is made with the patient in slight, that is, 2 or 3 degree Fowler's position, the solution flowing caudad instead of cephalad.

For hemorrhoidectomy we have employed a separate technic. The spinal puncture is made in the fourth lumbar interspace. The solution consists of 1 cc. (10 mg.) of 1 per cent pontocaine and 1 cc. of 10 per cent glucose, to which is added 1 cc. of spinal fluid withdrawn after the syringe has been connected to the needle in the spinal canal. The injection is made very slowly, with the table level and the patient's head elevated. Following the injection the patient is placed on his back for two or three

minutes and the anesthesia tested. With this technic anesthesia is usually confined to below the twelfth thoracic segment which is satisfactory for rectal or lower urinary tract operations. The patient may safely be placed in either the Buie (fig. 5) or lithotomy position immediately.

Considerable changes of these details may be made if desired. However, when using the heavier solution, care must always be taken to see that the head is kept well elevated and that the patient is not left too long in a downward slant.

TABLE 1

MODIFICATION OF SISE'S TABLE FOR DETERMINING DOSAGE OF PONTOCAINE FOR SPINAL ANESTHESIA IN ADULTS

	Pontocaine, mg.	10% Dextrose, cc.	Position for injection	Head position
Anus and perineum	10	1 (1 cc. spinal fluid)	10° Fowler	Elevated
Lower extremities	10–14	1.5–2.1	Level	Elevated
Lower abdomen	14–16	2.1–2.4	10° Trendelenburg	Elevated
Upper abdomen	16–20	2.4–3.0	10° Trendelenburg	Elevated

The dose of an anesthetic drug in any given case is a matter of judgment. Sise's (1) table of doses of pontocaine in milligrams for adults has proved valuable and is given in table 1. These doses are meant as suggestions and should be considered starting points for the anesthetist's judgment.

Before the introduction of fractional spinal anesthesia by Lemmon (4), nupercaine was used exclusively when an anesthesia of longer duration

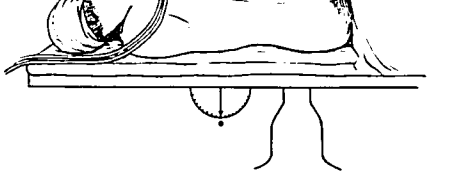

FIG. 6. Patient in position for spinal puncture when nupercaine (1 : 1500 dilution) is to be used as the anesthetic drug.

than obtainable with pontocaine was desired. Since the advent of the former, nupercaine has been used less frequently but is still desirable when steep Trendelenburg position is immediately required. The technic is as follows:

The patient is placed in the lateral decubitus position without any pillow under the head (fig. 6). The 20 cc. ampule containing the 1 : 1500

solution of nupercaine in 0.5 per cent saline solution is placed in the warm sterile water and warmed to at least body temperature. The 20 cc. syringe is also warmed. The syringe is rinsed with 1 cc. of the anesthetic solution to make sure that the syringe is not alkaline, to prevent precipitation of the drug. For anesthesia in the upper abdomen the spinal

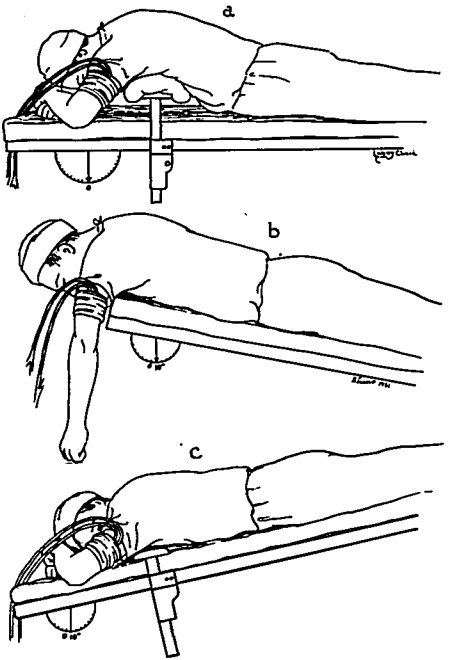

FIG. 7. *a*, Position of patient for obtaining desired height of anesthesia with hypobaric nupercaine solution (1 : 1500 dilution). *b*, Optional position for obtaining height of anesthesia with nupercaine. *c*, Position after obtaining height prior to turning patient supine.

puncture is made in the manner previously described in the second lumbar interspace. Five to 10 cc. of spinal fluid is withdrawn and discarded. The previously estimated dose of nupercaine is injected at the rate of 0.5 cc. per second, and the patient is immediately turned to the prone position with no pillow under the head. An elevating bar under the upper portion of the patient's sternum is elevated to a height of about 8 inches so as to make the upper thoracic portion of the spine the highest

part, leaving the cervical and lumbar portions, as well as the head, drooping downward (fig. 7). Care must be exercised to keep the patient's head down at all times. This solution is lighter than spinal fluid, and anesthesia usually extends upward to the desired level in from two to twelve minutes. The height of anesthesia should be tested frequently. When the desired height is obtained the elevating bar is lowered, the table is placed in Trendelenburg position of 5 to 10 degrees and the patient turned to the supine position, care again being exercised to keep the head dependent. Anesthesia is then usually found to have extended one or two spaces higher than it appeared to be when last tested posteriorly.

Should the anesthesia develop rapidly to a level which might be dangerous (above the fifth thoracic segment) the patient should be left prone four to five minutes after being placed in 5 to 10 degree Trendelenburg position. This maneuver is an attempt to confine that portion of

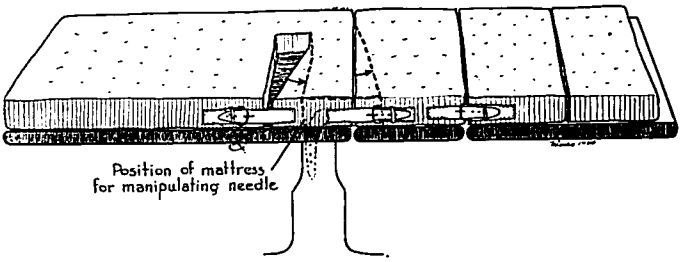

FIG. 8. Mattress used for fractional spinal anesthesia, showing cut-out section which prevents bending of needle.

the drug which may be too high cephalad to the sensory roots of the spinal cord, and guard against high motor paralysis.

For operations in the upper part of the abdomen, the dose is from 15 to 20 cc., 15 cc. being the dose for a woman 5 feet in height, 16 cc. for a woman 5 feet 3 inches in height, 17 cc. for a woman 5 feet 6 inches in height, and so forth. Formen, 1 cc. more is used than for women. Twenty cubic centimeters is the maximal dose.

For anesthesia of the lower abdomen, the dose is computed in cubic centimeters by dividing 100 by the number of the uppermost thoracic nerve segment which is to be anesthetized. Thus, if operation is to reach as high as the umbilicus, anesthesia should extend somewhat higher, to the eighth thoracic segment, and the dose would be determined by dividing 100 by 8, or 12.5 or 13 cc. The injection is made in the third lumbar interspace. The patient is placed in the prone position with the head dependent over the end of the table but the thorax is not elevated. The foot of the table may be lowered to insure adequate height. After

anesthesia is established the table is adjusted to 3 or 4 degrees Trendelenburg and the patient turned supine.

For anesthesia of the perineum, 6 to 10 cc. is used. The injection is made in the third or fourth lumbar interspace, with the table slanted so that the sacral end of the spine is higher than the cervical. The patient is placed in the prone position until anesthesia has developed and then he is placed in the supine position.

Fractional spinal anesthesia requires in addition to the special needles a special, rubber covered mattress, 5 inches thick, 18 inches wide and 6 feet long, with a cut-out part, 7 inches in length, which comes under the lumbar spine when the patient is supine (fig. 8). The mattress is divided in half so that the portion which supports the lower extremities may be detached for perineal operations * (fig. 9).

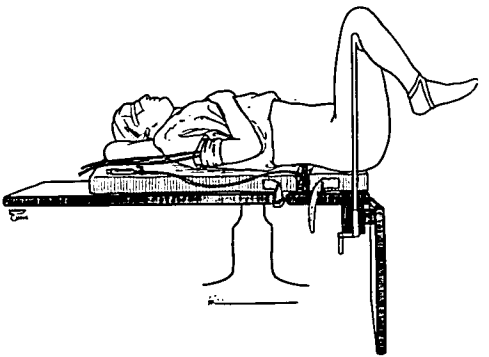

FIG. 9. Position of patient on mattress for perineal operation, showing needle in place and lower part of mattress removed.

There are two technics now employed with this method: (1) using 3½ per cent procaine in normal saline solution, and (2) using 0.25 per cent pontocaine in 6 per cent glucose solution. These technics have several important differences. The patient is placed on the special mattress in the left lateral decubitus position so that the back is toward the side of the mattress with the opening in it. The second or third lumbar interspace is anesthetized as previously described. The long Sise introducer is passed through the interspinous ligament and then withdrawn, leaving a track for the soft German silver needle to follow. The needle should not be passed through the Sise introducer and the introducer left in place. Should the introducer be left in place the danger of the needle being

* This apparatus is manufactured by George Pilling and Son Company, Philadelphia, Pennsylvania.

broken off in the patient's back would be increased. Furthermore, the needle could not be so firmly held in position by the soft tissues.

Recently Dr. George C. Moore (2) has designed an introducer similar to a grooved director through which the needle may be inserted and the introducer removed after the needle is in place. The introduction of this instrument is an important contribution to fractional spinal anesthesia.

Special care should be exercised to insure a free flow of spinal fluid through the needle. To this needle in situ is connected the previously filled syringe and rubber tubing containing either the procaine or pontocaine solution to be used (fig. 10). The patient is then turned on the

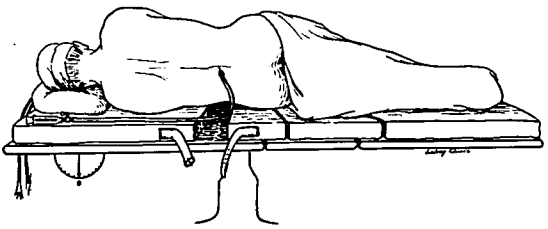

FIG. 10. Patient in left lateral decubitus position; needle in place and syringe and tubing connected.

back, extreme care being taken to see that the needle is in the cut-out opening in the mattress and is not dislodged from the spinal canal (fig. 11*b*). When complete abdominal anesthesia is desired with procaine, the patient is placed in a 10 degree Trendelenburg position for induction after the shoulder braces and wrist restraints have been properly adjusted. An initial injection of 3 cc. (100 mg.) to 4½ cc. (150 mg.) of the mixture is made in the following manner: 1½ cc. of spinal fluid is withdrawn, followed immediately by the injection of 2 cc.; this procedure is repeated until 3 or 4 cc. has been injected. By this combination of injection and barbotage, the desired level of anesthesia is usually obtained in four or five minutes. If the desired level is not obtained in this time, an additional injection of 1½ cc. is made in the same manner. Since the specific gravity of the anesthetic solution is slightly greater than that of spinal fluid, the factors of gravity as well as volume, barbotage and site of injection may be brought into play to obtain the desired height of anesthesia. This initial dose of procaine will produce anesthesia for upper abdominal work usually for one hour. At this time an additional dose of 1.5 to 3 cc. (50 to 100 mg.) is administered in the same manner as the initial dose. Subsequent doses may be added as needed.

With pontocaine, the solution consists of 4 cc. of 1 per cent pontocaine in normal saline and 6 cc. of 10 per cent glucose, making a 0.4 per cent solution of pontocaine in 6 per cent glucose (1½ parts glucose to 1 part pontocaine). The patient is turned supine and placed in 10 degree Tren-

delenburg position; 3 cc. (12 mg.) or 4 cc. (16 mg.) is injected at the rate of 0.25 cc. per second (fig. 11*b*). Careful, frequent testing enables the anesthetist to watch the progress of anesthesia upward when either method is employed. After four to eight minutes anesthesia will usually be found to extend to the fourth thoracic interspace, after which the patient is turned level.

If the initial injection of pontocaine-glucose is made with the patient in 10 degree Trendelenburg position but before he is turned supine (fig. 11*a*), anesthesia will develop more rapidly (one to two minutes). When this modification is used the technic is the same as that described for

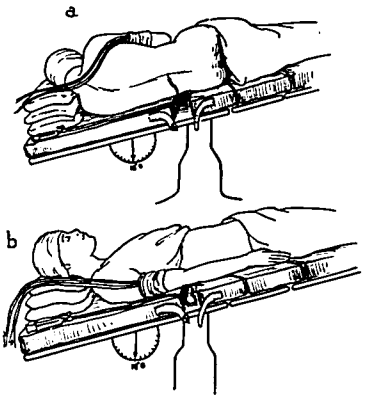

FIG. 11. *a*, Position of patient for injection of pontocaine-glucose mixture for fractional spinal anesthesia when injection is made prior to turning the patient supine. *b*, Position of patient for injection of pontocaine-glucose mixture for fractional spinal anesthesia when injection is made after patient is turned supine.

conventional spinal anesthesia using pontocaine-glucose, except that the injection is made after the tubing and syringe have been connected. The same precautions with reference to early and frequent checking of the height of anesthesia, elevation of the head and not leaving the patient in the head down position for over one minute should be observed.

After one hour the stopcock on the Luer-lok connection at the syringe is opened and spinal fluid allowed to flow into the syringe in an amount equal to that remaining in the syringe and tubing, so that each cubic centimeter contains 2 mg. of pontocaine. Subsequent injections of 2 to 5 cc. (4 to 10 mg.) are made as needed in the same manner described for procaine.

This method of anesthesia has proved satisfactory in our hands for operations requiring as long as four and a half to five hours.

Many physicians do not appreciate the great importance of supervising the patient under spinal anesthesia after the injection has been made and the anesthesia established. Conditions may arise during anesthesia which may be quite dangerous, but these can be prevented or controlled if properly handled. A fall in blood pressure is an almost constant and much discussed accompaniment of spinal anesthesia. A slight fall may be normal and usually demands no treatment. A marked fall in blood pressure is treated by giving the patient oxygen and some vasoconstrictor drug, together with the Trendelenburg position, if feasible. We most frequently employ a mixture of 5 units of pitressin and 25 mg. of ephedrine intramuscularly as suggested by Melville (5) and later by Raginsky (6). When this mixture is given subcutaneously or intramuscularly, it not only raises the blood pressure but sustains this rise for a much longer period than either epinephrine or neosynephrin, although its effect is not rapid. Neosynephrin is sometimes used and produces an immediate elevation of blood pressure. Either of these drugs, the pitressin-ephedrine mixture or neosynephrin, may be given in small doses (2 to 3 minims) intravenously in emergencies to produce an immediate rise in blood pressure, although not as long sustained as following subcutaneous or intramuscular injections.

Nausea and vomiting under spinal anesthesia are sometimes controlled by administration of oxygen from a gas machine. Should this not prove effective, light supplemental anesthesia of cyclopropane or sodium pentothal intravenously is administered.

Depressed or arrested respiration from paralysis of the muscles of respiration due to high spinal anesthesia is a distinct danger and must be carefully watched for. Treatment must be prompt and effective and is best carried out by giving artificial respiration with oxygen by means of a gas machine. This procedure is carried out by placing a mask over the patient's face, insuring a patent airway (an endotracheal tube if necessary), and, by rhythmical compression upon the rebreathing bag of the gas machine, the lungs are inflated with oxygen. The weight of the chest itself serves to deflate the lungs.

Central failure of respiration is much more serious and is secondary to a severe fall in blood pressure. It is treated by immediately instituting measures to elevate the blood pressure, as previously described, and furnishing oxygen in the manner just described.

Most serious and rapidly occurring effects of spinal anesthesia are apt to occur in the first half hour after injection. Therefore, close attention should be given to the patient at all times and especially at this time. During every instant of this time the anesthetist should know absolutely the color of the patient, the character and extent of respiration and the quality of the pulse, besides having a good idea of the extent of the patient's mental alertness. Spinal anesthesia should not be administered without a gas machine ready at all times for the administration of oxygen. A hypodermic syringe and vasopressor medication should be at hand for immediate use if indicated.

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For the information of anesthesiologists who are contemplating examination for fellowship in the American Society of Anesthetists, Inc. or who are training physicians for the specialty, the following questions have been employed in the past in *Anatomy:*

1. Give topographical landmarks for caudal transsacral block. Illustrate with drawings if you wish.
2. Locate four accessible veins in the upper and lower extremities for intravenous medication. Illustrate with drawings if you wish.
3. (*a*) Define the epidural space and (*b*) describe its contents. (*c*) Define the subarachnoid space and (*d*) describe its contents.
4. (*A*) What is the average diameter of the trachea: (1) in an adult male; (2) in an adult female; (3) in a ten-year old child. (*B*) Give the length in inches or centimeters from the incisor teeth to the bifurcation of the trachea in (1) the average adult male; (2) the average adult female.