SERIAL SPINAL ANESTHESIA * †

FREDERICK P. HAUGEN, M.D., HENRY S. RUTH, M.D., AND IVAN B. TAYLOR, M.D. ‡

Philadelphia, Pa.

THERE has been a continuous search for less toxic, yet longer acting drugs for spinal anesthesia following Corning's and Bier's historic work. Procaine, synthesized by Einhorn in 1904, continues to be regarded as the safest available drug, in spite of its brevity of action. Its application to spinal anesthesia, therefore, has induced further investigation to determine the safest and most satisfactory method of supplementation when its anesthetic effect becomes inadequate before the surgical procedure is completed. This contribution offers comments on a method of spinal anesthesia that solves some of the problems associated with the intradural administration of anesthetic drugs.

The credit for developing a method whereby additional amounts of anesthetic drugs may be injected into the subdural space at will belongs to Lemmon of Philadelphia (1). Search of the literature has revealed no previous report of such a technic. Vehrs (2) suggested the use of a special operating table that would permit the insertion of a needle for a second injection when necessary. Sebrechts (3) described a method of using Jones solution of percaine (nupercaine) that he termed "Fractional Spinal Anesthesia," where all additions of the drug are made preoperatively until the desired level of anesthesia is obtained, whereupon the needle is withdrawn. We believe that the term "Continuous Spinal Anesthesia" does not adequately describe Lemmon's technic, for ordinary spinal anesthesia is continuous as long as it is effective. Too, with Lemmon's technic, injections are not made continuously, but serially, as indicated. Therefore, we suggest the name "Serial Spinal Anesthesia" as more accurate and descriptive.

EQUIPMENT

Special equipment is required. The mattress used is adaptable to the standard operating table. It is about 5 inches thick, and is covered with a heavy rubberized material. The mattress is in two sections, one to support the head and trunk, and the other the limbs. The lower section can be folded into three segments to conform to the Trendelenburg

* From the Departments of Anesthesia, Presbyterian Hospital, Hahnemann Medical College and Hospital, and Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania.

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‡ Presently located at Wayne University College of Medicine, Department of Anesthesia, Detroit, Michigan.

position and is secured to the upper, or body portion, by straps. The upper section is constructed with an L-shaped opening which underlies the lumbar region when the patient is in the supine position. This opening through the entire thickness of the mattress permits access to the needle in situ during the operation, prevents pressure on the needle, and compression of or tension on the tubing by the body weight of the patient. It may be found necessary to use shoulder braces with longer shafts because of the thickness of the mattress.

The special needles are made of a German silver alloy, and can be bent at sharp angles without breaking. They are necessarily thicker walled than the conventional spinal needle, and are supplied in 19, 18 and 17 gage, varying slightly in length. The stylets are of steel wire, and do not fit as snugly as in others. It has been our experience that after the alloy needle has been used a few times, its channel becomes so irregular that the stylet supplied is valueless. However, after this occurs, the needles may be used without them. There is a small opening near the tip opposite the short bevel which is an added precaution against a clogged or obstructed lumen. This refinement was also suggested by Dill for a specially designed needle in 1932 (4). It will be found, however, that the needles do become clogged at times by small bits of muscle tissue.

The tubing is made of firm rubber with an inside diameter of 2 mm., about 30 inches in length, and fitted with a Luer-lok connection for the spinal needle at one end, and a stop-cock adaptor to the standard Luer syringe at the other end. The capacity of the tubing should be 2 cc. of fluid. A cap or a plug fitting the hub of the needle is necessary to prevent leakage of spinal fluid after the puncture is made, while the solution is being prepared. Ampules of procaine crystals containing 500 mg. are obtainable from the leading drug houses. Five cc. ampules of 10 per cent procaine solution would also be convenient for preparing a 5 per cent solution. The remainder of the equipment consists of a 10 cc. syringe, a 1 cc. syringe with 1 per cent procaine for making a skin wheal, and a Sise director.

TECHNIC

The patient is placed on the mattress in the lateral position for the spinal puncture, with the elected site in line with the center of the opening in the mattress. The side of operative incision should be down. After the wheal is made, the Sise director is introduced through the ligament, bearing in mind that the flexible needle has to follow its course, and if the course of the director is wrong, the puncture may be unsuccessful. The needle may then be inserted through the director, or, the director may be withdrawn when it has penetrated the ligament, and the spinal needle inserted in its path. With these needles, more than with any other type, the anesthetist must recall that to change the direction of the point of the needle it must be withdrawn almost to the

skin and out of the grasp of the interspinous ligament—hence the importance of the careful insertion of the director. We have found that if the director is left in place with the needle through it, it may act as a fulcrum to dislodge the needle when the patient is turned to the operative position. To prevent this, a longer needle may be used, and the director pulled out of the tissues and left free on the exposed shaft. The lumbar interspace chosen is of no great importance, the one offering the greatest ease of introduction being selected. A proper tap is a necessity in this method, and one which permits a free and unhesitating flow of fluid should be obtained. When this has been achieved, 10 cc. of cerebrospinal fluid is withdrawn, and the needle capped with the Luer plug. The procaine crystals are dissolved, making, then, 10 cc. of a 5 per cent solution. Lower concentrations may be prepared as desired, but in procedures requiring good muscular relaxation this concentration has proved to be more consistently satisfactory. The tubing is attached to the syringe, and filled with the solution to remove the air, and the stop-cock closed. It is now firmly attached to the spinal needle, and with each cubic centimeter representing 50 mg. of the drug, the desired dosage is administered. The patient should be turned bodily to avoid any sudden twists that might dislodge the needle. If the patient is to be in the supine position, the needle should be in the center of the opening in the mattress. It has not been found necessary to tape the needle in place except in the kidney position, when it may be bent over and secured. A small cardboard box with a slot in the side, placed over the needle and taped in place, makes a good guard to prevent interference by the operating team when the patient is in the lateral or prone position. The tubing is brought to the side of the mattress and carried cephalad where it is fastened to the sheet covering the mattress. The set-up is now checked to see that fluid may be withdrawn and injected with ease. Additions are made as needed in 25–50 mg. doses. A moderate Trendelenburg position will facilitate the upward extension of the additions to the original injection. The initial effect of such additions may be apparent in thirty seconds, and the maximum may require five minutes, depending upon the anatomical region involved.

Certain signs and symptoms may be observed as indices for additional injections. A patient who has been lying quietly may become restless as, perhaps, the sympathetic nerves regain their power of transmitting stimuli. Flushing of the face and the occurrence of warm perspiration, or expressions of discomfort from excessive warmth by the patient, have been noted as signs. The blood pressure may rise and the pulse rate quicken a few minutes before a complaint of pain is made. The surgeon may notice an increase in the tonus of the abdominal muscles, or a lessening in the contraction of the intestines before sensation returns to the patient. The anesthetist should attempt to reinforce the anesthesia before pain appears, and thus contribute much to the smoothness of the anesthesia. We tend to sedate patients quite

heavily, frequently using morphine during the operation by the intravenous route for its quicker effect.

Figure 1 illustrates reactions during a lengthy operative procedure in an elderly patient, using a relatively small amount of procaine. The operation was an extensive resection of the colon and ileum. It will be noted that sudden drops in blood pressure have been avoided by an initial dose of 100 mg., and small additions thereafter. This patient was given a similar anesthetic for a second operation of similar duration four months later, and her record at that time was almost a

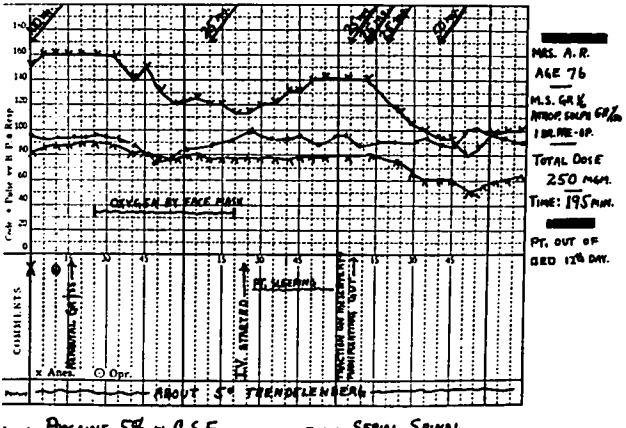

FIG. 1. Anesthetic record of a lengthy operative procedure with small dosage of procaine.

duplicate of this chart. She was discharged without noteworthy complication.

Figure 2 illustrates the value of this method in certain physically handicapped patients. This man was given only 45 mg. of 3 per cent procaine over a period of forty-six minutes for a first stage prostatectomy. By a single injection method, such a small dose probably would not have been considered for a suprapubic operation, but it proved sufficient to complete the procedure without further additions. The avoidance of a sudden drop in blood pressure was of particular importance, and this was achieved remarkably well. It is doubtful if the withdrawal of 4 cc. at the end of the operation had anything to do with the return of motor function of the extremities a few minutes later.

Figure 3 is quite interesting. The contemplated operation was a bilateral inguinal hernia. We are sure that 135 mg. of procaine given at the beginning of the operation would not have lasted for two and one half hours, but in this patient by the serial injection method that quantity was sufficient. The 3 per cent solution was used. Muscular relaxation was not of great importance, and by the use of the Trendelenburg position and a more dilute solution, the required level of anesthesia could be maintained. We do not doubt that similar results in

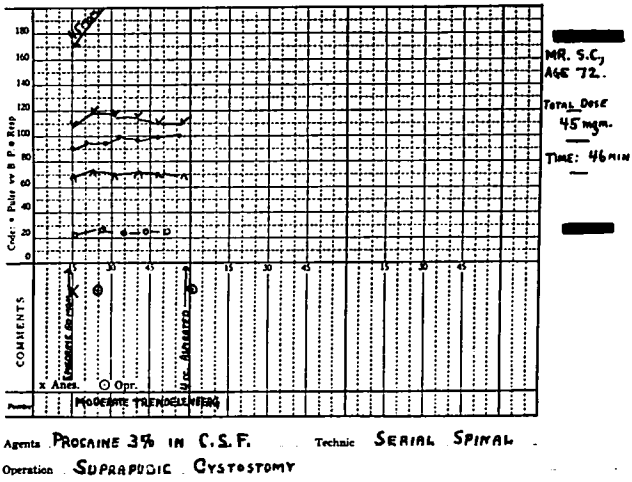

FIG. 2. Anesthetic record of an operative procedure in an elderly patient, using a small dosage of procaine.

this type of case may be achieved with some of the longer acting anesthetic drugs, but this chart is interesting to one who favors procaine.

Figure 4 is illustrative of a long operative procedure in the upper part of the abdomen. The three and one half hour gastrectomy required 475 mg. of 5 per cent procaine. The total dosage used was above the average. In upper abdominal procedures we often use sufficient pentothal sodium to produce unconsciousness. This contributes to the comfort of the patient and may reduce the amount of procaine required. We believe it to be logical to supplement spinal anesthesia to overcome certain annoying traction reflexes, which, after all, might not be relieved by excessively high spinal anesthesia.

The types of operations done with this method of spinal anesthesia are listed (table 1). This method has been largely employed for those

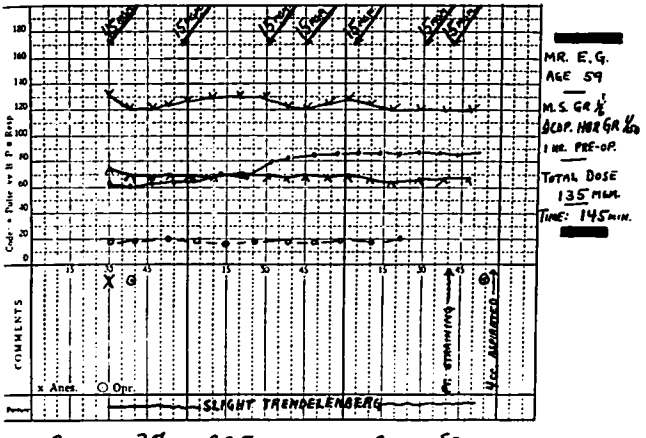

FIG. 3. Record of a patient requiring only 135 mg. of procaine over a period of two and one-half hours.

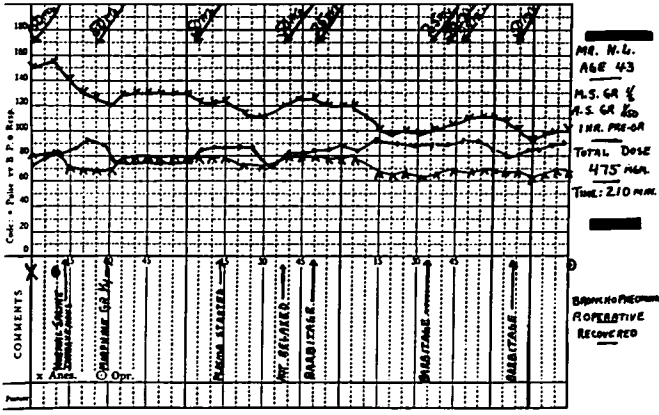

FIG. 4. Example of an upper abdominal operation done under spinal anesthesia by the serial injection method.

TABLE 1

TYPES OF OPERATIONS

Operations on stomach	37
Operations on biliary tract	39
Intestinal anastamoses, resections, etc.	61
Exploratory laparotomies, appendectomies	39
Herniorrhaphies	21
Urologic operations	29
Gynecologic operations	13
Splenectomy	2
Thoraco-lumbar sympathectomies	2
Diaphragmatic hernia	1
Orthopedic operations	5
Diagnostic (hysteria)	1
	250

patients where the time factor is too uncertain to make the injection of a single dose of procaine feasible without supplementation. It has also been used in shorter operations where it was desirable to use the minimum amount of drug because of the physical condition of the patient.

Table 2 shows the average time of operation and the average dose of procaine used. We believe that the average of 190 mg. providing

TABLE 2

SUMMARY OF DOSAGES

Average amount of procaine used	191.7 mg.
Average time of operation	90.0 min.
Smallest amount of procaine used	45.0 mg.
Largest amount of procaine used	600.0 mg.
Number of cases supplemented	17

one and one half hours of anesthesia is commendable, especially when the high proportion of upper abdominal procedures is considered. The smallest and largest doses are also listed. When greater doses are used in a patient, we suspect that some of the drug is being delivered into the epidural space. This might occur from leakage around the needle or result from other punctures of the dura when attempting the placement of the needle in the spinal canal. A slow leak in the apparatus may also account for the use of excessive amounts.

COMMENTS

From our limited experience with this method, we feel that it has definite merit and is worthy of continued study and application. The problem of the choice of anesthesia is too involved for this presentation. Therefore, the following comments apply, particularly after one *has decided* to use spinal anesthesia produced by procaine.

The element of control introduced by this method as compared with

that of the single injection has been emphasized by Lemmon in his recent publication (5). The advantages and indications for the use of serial spinal anesthesia are derived from this factor of control. Such advantages include: smaller initial dose, giving increased safety; anesthesia may be maintained over a prolonged period; failure may be prevented in the rare patient that requires a larger dosage; an opportunity is presented for acquiring more knowledge of spinal anesthesia.

The disadvantages encountered are largely technical in nature and occur with sufficient frequency to discourage its use when one is certain that a single injection is adequate. These disadvantages may be listed as: technical difficulty of introducing the malleable needle; slightly increased time factor; patient should be turned bodily; displacement of the needle may occur when the patient is moved; there is an increased possibility of trauma to the structures at the site of injection as compared with the conventional type of spinal anesthesia.

The indications for this method will vary, but assuming one has determined to use procaine for spinal anesthesia, the general indications are: upper abdominal procedures requiring more than one hour and lower abdominal operations of greater length; exploratory laparotomies that may be either short or long in duration, depending upon the condition encountered; patients in poor physical status—in order to avoid a large single injection.

The fall in blood pressure that may accompany spinal anesthesia appears to be proportional to the area of the body anesthetized in a given individual. However, the rapidity with which the paralysis develops may be significant in this fall in pressure. If it is established slowly, the vascular system may have a better opportunity to compensate for the changes produced by the paralysis. The use of a small initial dose appears to be followed by a more rapid recovery from a severe drop in blood pressure, if it occurs, than when a large initial dose is employed.

The opportunity for withdrawal of spinal fluid on the appearance of unfavorable symptoms should not be unduly emphasized for several reasons. If it is argued that such a withdrawal is remedial only because the unnecessary and excessive portions of the drug are eliminated, it may also be stated that the administration of such excessive amounts may be easily avoided with this method by a more careful selection of the dosage. This series did not demonstrate that the intraspinal action of anesthetic drugs is quickly reversible at all times. However, if toxic signs develop within a very few minutes after the injection of the drug, withdrawal of the solution may be of value.

SUMMARY

The term "Serial Spinal Anesthesia" is suggested as more descriptive and accurate than "Continuous Spinal Anesthesia" for the method

developed by Lemmon. Special equipment necessary is listed and the technic of administration is described in detail. The comments presented here, although based on a limited series of cases, confirm the belief that the element of control introduced by this method is a definite advantage for many types of operation when spinal anesthesia is employed.

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For the information of anesthesiologists who are contemplating application for certification by the American Board of Anesthesiology, Inc., or who are training physicians for the specialty, the following questions have been employed for Part I (written) examination in the past in *Pharmacology:*

1. What anesthetic agents and methods of administration would you advise for removal of a carcinoma of the tongue from a patient otherwise normal? If a cautery were to be used, which method would you prefer and why?
2. What is the fate of tribromethanol in the body? In what form is it ordinarily marketed? What precautions should the anesthetist take in preparing it for administration, and why?
3. Discuss the use of epinephrine in local anesthetic solutions.
4. How is avertin in amylene hydrate detoxified and eliminated from the body?
5. Describe the action of morphine when given in *a.* therapeutic dose; *b.* toxic dose.
6. State the advantages and disadvantages of *a.* ether; *b.* tribromethanol (avertin).
7. What percentages or partial pressures of the following agents are required in the inspired atmosphere to maintain surgical anesthesia: *a.* nitrous oxide; *b.* ethylene; *c.* cyclopropane; *d.* diethyl ether; *e.* divinyl ether (vinethene).
8. In what ways can the anesthetist protect the patient against the toxic effects of procaine?
9. Discuss choice of drugs for preanesthetic medication for the average adult surgical patient when cyclopropane is to be administered. Let your answer include experimental and clinical data.
10. What effect does each of the following drugs and conditions have upon the size of the normal spleen in the intact animal? *a.* hemorrhage; *b.* ether; *c.* cyclopropane; *d.* high spinal anesthesia.
11. Define analeptic. Enumerate three specific physiological disturbances where an analeptic is useful. In each instance name an indicated analeptic.