

REGIONAL SPINAL ANESTHESIA *

UTILIZING THE CONTINUOUS SPINAL TECHNIC OF TUOHY

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IN 1947, Saklad (1) reported his results of a study in which Tuohy's (2, 3, 4) continuous spinal anesthesia by the catheter technic was enlarged upon by passage of the catheter well up into the subarachnoid space, not just "4 or 5 cm. . . to prevent the catheter from slipping out of place" as described by Tuohy, but sufficiently high to deliver the anesthetic agent directly to the specific nerve roots which are to be affected. The thought occurred to us that the revolutionary concept which thus appeared to be inherent in the Tuohy catheter technic deserved further investigation. On theoretical grounds, this concept appeared to offer the following advantages over existing technics (1) The agent would be delivered in its maximal concentration directly adjacent to the medium desired to be affected, that is, the specific nerve roots. (2) The dependence of diffusion for a high level of anesthesia would thus be eliminated. (3) The nerve roots not to be affected would not unnecessarily be subjected to high concentrations of the drug. (4) Weaker concentrations of anesthetic agents could be used. (5) Anesthesia at higher levels would be assured. (6) Small initial and additional doses of the agent could be used. This would result in safer "minute-to-minute" control (recoverable agent). (7) The above factors should produce a technic which approaches the safety of local anesthesia, since the agent would be delivered to the specific anatomic site of election directly rather than by diffusion.

This paper is a report on two sets of patients (a total of 466 cases) Group A, patients from the U. S. Public Health Service Hospital in Baltimore, and Group B, patients from the U. S. Public Health Service Hospital in Savannah, in whom an attempt was made to prove that these thoughts were practical as well as theoretical. Although the work was done independently in the two institutions, the technic employed was the same in both and the results obtained parallel each other closely.

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TECHNIC

After adequate premedication, the patient is prepared in the usual manner for spinal anesthesia. An initial skin wheal is made over the selected lumbar interspace, utilizing a vasopressor drug in procaine. (Group A: 184 patients received ephedrine sulfate, 50 mg. per cubic centimeter of 1 per cent procaine and 24 cases received methoxamine hydrochloride 15 mg. per cubic centimeter of 1 per cent procaine. Group B: All the patients received ephedrine sulfate, 50 mg. per cubic centimeter of 2 per cent procaine.) The spinal puncture is carried out, using the 17 gauge Huber point needle as described by Tuohy. The design of the bevel is such that the catheter can be threaded either cephalad or caudad according to the direction in which the bevel is facing when the tap is made. The puncture in the usual case is made with the bevel of the needle directed cephalad so that no unnecessary turning will be required when the needle has reached the subarachnoid space. Before the tap, the selected catheter, marked by us in centimeters, is checked to be certain that it will pass easily through the Huber point needle. It is also checked for fraying, breaks and patency. After the tap is completed, the distance the catheter must be inserted up the spinal canal in order



FIG. 1.

to reach any desired point is determined by measuring it from the site of the needle puncture up along the length of the back. Care must be taken during this procedure to maintain sterile technic and to prevent contamination of the sterile catheter. If the needle has been properly placed, the catheter will slip easily through its rounded end and may then be passed the calculated distance into the subarachnoid space. The needle itself measures approximately 9.5 cm., and this factor must be considered when the distance the catheter is to be inserted is determined. Even when an attempt is made to use the catheter for low spinal anesthesia, the catheter must be inserted sufficiently beyond the bevel of the needle into the subarachnoid space so that it will not slip out. When placement has been satisfactorily completed, the needle is withdrawn over the catheter. If, after the needle is withdrawn, the catheter is found to be too far in, it can be gently withdrawn to the desired centimeter marking. The catheter must never be pulled out through the needle as this might result in shearing of the catheter, leaving a piece in the subarachnoid space.

After the needle has been withdrawn, a 23 gauge hypodermic needle is inserted into the end of the catheter and the 10 cc. syringe containing the spinal anesthetic drug is attached. The drug used in these 330 cases was metycaine hydrochloride, 1.5 per cent concentration. Since this comes in a ready-to-use solution, no mixing or preparation is necessary. The catheter is covered with a sterile gauze sponge at the site of emergence from the skin and then taped in place at several strategic places along the back. The initial dose of the agent, 1 cc. or 15 mg. of 1.5 per cent metycaine, is given and the patient is turned into the position necessary for the particular surgical procedure, with the syringe of anesthetic agent placed in a sterile towel and fastened to the pillow at the patient's head. The blood pressure is determined to compare with the preanesthetic reading, and then is rechecked at regular intervals throughout the operation. Intravenous fluids are started immediately. The level of anesthesia is ascertained with a needle point. Since the initial dose is given with the patient in the lateral position, the area of analgesia is almost always unilateral for a brief period. If it is tested immediately and then again within sixty to ninety seconds, an accurate idea of the placement of the tip of the catheter may thus be obtained. If the patient appears to be unusually susceptible to the drug and the area of analgesia is widespread, or if the catheter is too high and the segmental zone of analgesia at too high a level is obtained, the patient may be turned on his side and the catheter withdrawn the desired distance. For most procedures, and in most individuals, this small initial test dose of 15 mg. of metycaine is sufficient to proceed with the operation. Occasionally, it is necessary to increase this dose to 30 mg. More of the agent is added as needed, usually about every twenty to thirty minutes, and in amounts varying from 7.5 to 30 mg. At times, the pressure of the spinal fluid is such that it pushes back into the syringe

between injections. This may be easily prevented by fastening a piece of tape across the butt of the plunger and down each side of the barrel of the syringe.

We have omitted until now any mention of the catheters used for this study. In Group A, plastic tubing (5) was used (supplied by the Becton Dickinson Company). The major part of our study was done during the experimental stage of production of this plastic tubing. Consequently, many different qualities of catheter were tried in an effort to evaluate strength, durability, sterilization properties, and so forth. Their final product, which is a Vinyl compound now on the market, meets all our requirements. It is sterilized by autoclaving on the spinal tray at 250 F. and 15 pounds of pressure for thirty minutes. In Group B a 3½ French ureteral catheter, specially designed for the Tuohy technic, was used in most cases. In some cases, numbers 3 and 4 French ureteral catheters and vinyl ethylene catheters were also used. The ureteral catheter is also sterilized by autoclaving on the spinal sets.

RESULTS

The accompanying tables, summarizing the results, bear out our initial thesis that adequate spinal anesthesia can be obtained by minimal doses of the agent if catheter placement is precise. A total of 330 cases was managed with metycaine (table 1). Two additional smaller groups, 69 in which procaine was used (table 2) and 67 in which xylocaine (6) was used (table 3), brings the total for the entire group to 466. The average upper level of analgesia in many cases represented the upper limit of a band of sensory loss. In most cases of abdominal operations, for example, motor power of the lower extremities was retained. In Group A, the greatest distance a catheter was passed was 30.3 cm. for an upper abdominal operation; in Group B, the greatest distance was 34 cm., also for an upper abdominal procedure.

The relationship of amount of drug to duration of anesthesia shows a remarkably long duration per milligram of metycaine, 1.2 to 1.9 minutes per milligram for the average procedure. These figures ac-

TABLE 1
DRUG: METYCAINE HYDROCHLORIDE 1.5 PER CENT

Groups	Distance of Catheter from Skin, cm.		Height of Analgesia	Dose, mg.		Duration, minutes		Ratio of Drug to Duration, mg./min.		Ratio of Duration to Drug, min./mg.	
	A	B		A and B	A	B	A	B	A	B	A
	Low spinal (65 cases)	7.5	13.1	T 9-10	62.3	59.5	122.0	110.4	.51	.54	1.9
Mid spinal (138 cases)	10.0	14.9	T 6-7	93.3	63.4	119.0	92.7	.75	.68	1.2	1.4
High spinal (127 cases)	22.5	22.4	T 4-5	98.2	77.1	141	129	.69	.59	1.3	1.7

TABLE 2

DRUG: PROCAINE HYDROCHLORIDE, 5 PER CENT

	Distance of Catheter from Skin, cm.	Height of Analgesia	Dose, mg.	Duration, minutes	Ratio of Drug to Duration mg./min.	Ratio of Duration to Drug min./mg.
Low spinal (11 cases)	9.3	T 8-9	140	132	1.06	.87
Mid spinal (29 cases)	11.1	T 6-7	188	120	1.5	.64
High spinal (29 cases)	20.4	T 4-5	215	132	1.6	.61

TABLE 3

DRUG: XYLOCAINE HYDROCHLORIDE 2 PER CENT

	Distance of Catheter from Skin, cm.	Height of Analgesia	Dose, mg.	Duration, minutes	Ratio of Drug to Duration, mg./min.	Ratio of Duration to Drug, min./mg.
Low spinal (21 cases)	11.3	T 7-8	72.4	120.2	.60	1.6
Mid spinal (39 cases)	12.8	T 6-7	75.3	88.2	.81	1.04
High spinal (7 cases)	16.4	T 4-5	168.6	192.9	.87	1.1

tually err on the low side, since the duration was taken from the time the anesthesia was started until the operation was completed. No attempt was made to determine the time the anesthesia actually ended in either group. The longest operation in either group, a gastric resection, consumed five hours and ten minutes (310 minutes), necessitating 180 mg. of metycaine, representing 1.7 minutes per milligram as the "analgesia index." In another long procedure, a nephro-enterostomy, which consumed 210 minutes, only 75 mg. of metycaine was used, or an "analgesic index" of 2.9 minutes per milligram. These figures take an added meaning when contrasted with the usual dose for single spinal injection of metycaine in which 120 to 150 mg. is used for a procedure lasting from forty-five to sixty minutes.

A brief discussion of the two smaller studies which were made simultaneously with the main study will serve to demonstrate that these results can be obtained regardless of the anesthetic agent employed. Group C comprises the 69 patients who were anesthetized with 5 per cent procaine. In these cases, a 500 mg. ampule of procaine crystals was dissolved in 10 cc. of spinal fluid which was withdrawn at the time of the spinal tap, and before the catheter was inserted. Group D is composed of 67 patients anesthetized with 2 per cent xylocaine which is commercially prepared and stable in solution (6). The results with these agents are summarized in tables 2 and 3. Again, relatively small doses produce adequate anesthesia. For purposes of comparison, it

might prove interesting to refer to other work done with fractional spinal anesthesia by the Lemmon (7, 8) technic, and utilizing procaine as the agent. Lemmon, in an analysis of his first 500 cases, reported the average total dose of procaine as 242 mg. and the average length of operation as fifty-three minutes. Computing from the supplementary table, our average dose of procaine per hour in low spinal operations is 63.6 mg., in mid spinal is 90 mg., and in high spinal is 96 mg. Converting the procaine value to a metycaine equivalent by the factor of 0.39 (approximate) and computing the results, the value of 0.39 minutes per milligram is found to be the analgesic index for the Lemmon technic. In 1944, Hale and Shaar (9) reported on 703 cases done by the malleable needle technic. The average duration of their operations was 112 minutes and the average dose of procaine employed was 230.18 mg., their average dose per hour being 122.46 mg. In 1942, when the Lemmon technic was still very new, Haugen, Ruth and Taylor (10), in a study of "serial spinal anesthesia" (which they thought was a more descriptive term than "continuous") reported that they used an average of 191.7 mg. of procaine for an average operating time of ninety minutes. No figures for comparison are available for the Tuohy modification, but it is assumed that there would be no significant difference between it and the Lemmon technic since, as Tuohy has stressed, they are identical except for the use of the indwelling catheter in place of the malleable needle.

Complications.—Headache continues to be the most troublesome complication and occurs in about 10 per cent of the cases. Although the large size of the Tuohy needle may be partly responsible for the occurrence of headaches, it is our impression that although the incidence of headache following this method of anesthesia is higher than that attendant upon single dose spinal anesthesia, it is not greater than that which occurs following the use of the malleable needle.

There was one case of slight erythema and tenderness around the puncture site, but no instance of obvious infection. On occasion, when the catheter is passed, a twinge of radiculitic pain may occur as the tip of the catheter strikes a nerve root. However, we have had no case of postoperative radiculitis or paresthesia. Paralysis of the bladder has not resulted in any case and, indeed, it is our impression that the incidence of postoperative catheterizations is actually reduced. No deaths attributable to the anesthesia have occurred.

Several instances of "massive spinal anesthesia" were encountered when only 15 mg. of metycaine was used. The first two of these occurred in elderly, chronically ill patients, both of whom had carcinoma of the stomach and for whom gastric operations were contemplated. Cutaneous analgesia from toes to chin appeared at once. Within sixty to ninety seconds the blood pressure, pulse, and for a short time, respiration collapsed. Both patients responded to supportive measures and withdrawal of spinal fluid. It was thought at first that the catheter had been threaded too high. Three subsequent cases occurred, however,

in which the operation was in the lower part of the abdomen. The common factor in all these cases was dehydration. In the last 3 cases the patients had acute appendicitis, had been vomiting, and were somewhat dehydrated. Intravenous administration of fluids was not started until the initial dose of 15 mg. of metycaine had been given. In the first 2 cases, one patient was extremely emaciated and "chronically dehydrated." A palliative gastrostomy was being done. The other was thought to be well hydrated, but in retrospect, was found to have been on Wangenstein suction because of gastric retention throughout the night before operation. After this danger was recognized, and dehydration corrected before even the small initial dose of metycaine was given, no further difficulty was encountered. The exact mechanism of the "massive spinal" in the face of dehydration is not clear: whether the cerebrospinal fluid volume is "shrunk" and the agent, hence, not diluted as effectively, whether neural tissue is more susceptible when dehydrated, or whether there are still other factors which produce the phenomenon. It is suggested that, whatever the mechanism, it may be responsible for the "high spinal anesthetics" which occasionally occur using the conventional technics, and it is also suggested that the state of hydration of any patient who is to receive spinal anesthesia be carefully investigated.

One other complication of this method occurred in a patient operated upon before this study was undertaken, and is mentioned to stress the warning given under the description of the technic involved. In the process of inserting the catheter it was injudiciously withdrawn with the needle *in situ* and a portion of plastic catheter was sheared off and remained in the subarachnoid space. Since the patient was suffering from a carcinoma, no immediate attempt to recover the catheter was made. He was observed carefully, but since he suffered no ill effects, laminectomy was not performed. He never exhibited any untoward results from his mishap and subsequently died of the carcinoma, two years later. This complication can be avoided by adhering strictly to the rule of never attempting to withdraw the catheter after it has passed through the opening in the needle without first withdrawing the needle.

Failures.—Our results were classified as "perfect," "satisfactory" or "unsatisfactory." In most of these cases the results were rated as "perfect." If the patient had some discomfort, as they occasionally did when the viscera were handled, but it was not sufficient to resort to the use of supplemental anesthesia, the procedure was considered "satisfactory." If another anesthetic agent and method had to be used, the procedure was considered a failure. In Lemmon's (7, 8) original paper, he stated that in 200 continuous spinal anesthetics by the malleable needle technic, no instance occurred in which the spinal agent failed to "take." In 1950, Dripps (11), in a comparative study of the two technics of continuous spinal anesthesia, indicated that in approximately 1,000 anesthetics in which the malleable needle was used there was an incidence of absolute failures of 33 or 3 per cent, while in approximately 500

catheter cases there were 43 or 8.5 per cent absolute failures. In our study, there were 13 failures in the 330 cases in which metycaine was used (Groups A and B), and no failures in the two smaller studies in which procaine and xylocaine were employed (Groups C and D), giving an incidence of failure of 2.8 per cent in a total of 466 cases. Three failures were due to inadvertent insertion of the catheter into the peridural space and not recognizing it until the patient was prepared and draped for operation. Rather than perform another puncture at this time, the procedure was abandoned in favor of another method of anesthesia, and the case counted as a failure. In 3 other cases, anesthesia did not result after injection of what were considered adequate doses of drug. The administration of 100 mg. of 5 per cent metycaine through the catheter resulted in excellent anesthesia. Drug resistance is eliminated as a possible cause since the agent was the same, and only the concentration varied. The only explanation we can offer is that there is an individual variation in response to drugs. Another failure occurred in a patient undergoing cholecystectomy. The catheter was passed 34 cm. and a total of 90 mg. of metycaine given in 15 mg. portions. Spotty analgesia was obtained which was not high enough. When the plastic catheter was withdrawn it was found to have assumed a serpentine form and it is thought that it was curled back upon itself in the subarachnoid space. Two other similar failures occurred, in both of which a level of anesthesia was obtained which was inadequate for the procedure. It is our belief that in these two cases, the catheter may have taken a caudal course through the needle rather than the cephalad course which we envisioned. Unfortunately, roentgenograms were not taken and we have no way of being certain whether our guess is correct. In another case, in which an orthopedic procedure was performed on the lumbar spine, the catheter was inadvertently dislodged during the surgical manipulations. We include this as a failure, since it resulted from the nature of the anesthetic method being used. Such interruption of anesthesia would not be a potential danger with the single dose method of spinal anesthesia. In the remaining 3 cases in which no anesthesia was obtained, no reason for the failure could be ascertained. In all, free flow of spinal fluid could be obtained from the end of the catheter after the needle had been withdrawn. Dripps has speculated that such an occurrence might be explained by the presence of meningeal openings, made by the needle, which were large enough to cause leakage of spinal fluid into the peridural space. Such fluid might then conceivably appear in a catheter which was situated peridurally, leading the anesthetist to the false assumption that the catheter was placed correctly in the subarachnoid space.

COMMENT

In the Baltimore groups no attempt is made to rely solely on the spinal anesthesia to maintain the patient through the surgical procedure, if such a course appears to be unwise. Whenever an indication

exists for supplemental anesthesia, it is used unhesitatingly. Many of our patients are operated upon for neoplasms. Almost routinely, these patients are given sodium pentothal and nitrous oxide analgesia as supplement to spinal anesthesia in order to permit freedom of discussion of the pathologic conditions found at operation, without unduly alarming the patient. Any patients who are considered emotionally unsuitable to remain awake throughout their operation, or any patient who express a desire to be asleep, are also given light pentothal and nitrous oxide analgesia. Before the analgesia is induced, the sensory level of spinal analgesia is carefully determined and its efficiency evaluated. The patient is then rendered analgesic and the operation proceeds.

It is our thought that with still further perfection of technic, we will be able eventually to achieve even greater success in terms of safety to the patient with this method of anesthesia. It is not unreasonable to assume that if leg amputations can be done under anesthesia with 15 mg of metycaine simply by placing the metycaine around the nerve roots which are desired to be affected, then upper abdominal surgery, such as cholecystectomy and so forth, can also be done with doses of the same magnitude if the drug can be placed precisely where it is needed. The revolutionary concept inherent in the Tuohy technic, namely, the avoidance of excessive concentration of anesthetic agent at the level of the second lumbar segment, may in time prove to be the answer to those of us who are seeking to eliminate as much as possible the undesirable sequelae of spinal anesthesia. Saklad (1) recognized this need to eliminate damage to the subarachnoid nerve elements, particularly the cauda equina, and developed a technic of segmental anesthesia limiting the extent of sensory, motor and autonomic effects. We believe that the results of our clinical study tend to confirm the theoretical advantages postulated by Saklad in his study, and by us before this study was undertaken.

Several other considerations come to mind. This method lends itself well to the teaching of surgical technic, since both the teacher and the pupil are freed from the need for haste. It appears to be preeminently suited to the needs of the surgeon in the small community hospital, who oftentimes must be his own anesthetist as well as surgeon. With a relatively inexperienced team he can achieve, in most instances, adequate anesthesia, even in the upper part of the abdomen, and maintain it for as long as he wishes. An interesting sidelight of this study is the facility with which this method can be adapted to the clinical testing of new agents for spinal anesthesia, as illustrated in our study of xylocain hydrochloride.

SUMMARY

A concept of continuous spinal anesthesia, utilizing the Tuohy catheter, is presented. The catheter is passed a variable distance up the subarachnoid space, thus delivering the analgesic agent to the specific anatomic site directly rather than by diffusion.

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SIXTH NEW YORK POSTGRADUATE ASSEMBLY

The New York State Society of Anesthesiologists has announced the Panel Subjects and Panel Chairmen for its Sixth Annual Postgraduate Assembly to be held in New York City, December 10-13, 1952. They are:

Instruments of Medical Measurement	Albert Faulconer, M.D.
Obstetrical Anesthesia	Virginia Apgar, M.D.
Shock Mechanisms	Ephraim Shorr, M.D.
Temperature Regulation	Eugene F. DuBois, M.D.
Intravenous Therapy	Henry T. Randall, M.D.
Respiratory Acidosis	Herbert C. Maier, M.D.
Physiological Changes During Cardiovascular Surgery	George H. Humphreys, M.D.
Jurisprudence in Anesthesiology ...	Harry A. Gair, Esq.

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