THE USE OF LUCAINE IN THE STUDY OF SPINAL ANESTHESIA *

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LUCAINE, a local anesthetic of the piperidine group, has been investigated by four groups of clinicians during the past three years (1, 2, 3, 4). According to these workers, when the drug was used for the production of spinal anesthesia there was relatively little block of motor nerves. This ability to interrupt the conduction of pain impulses and to spare conduction along motor paths suggested the use of lucaine for pain relief during urologic procedures (2, 3), child birth (1, 4), extrapleural thoracic operations (3) and other instances in which profound motor relaxation is not essential. The statement was also made that hypotension is less severe following spinal anesthesia produced by lucaine since motor paralysis is minimal or absent altogether (2, 3). The use of the drug in 780 patients has been reported to date.

We have injected lucaine into the subarachnoid space of 210 patients in an attempt to evaluate this new local anesthetic agent. Our conclusions, on the basis of this work, differ somewhat from those of the groups referred to previously. We do not believe that the drug will gain favor with the average clinical anesthetist, primarily because inadequate anesthesia can be anticipated in 6 to 8 per cent of the cases. Dependability, therefore, appears to be lacking.

On the other hand, there are a number of reasons for describing the actions of lucaine in more detail. The drug offers an unusual opportunity to the investigator and teacher interested in spinal anesthesia. It permits, for example, an analysis of the role of muscular weakness or paralysis in the production of hypotension associated with spinal anesthesia. It enables one to study the differential action of a local anesthetic on sensory modalities. In patients under the influence of lucaine one can study the neurophysiologic mechanisms responsible for muscular relaxation and find justification for the thesis that block of afferent impulses may be sufficient for its production. Finally, the drug is useful in teaching since one can compare its action with that of standard substances producing greater intensity of nerve block in the subarachnoid space.

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METHODS

Patients were unselected as to age, sex and types of operative procedures (tables 1 and 2). Lumbar puncture was performed with a 20 gauge needle in the obstetric series, and with a 20 or 22 gauge needle in the other groups. A pressor drug was injected intramuscularly before the administration of spinal anesthesia in 28 per cent of the

TABLE 1

TYPE OF PROCEDURE (210)

1. Obstetrics	
Vaginal delivery	103
2. General Surgery	
Perineal	29
Lower extremity	16
Herniorrhaphy	4
Intra-abdominal	3
Total	52
3. Urology	
Transurethral	22
Suprapubic	5
Testis	3
Total	30
4. Gynecology	
Perineal	24
Intra-abdominal	1
Total	25

cases. Various dosages were used (table 3). The drug is difficult to get into solution in concentrations in excess of 1.0 per cent (1 cc. = 10 mg.). In the majority of patients a 1 per cent solution was injected. When glucose was used, a 10 per cent solution was diluted with an equal

TABLE 2

AGE OF PATIENTS

Years	Female	Male
10–19	11	5
20–29	75	4
30–39	44	6
40–49	13	5
50–59	7	8
60–69	1	18
70–79	1	12
	152	58

volume of cerebrospinal fluid prior to the addition of lucaine. The specific gravity of a 1 per cent solution is 1.012 if cerebrospinal fluid is used, or 1.024 if 10 per cent glucose is used in equal parts with cerebrospinal fluid (1).

TABLE 3

DISTRIBUTION OF CASES ACCORDING TO DOSE AND VEHICLE

Dosage, mg.	Glucose, 5 per cent	Cerebrospinal Fluid
20	103	32
30	24	20
40	19	10
60	2	0
	148	62

The patients were observed in the postoperative period on the day of operation, second, fourth, sixth and ninth postoperative days and were contacted by mail or telephone at the end of six to twelve months.

RESULTS

Adequacy of Anesthesia.—Sixteen (8 per cent) of the 210 patients had insufficient pain relief. In each there was some diminution in the discomfort produced by pinprick, but the incision or other superficial operative manipulations caused severe pain. Eleven (18 per cent) of the failures occurred in the group of 62 patients who received lucaine dissolved in cerebrospinal fluid. In only 3 per cent of the group of 148 patients injected with lucaine dissolved in the solution containing glucose was anesthesia inadequate (table 4).

Onset and Duration of Action.—Peak intensity of action was reached more slowly than with procaine. Maximal intensity was frequently delayed for eight to twelve minutes. Only 53 of the procedures required more than one hour for their completion, so that it is impossible to use the entire series for determining duration. The average duration of anesthesia in the 53 cases was seventy-five minutes, the range from sixty to 120 minutes.

Degree of Muscular Paralysis.—Some diminution in motor power in the lower extremities occurred in every case. In 115 patients (55 per cent) the extent of this paresis was classed as barely perceptible

TABLE 4

RELATIONSHIP OF DOSE AND VEHICLE TO ADEQUACY OF ANESTHESIA

Dosage, mg.	Glucose			Cerebrospinal Fluid		
	Total No.	Inadequate		Total No.	Inadequate	
		No.	Per Cent		No.	Per Cent
20	103	4	4	32	7	20
30	24	0		20	3	15
40	19	1	5	10	1	10
60	2	0		0	0	
	148	5	3	62	11	16

or minimal (table 5). As the table indicates, a greater degree of paralysis occurred as the dose of the drug was increased.

Decrease in Blood Pressure.—One hundred and forty-six of the 210 patients received no pressor drug prior to the induction of spinal anesthesia. The blood pressure reactions of these individuals are listed in table 6 according to the level of sensory anesthesia and the extent of muscular weakness or paralysis in the legs. Twelve patients (15 per cent) with barely perceptible motor involvement, and 10 patients (16 per cent) with partial or complete motor block had decreases in blood pressure in excess of 25 mm. of mercury. There appeared to be no correlation between hypotension and paralysis of leg muscles.

TABLE 5

EFFECT OF DOSE AND VEHICLE ON THE DEGREE OF MOTOR PARALYSIS OF THE LEGS

	Minimal*	Partial*	Complete*
	A. 20 mg.		
Glucose	70	32	1
Cerebrospinal Fluid	17	15	0
	B. 30 mg.		
Glucose	11	9	0
Cerebrospinal Fluid	14	9	1
	C. 40 mg.		
Glucose	1	6	3
Cerebrospinal Fluid	2	14	3
	D. 60 mg.		
Glucose	0	0	2
Cerebrospinal Fluid	—	—	—
	115	85	10

* Minimal block refers to a sensation of heaviness in the legs or barely perceptible interference with motor control. Partial block refers to all degrees of weakness between minimal and complete.

Muscular Relaxation.—Only 10 intra-abdominal operations were attempted. Four of these patients were able to tense the abdominal wall voluntarily just before the incision was made. These 4 were then anesthetized just to the point of unconsciousness with pentothal and nitrous oxide. In all there was flaccidity of the abdominal muscles during the operation. The dosage of lucaine in the remainder was sufficiently great to provide muscular relaxation by direct block of motor nerves.

Sequelae.—The incidence of headache following spinal anesthesia

was the same as that following procaine, pontocaine or nupercaine in our clinic, namely 15 per cent for all patients other than those in obstetrics in whom the frequency rose to 26 per cent. Criteria for listing a headache involved one or more of the following: (1) one which was *definitely different* from any previously experienced by the patient; (2) one which was obviously related to *assumption of the erect position,* that is, either brought on only by this maneuver, or made a great deal worse by it; (3) headaches with predominantly *occipital and nuchal components* including stiff neck, pressure over the neck, spasm of neck muscles or pair across the shoulders; (4) headaches or perhaps more accurately "pains" localized in or *behind the eyeballs* and related to assumption of the head-up position; (5) headaches *relieved by abdominal compression,* that is, supposed increase in extradural pressure.

TABLE 6

RELATIONSHIP BETWEEN INITIAL BLOOD PRESSURE, LEVEL OF SENSORY ANESTHESIA, DEGREE OF MOTOR PARALYSIS IN LEGS AND CHANGE IN BLOOD PRESSURE AFTER SPINAL ANESTHESIA (NO PRESSOR DRUG).

B.P. Decrease, mm. of mercury	Minimal Motor Block		Partial or Complete	
	Average Sensory Level	No. of Cases	Average Sensory Level	No. of Cases
A. Initial systolic pressure less than 120 mm. of mercury				
0–20	D8	41	D8	35
25–50	D6	3	D7	1
B. Initial systolic pressure 120 to 160 mm. of mercury				
0–20	D8	28	D9	17
25–50	D8	7	D8	5
C. Initial systolic pressure above 160 mm. of mercury				
0–20	L3	1	D12	2
25–50	D7	2	D7	1
60–100	—	—	D4	3
		82		64

Undoubtedly, some headaches have been included which may not have been related to spinal anesthesia, but we believe that this number is not large. It is our opinion that those investigators who omit from their data headaches which are brief in duration (that is, less than three days) or are mild in intensity are begging the question if such headaches satisfy any or all of the above criteria.

There was no apparent difference in postoperative nausea or vomiting, or in immediate or delayed (six to twelve months) neurologic complications following the use of lucaine.

COMMENT

Several observations of note have been recorded in this series.

The addition of glucose as a diluent of lucaine appeared to increase significantly the intensity of sensory anesthesia. The number of patients to whom lucaine was administered in cerebrospinal fluid and who thereafter had inadequate relief of pain was five times that noted in the glucose series. It should be pointed out that Schotz (3) administering lucaine in spinal fluid, found that 30 mg. of the drug was required for anesthesia of the lower extremities, whereas Roman and Adriani (2) using glucose, needed only 10 mg. for similar procedures. Furthermore, Finer and Rovenstine (1) reported an increased duration of action when glucose was added. Two possible explanations come to mind. The increase in specific gravity of the anesthetic solution resulting from the addition of glucose might have caused greater exposure of the posterior roots than occurred when the drug was dissolved in spinal fluid, or the glucose itself might have affected the nerve roots directly in such a fashion as to influence conduction. This latter possibility is being investigated in animals. Whatever the ultimate explanation, it is apparent that the addition of glucose may be of importance other than to provide better control of the level of spinal anesthesia.

The alleged ability of lucaine to provide sensory anesthesia and spare motor function is probably not a specific property of this drug but is, rather, a function of the concentration and dosage. Two facts tend to support this belief. Complete and reversible motor paralysis can be achieved readily with lucaine by increasing the concentration from 1 per cent to 2 per cent and by increasing the dose to 40 to 60 mg. In addition, this characteristic of lucaine can be reproduced with other local anesthetic drugs. For example, injection of an 0.2 per cent solution of procaine into the subarachnoid space results in block of vasomotor fibers and those nerves subserving the sensation of the pain of pinprick (5). Other sensory modalities such as touch, pressure, vibration, temperature and sense of position are spared and there is, of course, no motor block. This situation appears to be analogous to the use of lucaine in doses of 20 to 30 mg.

The value of a local anesthetic which produces minimal interference with motor nerves when used for spinal anesthesia remains to be proven. Certain clinical impressions referred to in the introduction deserve comment, however. In obstetrics preservation of a voluntary expulsive force may well be useful. Barnes and Hapke (4) stated that lucaine provided adequate pain relief in 95 per cent of a series of 362 patients delivered vaginally. The frequency of the use of forceps rotation or midforceps was 2.3 per cent in this group and 6 per cent in a comparable series of 300 patients delivered with nupercaine as the spinal anesthetic agent. If substantiated, this could prove to be of real importance and would justify extensive studies. It is possible, but unlikely, that the use of such a technic might be followed by a de-

creased incidence of thrombophlebitis. There are no data on this. The suggestion has been made that lucaine be administered for extrapleural thoracic operations since it would not endanger respiratory activity, but no one has reported on such cases. Finally, the claim has been made that absence of motor paralysis accompanying spinal anesthesia should reduce the incidence of hypotension. Our data do not support this assumption. It should be recalled that Sarnoff and Arrowood (5) have shown with differential spinal block that the role of muscular paralysis in the genesis of the hypotension caused by spinal anesthesia is limited. These workers recorded decreases in arterial pressure in patients subjected to differential block which were of the same order of magnitude as those seen after full spinal block. It is possible that interference with the thoracic pump mechanism by weakening or paralyzing muscles of respiration might contribute to the lowered blood pressure, but it is apparent that the leg muscles contribute relatively little to circulatory adequacy while the patient is horizontal.

The use of lucaine for spinal anesthesia *does* provide an opportunity for studying the neurophysiologic basis for the production of muscular relaxation. Although the series was small, it seemed that interruption of the sensory portion of the reflex arc concerned with maintenance of muscle tone could provide satisfactory relaxation for intra-abdominal operations if voluntary muscular activity was prevented by a light plane of general anesthesia. Similar observations have been made by other investigators (1, 2, 3) but the significance of this in clinical anesthesia may not have been stressed sufficiently. A description of the mechanisms responsible for muscle tone will, therefore, be presented briefly.

If pull is exerted upon a tendon, the muscle of that tendon actively resists the extending force. This resistance is a reflex contraction and is known as the stretch reflex. The knee jerk so frequently elicited in clinical medicine is in reality a brief stretch reflex. It is obtained by tapping the tendon of the quadriceps at a point where it is unsupported by bone, thus imparting a brief and slight stretch to the muscle.

The afferent pathway for such a stretch reflex arises within the muscle itself, originating in proprioceptive tension receptors. The nerve impulse travels to the spinal cord where it may activate internuncial neurons locally and thereby cause a discharge of electrical activity down a motor nerve to the muscle. This is the simplest reflex arc. In the intact individual, however, the sensory discharge ascends higher in the central nervous system, reaching the cerebral cortex in many instances. From here impulses descend by way of the pyramidal tract or over the extrapyramidal system to influence the anterior horn cells in the spinal cord, and thus effect a muscular contraction.

If unlike the single stimulus of the reflex hammer at the knee, there is a long-maintained stretch of muscle, afferent nerves from the muscle carry a steady, asynchronous discharge of impulses toward the reflex

centers. When subjected to this steady asynchronous impulse barrage, the motoneurons respond with a discharge of low frequency which results in maintenance of smooth tension. This stretch-evoked reflex activity is the mechanism responsible for "tone" in striated muscle.

If the tendon to the muscle is cut, allowing it to slacken, tone disappears. If the sensory nerve supply of the muscle is blocked, tone disappears in that muscle. If the background of impulses impinging upon the motoneurons from higher centers is diminished or abolished by severing the spinal cord, tone disappears from the muscles innervated from below the section, that is, the phenomenon of spinal shock.

Block of sensory nerves alone, therefore, can cause a diminution or abolition of muscle tone. Since motor nerves are unaffected, however, activity set up in motor paths by reflexes arising outside of areas involved in the sensory block can initiate muscular contraction at any time. It is for this reason that supplemental general anesthesia is so frequently necessary.

The problem of muscle tone, and analyses of abnormalities of stretch reflexes manifested by spasticity and rigidity require much more work before their solution is complete. Drugs such as lucaine may be useful in such studies.

SUMMARY

Lucaine, a local anesthetic of the piperidine class, has been administered to 210 patients for the production of spinal anesthesia. The following conclusions have been drawn:

The use of glucose as a solvent for the drug increased the intensity of the resulting anesthesia. There were, for example failures in 18 per cent of cases when cerebrospinal fluid was used as a diluent and in only 3 per cent when 10 per cent glucose and cerebrospinal fluid were mixed in equal volumes.

There did not appear to be justification for the belief that retention of motor power in the legs during spinal anesthesia would reduce the incidence or severity of hypotension.

Lucaine permits an analysis of the neurophysiologic basis for the production of muscular relaxation.

The most promising clinical field of usefulness for lucaine appears to be obstetrics. Other possible uses of the drug are listed.

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