SPINAL ANALGESIA WITH LUCAINE®: A CRITICAL APPRAISAL BASED ON 6,000 CASES

BARNETT A. GREENE, M.D., SAMUEL BERKOWITZ, M.D., EMANUEL FELDMAN, M.D., MORRIS GOLDSMITH, M.D., AND BARNARD ROBBINS, M.D.

THE use of Lucaine® * hydrochloride for spinal analgesia without extensive or profound motor paralysis was first reported in 1947 by Finer and Rovenstine (1). Even though the principal features of this type of anesthesia were confirmed by Roman and Adriani (2), Cull and Schotz (3), Barnes and Hapke (4), De Vivo (5), and Greene and Biezunski (6), the drug has not been utilized widely. This may be due to one or more of the following reasons:

1. Lack of appreciation of the many indications for analgesia without significant paralysis of voluntary muscles.
2. Apparent undependability. "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" (7).
3. *The absence of standardized and appropriate techniques.*
4. *Unconvincing and inaccurate earlier accounts of the behavior of arterial blood pressure, particularly stressing the retention of motor power in the lower extremities as an aid to the maintenance of blood pressure.*
5. The relatively high incidence of postpuncture headache and the possibility of disproportionately serious neurological sequelae when spinal anesthesia is employed for the minor procedures which are particularly suitable for Lucaine spinal analgesia.

Each of these possible obstacles to the regular use of Lucaine spinal analgesia is considered below. Our material and methods are presented in relation to these considerations.

INDICATIONS FOR SPINAL ANALGESIA

Listed below are the large number and variety of procedures which we have managed with Lucaine analgesia.

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* Lucaine® hydrochloride, brand of piridocaine hydrochloride, was generously supplied by Maltbie Laboratories, Inc., 240 High St., Newark 1, New Jersey.

List of Procedures

Anorectal operations	650
Proctoscopy	25
Pilonidal operations	203
Cystoscopy	244
Transurethral operations	74
Circumcision	16
Bartholin cyst, excision	24
Vaginal plastic repair	192
Supracondylar amputation	10
Saphenous vein, ligation and stripping	214
Superficial lesions of feet, toes or sacro-iliac areas	141
Uterine curettage	84
Culdoscopy	200
Orchidectomy	18
Varicocelectomy	31
Hydrocelectomy	24
Herniorrhaphy, inguinal or femoral	74
Appendectomy	82
Suprapubic cystotomy	41
Labor and vaginal delivery	3,400
Cesarean section	225
Lumbar aortography	39
Upper abdominal wound dehiscence, closure	6
Upper abdominal and thoracic wall procedures	24
	6,041

For diagnostic examinations, for example culdoscopy, and for various minor operations in the lumbosacral zone, analgesia need not be accompanied by any muscular paralysis, even of the rectal sphincter. Many surgical or obstetrical procedures require only relaxation of muscles innervated by sacral nerves. In several types of superficial abdominal operations, for example inguinal or femoral herniorrhaphy (and others listed above), abdominal relaxation is quite adequate with blockade of only the sensory portion of the spinal cord reflex arc; when analgesia is effective and the patient is cooperative or lightly asleep, the patient does not exercise the retained voluntary contractility of the abdominal wall.

Whenever possible, spinal anesthesia should be restricted to analgesia with minimal or no muscular paralysis, just as general anesthesia is maintained at a light plane unless greater depth is required. Provided that other considerations do not forbid any form of spinal anesthesia, an analgesic block is indicated especially when the retention of thoracolumbar muscular control is particularly valuable to the patient, the surgeon, or the anesthesiologist. Such indications are the following:

1. When it is desirable to have a parturient utilize the accessory forces of labor. With analgesia to the ninth thoracic and with motor paralysis below the first lumbar nerves, the patient can cooperate in "bearing down" to assist the descent and the expulsion of the fetus at the request of an observer palpating uterine contractions; coopera-

tive "bearing down" is helpful, but it is less efficient than normally because the sensory pelvic reflex pathways are blocked. During an appropriate block, however, vomiting becomes a powerful propelling force because both the sensory and the motor components of the vomiting reflex are unaffected while the pelvic floor is relaxed.

Despite a favorable experience with more than 5,000 "obstetrical saddle blocks" with nupercaine, 1:200, and glucose (8), we now prefer Lucaine spinal analgesia. In over 90 per cent of the latter type of block, the patient has been able to lift her hips, move on and off the stretcher and the delivery table, and exert effective intra-abdominal pressure. The patient has always been able to cough, vomit, and breathe normally even though, at times, the level of analgesia rose to the fourth thoracic nerves.

2. When it is advantageous to have the patient assume and maintain an abnormal position, as for culdoscopy, proctoscopy, or lumbar aortography. The motor cooperation of patients, especially if obese or pregnant, not only eases the duties of personnel in operating, labor, and delivery rooms but also is desirable for various clinical reasons.

3. When it is essential to retain full respiratory activity during deliberately high spinal analgesia. There have been many instances when spinal analgesia to the third thoracic nerves has been the simplest and the most expeditious means of managing good-risk patients for superficial surgery in the upper abdominal or thoracic area. The patients were obliged to lie in a prone or a lateral position; regional block was regarded as impracticable or inadequate; endotracheal intubation would have been required for the safe use of general anesthesia. With Lucaine in appropriate dose and technique, we have always obtained satisfactory analgesia to the third thoracic nerves without significant motor paralysis or respiratory difficulty. The following 3 cases exemplify this indication: (a) A lipoma, 10 by 7 cm., in the left lateral wall of the chest in a 24 year old, 240-lb. male with a "bull neck." (b) A fibrosarcoma, 5 by 5 cm., deep in the posterior midline at the level of the fifth thoracic vertebra in a 44 year old muscular male. (c) A lipoma, 12 by 8 cm., in the right upper quadrant of the anterior abdominal wall in a 50 year old vigorous female weighing 230 pounds.

4. When it is vital that the patient be able to vomit effectively. Spinal anesthesia commonly is chosen to avoid the hazard of aspiration when a patient has a full stomach. Yet paralysis of a major portion of the abdominal wall, as produced by extensive and profound spinal anesthesia, removes or seriously diminishes the ability to vomit forcefully. However, with an analgesic dosage and technique, even a sensory level to the third thoracic nerves permits effective vomiting. This feature has been especially valuable, for example, in the emergency closure of an upper abdominal dehiscent wound in a 64 year old vigorous male after a hearty breakfast.

5. When it is important to have an efficient cough. With a predominantly analgesic block, regardless of its cephalad level, a patient is able to cough vigorously. The patient whose tracheobronchial tree is markedly "wet" can clear it well if necessary during analgesia. The patient can cough to delineate a hernial sac or test its repair if the surgeon so desires.

6. When it is necessary to retain a forceful expiratory phase of respiration. The voluntary and reflex muscular assistance of the abdominal parietes is important for optimum ventilation of the patient with marked obesity, emphysema, asthma, or expiratory dyspnea of any origin. There is no effective substitute for the patient's own power of vigorous *expiration* during anesthesia for operation or delivery. The following 2 cases illustrate this use: (a) Suprapubic cystotomy in an obese, plethoric, 64 year old male with marked bronchitis, emphysema, and asthma. (b) Exploratory celiotomy and cecostomy in a 54 year old female, dyspneic because of extreme obesity and severe distention secondary to obstruction in the transverse colon.

An incidental but noteworthy advantage of an analgesic block is the absence of a distressing degree of paresthesia and numbness which often are associated with profound spinal anesthesia and motor paralysis.

In general, an analgesic block is selected for *suitable* procedures when:

1. A lateral or a prone position is necessary during operation.
2. Marked obesity, abdominal distention, bronchitis, asthma, or emphysema is present, especially if analgesia is required for longer than thirty minutes.
3. Food has been ingested within four hours of operation or onset of surgical or obstetrical pain.
4. The patient has a short, thick neck or other type of potentially troublesome airway, a massive build, or other possible obstacle to smooth induction of general anesthesia.
5. The patient prefers to remain awake.
6. The pelvic musculature is the only group to be paralyzed.
7. The patient is to be delivered of a live fetus, especially if premature or immature.

The contraindications to any form of spinal anesthesia, for example lumbar skin infections, septicemia, and potential or known disease of the central nervous system, apply to the use of Lucaine. Psychiatric or psychological hazards, hypertension, hypotension, and marked hypovolemia are relative contraindications to be corrected or controlled if other circumstances warrant the use of spinal analgesia.

RELIABILITY

Sensory block without motor paralysis is obtainable with any local anesthetic agent if its concentration and dosage are just below those

which affect motor fibers. To produce a "differential block," we formerly used fractional and single-dose subarachnoid and epidural injections of procaine, Pontocaine®, or nupercaine in dilute and concentrated solutions, with and without postural control (9–12). An analgesic dose of Lucaine attains the same effect without the need for fractional methods or large volumes of solvent; it also avoids the mandatory use of a hypobaric technique which is awkward or undesirable for most operations on a supine patient.

Lucaine is as dependable for spinal analgesia as any other drug. Since the standardization of our technique, failures have occurred in 0.4 per cent of cases, the same incidence as with other agents in our experience. Inadequate analgesia is attributable, with rare exceptions, to faults in technique or lumbar puncture, dosage, or positioning of the patient. The relatively high incidence of unsatisfactory effect in earlier studies of Lucaine was probably due to the following 3 factors:

1. Cerebrospinal fluid as the solvent. A solution of a relatively small weight of anesthetic agent in spinal fluid is unreliable in behavior because the intraspinal spread of the anesthetic solution is unpredictable when its specific gravity differs little from that of spinal fluid alone. This is as true of 1 per cent Pontocaine and 0.5 per cent nupercaine as it is of lucaine. The specific gravities of 0.5 and 1.0 per cent of Lucaine hydrochloride in spinal fluid (one having a specific gravity of 1.008) are 1.011 and 1.012, respectively (1); these vary too little from the common range of spinal fluid specific gravity. Spinal anesthetic solutions are dependable and controllable only when they are significantly hyperbaric or hypobaric.

In our preliminary study, analgesia with Lucaine in spinal fluid frequently was unsatisfactory in degree and extent, confirming the report of Conner and Dripps that 18 per cent of 62 cases with Lucaine in spinal fluid were failures, whereas only 3 per cent of 148 anesthesias with Lucaine in glucose solution were inadequate (7). With definitely hypobaric or hyperbaric solutions, the reliability and the controllability of analgesia are increased greatly. The potentiating effect of glucose in a spinal anesthetic solution, to which Homeyer, Mintz, and Adriani called attention (13), is clinically important with Lucaine. Lucaine in 5 or 10 per cent glucose is more analgesic than the same dose of the drug in spinal fluid or distilled water.

2. The performance of lumbar puncture by residents. In several earlier investigations, Lucaine apparently was administered largely by residents. To reduce failures due to technical errors, our patients were managed by visiting anesthesiologists; few were injected by residents and these were supervised closely.

3. Several of the operations for which analgesic doses of Lucaine were selected in some published series were unsuitable for surgery in the absence of extensive muscular paralysis, for example deep intraperitoneal surgery, especially with the patient awake.

RECOMMENDED TECHNIQUE

After trial of various doses and solvents, we have standardized the technique and recommend the following schedule:

1. For analgesia below the fifth lumbar vertebra, 15 to 20 mg. of lucaine in 1.5 to 2.0 cc. of solvent. The quantities of lucaine and solvent vary with the patient's height, weight, and age, which modify the degree and the duration of spinal analgesia.

2. For analgesia to the first lumbar nerves 20 to 30 mg. in 2.0 to 3.0 cc. of solvent.

3. For analgesia to the eighth thoracic nerves, 20 to 30 mg. in 2.5 to 3.0 cc. of solvent.

4. For analgesia to the fourth thoracic nerves, 30 mg. in 4.0 to 5.0 cc. of solvent.

5. Hyperbaric solvents (5 to 10 per cent glucose) are employed for surgery or obstetrics. The hypobaric solvent is distilled water and is reserved for diagnostic procedures requiring the prone or the knee-chest position, for example culdoscopy (5), proctoscopy, translumbar aortography (14).

6. Ephedrine sulfate, 1 cc. containing 50 mg., or epinephrine hydrochloride, 0.6 cc. of 1:1,000 solution, replaces an equivalent volume of the solvent when analgesia is desired for more than 1 hour. Ephedrine prolongs it by thirty to sixty minutes, epinephrine by sixty to one hundred and twenty minutes; motor paralysis, however, is not potentiated.

7. The postural factors employed are: for true "saddle block," sitting thirty seconds, for "obstetrical saddle block," the horizontal position; for surgery cephalad to the groin, Trendelenburg of 10 to 15 degrees until hypalgesia reaches the desired height. A hypobaric solution is injected in the sitting position; the patient is then asked to assume immediately the desired posture (lateral, prone or knee-chest); if necessary, the table is tilted appropriately to spread or limit the analgesic zone.

8. In many instances of deliberately high spread of analgesia, its distribution may be segmental; for example, the zone of analgesia has a lower border from the first to the third lumbar vertebra. This observation demonstrates that 20 to 30 mg. are so near the minimal effective dose that the analgesic solution is rendered ineffective by dilution with cerebrospinal fluid in the caudal portion of the subarachnoid space. For this reason, when intense analgesia is desired in the sacral and the lumbar areas, Lucaine should be in hyperbaric solution and injected through the lowest lumbar interspaces, preferably in the sitting position; analgesia should be allowed to spread cephalad only after some of the Lucaine has been sent caudad by the use of the sitting or the horizontal position for thirty seconds.

9. An "obstetrical saddle block" usually is started when delivery is expected within two to three hours (8, 15). The dose then is 30 mg.

of Lucaine in 2 cc. of 10 per cent glucose and 1 cc. (50 mg.) of ephedrine sulfate. For the unusual instance when analgesia is desired for 3 hours or more, 0.6 cc. of 1:1,000 epinephrine is substituted for ephedrine. When delivery is certain within an hour, only 20 mg. of Lucaine in 2.5 to 3.0 cc. of 10 per cent glucose is required.

10. Analgesia begins a minute or two more slowly than with procaine but is adequate for surgery in five minutes. Stabilization of the level is not complete for about fifteen minutes; a vasopressor drug in the anesthetic solution delays fixation for an additional ten minutes. The cephalad spread of an analgesic block must be followed by the response to pinprick; the level is not demonstrated reliably by the cough test (16), which is dependable only in the presence of motor paralysis.

ARTERIAL HYPOTENSION

Hypotension is uncommon, mild, and gradual with an analgesic block, even at high levels (2–7). We therefore usually do not inject a prophylactic vasopressor in good-risk patients for most of the procedures listed earlier, contrary to our practice with profound spinal anesthesia; otherwise severe hypertension may be induced by the relatively unopposed action of the pressor drug.

The better maintenance of normal arterial pressure with analgesic doses and dilutions than with completely anesthetic solutions may be attributed to the 2 following differences in effect: (a) The onset and the spread of sympathetic nerve block is slower, permitting more time for compensatory mechanisms to maintain blood pressure. (b) In the absence of profound and extensive muscular paralysis, the respiratory variations of intrathoracic and intra-abdominal pressures are normal and continue to aid venous return in a physiological manner (17, 18).

These factors are more significant than the muscular mobility of the lower extremities, the reason emphasized by earlier investigators. Actually, the muscles of the lower extremities, though not paralyzed, remain motionless during operation and therefore do not assist venous return. Conner and Dripps (7) have proved (and our experience corroborates) that the absence of paralysis of the lower extremities bears no relationship to the incidence of hypotension.

The relatively benign effect of an analgesic block on blood pressure is not peculiar to Lucaine. It has been observed also with other agents [for example, intracaine (19) and Pontocaine (10)] when applied in doses and concentrations designed to produce analgesia without motor paralysis. Furthermore, even doses of procaine capable of paralyzing the lower extremities and the abdominal wall depress arterial pressure relatively little in normal subjects, in the horizontal position, in the absence of surgical and intraperitoneal trauma (17, 20). Such trauma is usually absent or minimal in procedures suitable for spinal analgesia with Lucaine.

There are some procedures, however, in which hypotension is common and severe with any form of spinal anesthesia, including those predominantly analgesic with Lucaine, Pontocaine, nupercaine, or procaine. In obstetrical patients (20, 21) and in operations on patients in a lateral or a prone position with torso flexed and legs hanging down (22, 23), hypotension is quite frequent, even with preanesthetic administration of a vasopressor. In these situations, arterial hypotension is primarily the result of mechanical and hydrostatic interference with venous return through the inferior vena cava and the veins of the lower extremities. We have confirmed, by arterial- and venous-pressure measurements correlated with various positions (unpublished observations), that pronounced arterial hypotension and retardation of venous return early in spinal anesthesia may be produced by (a) a full-term pregnant uterus lying on the inferior vena cava when the patient is supine, (b) an operating-table bar raised to obtain flexion or hyperextension, (c) a dependent position of the lower extremities. Similar and related observations have been reported by several investigators (20, 22–26), even with general or local anesthesia (22, 26) and without any anesthesia (24–27). Pooling of venous blood by mechanical and hydrostatic forces is facilitated and magnified by any form of sympathetic block because it decreases the tonus and increases the distensibility of veins (20, 28).

Appreciation of these causes of arterial hypotension is important because spinal analgesia is especially desirable for obstetrical procedures and for patients who are to lie in a prone or a lateral position. Hypotension in these circumstances usually is corrected by vasopressor medication, but it may be ineffective at times until appropriate mechanical measures or positional changes have been applied (20, 22, 24, 25).

POSTPUNCTURE HEADACHE AND NEUROLOGICAL SEQUELAE

Spinal analgesia with Lucaine is not likely to be popular among those who regard the risk of spinal anesthesia and its complications as too great for any but a major operation. In our hands, however, spinal anesthesia for minor purposes has been entirely satisfactory and remains the preference of our large group of surgeons in several hospitals predominantly serving private patients. We have never had any neurological sequelae other than "spinal headache." Even the latter has been reduced to an incidence of 0.3 per cent by the use of 24- and 26-gauge needles with hydration for prophylaxis (29–30). Spinal analgesia will become a regular part of an anesthesiologist's armamentarium only when he is expert in the art of spinal anesthesia, especially avoiding the unsuitable patient, performing lumbar puncture skillfully, and preventing postpuncture headache.

SUMMARY AND CONCLUSIONS

Subarachnoid Lucaine hydrochloride, in doses of 30 mg. or less, with and without epinephrine or ephedrine, offers a simple and de-

pendable means of obtaining any degree or extent of analgesia up to the third thoracic nerves without profound or widespread motor paralysis.

The retention of voluntary control of the muscles supplied by thoracolumbar nerves is valuable in obtaining the following 6 advantages:

1. Useful "bearing-down" force, for example in labor.
2. Ability to maintain voluntary control of lower extremities, as in knee-chest posture.
3. Full ventilatory activity regardless of the height of analgesia.
4. Capacity to vomit effectively, for example in the patient with a full stomach.
5. Forceful cough, for example in the "wet" bronchitic patient.
6. A vigorous expiratory phase of respiration, for example in the asthmatic, emphysematous, or very obese patient.

With an experience of more than 6,000 spinal analgesic blocks with Lucaine, we have standardized highly reliable techniques with hypobaric Lucaine for diagnostic procedures and hyperbaric Lucaine for obstetrical and surgical operations.

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