PERIDURAL ANESTHESIA FOR THORACIC SURGERY

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Peridural anesthesia has been administered for 2,172 thoracic surgical procedures at the Missouri State Sanatorium between October, 1945, and October, 1956. Almost every thoracic operative procedure has been performed utilizing this anesthesia, with the exception of the more complex intracardiac procedures. The patients' ages ranged from 9 to 73 years. It will be the purpose of this presentation to summarize our experiences with this technique.

Peridural anesthesia is a method of regional anesthesia in which the nerve impulse is obtunded by the injection of a local anesthetic drug into the space surrounding the spinal dura mater. This space is referred to as the peridural, epidural, or extradural space and extends from the sacral hiatus to the foramen magnum, with its periphery being formed by the walls of the vertebral canal. It contains venous and arterial plexuses, lymph vessels, adipose and connective tissues, and serves as a region for dispersal of the anesthetic solution. The actual site of action is controversial. The two most accepted views are: (1) The drug diffuses through the paravertebral foramina to where the spinal nerve roots have joined to form a mixed spinal nerve that is no longer ensheathed by the dura mater. Conduction is blocked at this area, and the resulting anesthesia is actually a multiple paravertebral block. (2) The drug diffuses through the dura and arachnoid mater into the subarachnoid space and cerebrospinal fluid in sufficient concentration to depress conduction in nerve tissue.

Local Anesthetic Drug

In selecting a local anesthetic drug, consideration must be given to the requirements of peridural anesthesia as a whole as well as to the special problems presented by this approach which involves the cervical and thoracic nerves. Since these particular segments of the nervous system control most of the muscles of respiration, complete blockade of their motor elements must be prevented. Considerable attention should, therefore, be given to the concentration of the anesthetic drug. For if the anesthesia is to be satisfactory, the drug must be in sufficient concentration to offer sensory but not motor anesthesia. The ideal drug should have a short latency period as well as a high

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diffusion ability that will minimize the incidence of partial or incomplete blocks and should produce a profound enough anesthesia for extensive surgical manipulation. Although duration of action is a desirable property, the ease with which a plastic catheter may be inserted and left in the peridural space diminishes the need for this property. Lidocaine (Xylocaine®) has been the most frequently used drug in this series, although other drugs such as hexylcaine ( Cyclaine®), 2-chloroprocaine (Nesacaine®), Win 3459-2 (Ravocaine®), tetracaine (Pontocaine®), piperocaine (Metycaine®), and procaine have been employed with varying success. Lidocaine has been preferred because of the excellent quality of anesthesia that it furnishes. This is particularly true when comparing dilute solutions. Concentrations of less than 0.5 per cent lidocaine will on occasion fail to furnish adequate analgesia in this technique, while a 1.0 per cent solution often offers unnecessarily high incidence of intercostal paralysis. The concentration most commonly employed during this series was 0.8 per cent with 1:250,000 epinephrine, which offered an effective conduction blockade averaging one hour.

Technique

Following application of the blood pressure apparatus and checking the emergency equipment, the patient is placed in a sitting position on the side of the operating table with marked anterior flexion of the lower cervical and upper thoracic vertebrae. The assistant faces the patient and places his chin over the patient’s occiput to keep the head flexed. He further supports the patient by holding his arms crossed anteriorly, which in turn pulls the shoulder girdle away from the site of injection. This position extends the spinous processes, bringing them into greater relief, thereby widening the interspace and facilitating introduction of the needle.

The skin is cleansed and painted with an antiseptic solution, the area draped, and a skin wheal made with the local anesthetic containing a vasopressor. The seventh cervical and first thoracic interspaces are the most accessible and, therefore, preferred as approach sites. A sharp-beveled, 18 gauge needle is used to create an opening in the skin to aid the entrance of the blunt, short-beveled peridural needle. The needle used for the thoracic approach should fit the following description: The shaft must be rigid enough to avoid deflection, have a large lumen to obtain maximum control for the operator during insertion, and most important, it must have a short, blunt bevel, which after piercing the ligamentum flavum will push the flexible meninges away without penetration. Needles have been prepared* to fit these specifications and have proven most satisfactory in clinical application.

The angle at which the peridural needle enters the interspinous ligament depends on the interspace chosen; however, it is always inserted

* Beecon, Dickinson & Co.
in the midline bisecting the angle between the spinous processes with the bevel cephalad. Entrance through the skin is made without difficulty because of the opening already created. In penetrating the supraspinal ligament, considerable resistance may be encountered owing to the bluntness of the bevel and the density of the ligament. Resistance encountered from the interspinal ligament is considerably less than that experienced with the supraspinal ligament. The needle is advanced through the interspinal ligament for a depth of 3 to 5 cm. to a third point of resistance, indicating that the ligamentum flavum has been reached. Should bone be encountered at this point, the needle should be withdrawn, as in spinal anesthesia, and reinserted (usually in a more cephalad direction). The stilet is now removed and a few drops of sterile saline solution are placed over the hub of the needle. The needle is advanced carefully through the ligamentum flavum until a definite "snap" is felt, indicating penetration of the ligament. The saline solution will disappear into the needle, demonstrating the negative pressure phenomena of the peridural space. This is referred to as the "drop sign," first described by Gutierrez (1). Three cubic centimeters of a normal saline solution are now injected to determine the resistance and to push the dura away from the bevel. This must be followed by gentle aspiration. Should spinal fluid or blood appear, or if there is any doubt as to the placement of the needle, the needle should be withdrawn and then reinserted until successful entrance into the peridural space is assured. When the bevel is lying in a venous sinus, the negative pressure is marked, and whenever a greater than average negative pressure appears, careful and frequent aspiration must follow.

A 10-cc. syringe is preferred for injecting the anesthetic drug because the force required to expel the contents of a larger syringe is so great that the needle could easily be pushed through the dura without the administrator's knowledge. While the syringe is being refilled, it is possible to recheck for the drop sign for assurance that the dura has not been penetrated. Frequent aspiration should be performed during injections. After approximately 5 to 10 cc. of solution have been injected, the patient may complain of pain in the shoulders, neck, back, or arms that is similar to the leg pain seen during the administration of an analgesic drug for caudal anesthesia. This pain may be rather disconcerting, causing the patient to become tense. The operator and his assistant encourage the patient to relax, and the rate of injection is slowed. This may be considered as further assurance that the needle is in the peridural space. The tense patient loses his negative pressure, and when the syringe is removed, the local anesthetic drug is forced back out the needle. This may be mistaken for cerebrospinal fluid. When the solution has dispersed itself, the pain resulting from the injection is gone, and as the patient relaxes, the negative pressure and drop sign invariably return. Fluid placed in the hub of the needle
pulsates with the circulatory rhythm and fluctuates with the respiratory cycle, while being sucked in by the negative pressure.

The time that should be allocated to the injection of the analgesic agent is somewhat controversial. Slow injections allow the drug to pool in areas of least resistance, whereas rapid injection forcefully disperses the drug throughout the space. Patients receiving slow injections have a greater incidence of spottiness or incomplete blocks, a slower onset of blockade, less discomfort during injection, and possibly less opportunity for a systemic reaction to the local anesthetic. Those receiving rapid injections have more rapid onset of anesthesia, more profound blockade with fewer incomplete blocks, more discomfort during injection, and possibly a greater incidence of toxic reaction. It is difficult to suggest a rate of administration that is applicable and desirable in all patients. Injection should be at a rate that produces a definite, but minimal, amount of discomfort in the dermatomes supplied by the spinal nerves located at the approach site. This permits verification of needle placement and assures a good quality of anesthesia. The total volume injected averages 30 cc. in the adult of medium size, but varies with the structural development of the vertebral column of the patient.

If the surgical procedure is of short duration and will definitely not exceed one and one-half hours, a single injection may be used and the needle withdrawn. For prolonged procedures, a catheter may be passed through the needle and left in place for administration of subsequent volumes of anesthetic solutions as necessary. We have used plastic tubing for the catheter in preference to the ureteral catheter. This tubing is relatively inexpensive and may be purchased in 100-foot rolls for division into desired lengths. Prior to autoclaving the tubing for use, the end to be inserted through the needle is rounded and smoothed to help prevent penetration of the dura during its placement. The tubing is also inserted into one of the peridural needles as far as the bevel and the area now at the hub marked with a dye. Three centimeters up from the hub the tubing is again marked. A wire stilet, similar to that used with urethral catheters, is now passed into the unprepared end of the tubing until it reaches the specially prepared end. During the actual placement of the catheter, the stilet augments the passage of the pliable plastic tubing, which is inserted into the needle until the first mark is at the hub. This indicates that the catheter has reached the bevel. The stilet is now withdrawn approximately 2 inches and the tubing is advanced until the second mark is now at the hub, indicating that 3 cm. of the catheter is within the peridural space, with no significance being placed on its direction or position. Leaving the wire stilet within the tubing aids in keeping the catheter in place while removing the needle. The stilet is now removed, the catheter is taped in place, and a sterile 10-cc. syringe with a short-beveled, 23 gauge needle, and containing 3 cc. of normal saline, is attached to
the loose end of the tubing. The saline is injected through the tubing to be sure there are no leaks along its course. Holes have been found by this procedure and are repaired by cutting the tubing at the site and splicing the two ends with the shaft of a 23 gauge needle, thus eliminating repeating the placement of the needle and catheter. This check eliminates the possibility of the anesthesiologist being unable to re-establish a block during a surgical procedure. The syringe and needle are wrapped in a sterile towel and placed near the patient’s head. The patient may be placed in the operative position immediately and preparation for the operation begun. The incision may be made in ten minutes following completion of injection. Prior to the administration of subsequent injections, 5 cc. of the analgesic drug should be injected and the patient observed for verifying that the catheter has not penetrated the dura or a blood vessel during its insertion.

MANAGEMENT

The technique of administering this anesthetic is not unusually difficult, but the management requires a thorough knowledge of respiratory physiology and experience with regional anesthesia. Every effort must be made to inform the patient as to what he may expect and will experience during the administration of the block and the operative procedure. Constant contact must be maintained with the patient to offer reassurance and to obtain maximal cooperation. It is important that the anesthesiologist be experienced in working with a conscious patient. He must be able to evaluate the patient’s reaction if he is to differentiate between a psychic response to operative manipulation, restlessness, discomfort, and actual pain. These responses are distinguishable to the alert and observant anesthesiologist. There are a few patients who groan throughout surgery and complain of everything. It is easy to associate their complaints with sounds from the instruments and cautery and not with painful, but silent, stimulation. Careful observation of reactions readily differentiates the patients who are suffering. Patients who are tired from a prolonged surgical procedure often move about late in the operation, and this may be mistaken for pain instead of restlessness. They may also express vague discomfort when the block begins to actively recede. If the block is allowed to wear off, they will inform you immediately by describing and locating a burning sensation in the area previously described as uncomfortable.

There is a very interesting series of events which occur prior to the termination of an effective block. During maximal sensory blockade, the arms and hands are relatively inactive. When the blockade is losing its effectiveness, the patient will gradually move his hands and fingers without clenching, and questioning at this time reveals there is no pain. Moisture is then noticed on the patient’s head and arms without pain being present. This is followed by a clenching of fists.
associated with slight discomfort. Very shortly thereafter, and quite suddenly, the patient will describe a burning sensation in the operative site. This all takes place over a ten-minute period and readily indicates the end point of a conduction anesthesia. Within five minutes after injection of a subsequent dose of lidocaine, the patient will again be pain free, and all the above signs will disappear. Obviously, the time to give a repeat injection is when the first moisture appears, providing a proper interval has elapsed since the previous injection to indicate the present block is losing its effect. Subsequent injections require varied concentrations of the anesthetic solution. This is determined by the effectiveness of the last injection and the time lapse since that injection. If the first blockade was not entirely satisfactory, if there was not an indication of impairment to respiratory function, or if the time since the first or previous injection has been such that the effect is almost gone, a concentration similar to the original solution is indicated. However, if the patient has evidenced undue motor blockade with the previous injection or the interval since the previous injection is less than average, the concentration should be reduced to 0.6 per cent or less. There is a compounded effect seen with repeat injections, and if repeat injections follow at too close an interval, muscle fibers are blocked and intercostal and diaphragmatic paralysis will result. For closure of bronchi and for re-expansion of collapsed lung, the patient is placed on positive pressures of oxygen by mask.

Physiological Disturbances

The physiological disturbances with this technique are predominately of the respiratory system. The patients whose preoperative ventilatory function was minimally impaired have presented few problems during surgery, and most are able to compensate without assisted ventilation. This is attributed to intact reflexes and an unanesthetized respiratory center that permits an increase in minute volume by increasing the respiratory rate. Patients with impaired ventilatory function, as is seen with emphysema, pulmonary fibrosis, asthma, previous pulmonary surgery, and damage from long standing disease (tuberculosis, histoplasmosis, or silicosis) are unable to compensate, thus necessitating assisted ventilation by face mask.

Although our management has appeared adequate from an objective view, it was decided that blood-gas and respiratory studies should be undertaken.† The study included a cross section of patients with varied degrees of impaired ventilatory function. The surgery for each patient was pulmonary resection as indicated. The study revealed that our management was sound. However, there appeared to be a greater degree of motor paralysis than was realized, which has prompted a reappraisal of the concentration of the anesthetic solution. Our present investigation may result in our lowering the concentration

† Results to be published.
of lidocaine to 0.6 per cent. The study also revealed that respiratory assistance was absolutely necessary for patients with moderate to severe impairment of ventilatory function, and advisable in any patient whose color or respiratory activity suggested inadequate ventilation. Compressed air proved to be adequate, although oxygen is the preferred agent except in the emphysematous patient.

Varying degrees of coughing will occur while the adhered lung is being freed, when sudden collapse occurs, and when excess traction is applied to the bronchial tree. This type of coughing is usually non-productive and is triggered by a "tickling" sensation in the larynx that is most annoying and difficult for the conscious patient to ignore or suppress. When the pleural adhesions are released, or when the lung is allowed to deflate gradually, many of the patients lose this laryngeal irritation. Some of the others can control this urge to cough and are aided by the use of intravenous morphine. However, there are patients whose coughing is so severe that it is impossible to proceed with the operation. In these patients, the main trunk of the vagus nerve, distal to the recurrent laryngeal nerve and proximal to the pulmonary plexus, is injected with 10 cc. of 1 per cent lidocaine. This completely controls the coughing paroxysms and is a worthwhile routine in all patients. Paroxysms of coughing seriously impair ventilation owing to the paradoxical respiration caused when the lung of the closed chest forces its contents into the lung of the open chest, because of obstruction of the glottis that intermittently accompanies the act of coughing. Voluntary coughing used to evacuate secretions seldom interferes with ventilation to any serious degree.

Hypotension is not an uncommon cardiovascular problem; however, it is usually moderate in degree and easily managed. When a majority of the cervical and thoracic nerves are blocked, it is apparent that hypotension is a logical sequela. This is managed by the prophylactic use of intramuscular vasopressors administered prior to insertion of the peridural needle.

Complications

There are few procedures which do not have associated hazards, and this one is certainly no exception. These complications are potential with any administration and best treated by adopting a routine which will aid in their prevention.

Subarachnoid Injection.—This is the most serious complication that is encountered with this technique. Large volumes of anesthetic solutions are injected close to the cranial vault with only the dura mater separating the solution from the cerebrospinal fluid. With the patient in the sitting position, and with the use of a large-bore, 18 gauge needle, the cerebrospinal fluid is forced out when the bevel is within the subarachnoid space. Cerebrospinal fluid will also be withdrawn by gentle aspiration with a syringe prior to injection of the anesthetic solution.
A test dose of 2 cc. of anesthetic drug, followed by a five-minute interval, may be used as further indication of needle placement.

Treatment of this complication is as follows: (1) aspiration of the spinal fluid immediately until at least 50 cc. is removed, (2) controlled respiration with oxygen by mask or endotracheal tube, and (3) stimulants and intravenous fluids to maintain the circulation. Norepinephrine is superior for this problem.

*Intravenous Injection.*—Frequent aspiration will indicate whether the bevel of the needle is lying within a vessel or plexus. This emergency should be handled in the same manner as a toxic reaction to a local anesthetic drug accompanying any form of regional anesthesia.

*Intercostal Paralysis.*—This occurs in varying degrees and is treated by assisting the respiratory actions until the effect of the anesthesia wears off and adequate motor activity returns.

**Advantages**

The status of the patient during surgery and in the immediate postoperative period is most gratifying to all concerned. The low incidence of nausea and the rapidity with which diets can be increased aid materially in the recovery.

The spread rate in the tuberculous patient is markedly reduced, as is the incidence of atelectasis and aspiration pneumonias. This is attributed to the preservation of the normal mechanism of evacuating material from the respiratory tree.

The cantery may be used to aid hemostasis.

Nursing care is minimized in the postoperative period.

**Disadvantages**

Paroxysms of coughing that occur in many patients often present a very difficult problem in management. This may be controlled, however, by direct injection of the vagus nerve with 1 per cent lidocaine.

This technique precludes employment of controlled ventilation and "corpse-like states." This may be disconcerting to the surgeon who demands a quiet operative field, and must be weighed against the advantage of maintaining the patients' ability to evacuate secretions and the excellent postoperative course.

The conscious patient prevents liberal discussion of surgical problems. The conscious patient has not interrupted our routine in regards to discussion, teaching, or casual conversation. Conversation that might be of concern to the patient is usually conducted in a low monotone.

Some individuals are psychologically unsuited for regional anesthesia. The tuberculous patients are usually accustomed to medical procedures during consciousness and are more adjusted to their illness, realizing its chronicity. They are willing to accept procedures that
will augment their care and are, therefore, willing to accept regional procedures.

Patients under the age of 14 are most difficult to manage.

This technique is more difficult to manage than a general anesthetic.

**Comment**

The purpose of this presentation has been to outline a technique of peridural anesthesia for thoracic surgical procedures. It is not our intention to advocate its routine or even frequent use in preference to general anesthesia. It is the personal responsibility of every anesthesiologist to include in his armamentarium a working knowledge of all methods and techniques of anesthesia in order that he may properly select the anesthesia of choice in any circumstance.

**Summary**

The authors have used peridural anesthesia for 2,172 thoracic surgical procedures. The technique of administration and the management of the patient during operation have been described.

Lidocaine was the local anesthetic drug most commonly employed because of the superior quality of anesthesia that it afforded. An indwelling plastic tubing allowed for serial injections to maintain adequate duration.

The results of blood-gas studies substantiate the authors' clinical observation that patients with low pulmonary function, those with moderate to severe coughing, and those with excessive mediastinal motion require assisted respiration. Blockade of the vagus nerve at the operative site is the preferred method for managing paroxysms of coughing.

Although this technique is best suited to the wet or tuberculous patient, or both, and particularly more applicable to extrathoracic procedures, it has been used satisfactorily for most intrathoracic procedures. Performing the block is not difficult for the anesthesiologist who is trained in conduction anesthesia. The management of these patients, however, requires a thorough working knowledge of respiratory physiology and experience with anesthesia for thoracic surgical procedures.

**Reference**