PERIDURAL ANESTHESIA IN THORACIC SURGERY,
A REVIEW OF 677 CASES *

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Conduction anesthesia has become increasingly popular during the last decade since physicians and patients alike realize the innumerable advantages which it offers. These advantages are especially applicable to the chronically ill patient, who as a result of his long illness, becomes a rather poor surgical and anesthetic risk. This is particularly true in diseases of the chest. It is our contention, therefore, that peridural anesthesia should be considered as a method of choice in thoracic surgery.

The first administration of peridural anesthesia was in animal experimentation in 1885 by Corning (1) and its subsequent development has been slow and sporadic. The first use of this method of anesthesia in human beings was by Sicard (2) and Cathelin (3) in 1901, who successfully approached the peridural space by way of the sacral hiatus; this procedure has since been known as caudal block. The adaptation of caudal block for obstetrical anesthesia was reported by Stoeckel (4) in 1909 and soon applied to the fields of gynecology, urology and proctology. Subsequent investigators (5) began to increase the volume of anesthetic solution in an effort to increase the area and effectiveness offered, and thus evolved caudal anesthesia.

Fidel Pages (6) in 1920, reported injecting the anesthetic solution into the peridural space by way of intraspinous approach and obtaining satisfactory anesthesia for abdominal surgery. Thirteen years later Dogliotti (7) described the first practical technic for administering segmental peridural anesthesia through a lumbar approach. It was 1941 (8) before mention was made of its application in thoracic surgery and even then it was stated that it could not be used for first stage thoracoplasties. In 1944, Vasconcelos (9) reported the use of peridural anesthesia for thoracoplasties, pneumonectomies, lobectomies

* The material used in organizing this paper is from the Missouri State Tuberculosis Sanatorium, Mount Vernon, Missouri, and the service of Dr. W. W. Buckingham who was either surgeon or consulting surgeon on all of these operations. Drs. A. J. Beatty, Y. F. Fujikawa and Paul Ottosen comprised the remainder of the surgical staff.
and esophagectomies and believed it to be the method of choice in thoracic surgery. Peridural anesthesia was introduced at the Missouri State Tuberculosis Sanatorium at Mount Vernon, Missouri, in 1945 by Dr. A. Neves of Rio de Janeiro who had seen it used satisfactorily in Brazil. One year later, the first 100 cases were reviewed and the report referred for publication (10).

In the selection of anesthesia for the average surgical case, one should be guided by any number of factors which might materially aid the ultimate prognosis. Each person concerned in an operation inserts a varying amount of influence on this selection. The patient usually has definite ideas as to what they do and do not want, but can be persuaded to receive what ever form of anesthesia the surgeon and anesthesiologist deem best. The surgeon demands a quiet, relaxed operative field and usually prefers an unconscious patient so that the case can be liberally discussed during the surgical procedures. The anesthesiologist is the last to be satisfied and is often influenced by the technic with which he is most familiar and one which will result in the least difficulty during operation. Unfortunately, the selection is often based on what is most acceptable to all concerned as it is usually possible to find such a technic in the majority of elective and emergency operations. In thoracic surgery the situation is entirely different and must be recognized as such for these patients are chronically ill and show varying degrees of debilitation which markedly affect their anesthetic status. The bronchopulmonary secretions from the tuberculous patient present a unique problem which concerns greatly the prognosis of the disease and success of the operation. Therefore, it may be stated that in selecting a method of anesthesia for thoracic surgery there is really need to consider but one thing, regardless of the personal desires of all concerned. "What is best for the ultimate prognosis of the patient?"

It may be well to remember that it was but few years ago when one had to sell a patient on pneumothorax, bronchoscopy or thoracic surgery. Now it is accepted as part of the treatment of the disease. This will also prove true in the acceptance of peridural anesthesia. The "grapevine" of an institution soon passes on the advantages and disadvantages or better termed, likes and dislikes of individuals who have had this anesthesia. They know of the excellent postoperative course, low incidence of nausea, and the general well-being of these patients and expect this as part of the treatment.

Our enthusiasm over the success we have encountered with this anesthesia is well founded. It is most impressive to see and review the low incidence of postoperative spread which results because the patient is able to expel secretions entering their tracheobronchial tree throughout the surgical procedure. During the immediate postoperative period the anesthesiologist does not have to be concerned with the many problems associated with a general anesthetic for these patients.
are not depressed, they are not bothered with nausea and vomiting and are not in need of bronchoscopy. Their general appearance is excellent in relation to their preoperative condition and the major surgical procedure which they have undergone. There are cases in which we believe this to be the only anesthetic that could be safely administered.

Table 1 lists the distribution of operative procedures and the number in which supplementary anesthesia was necessary in our series.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Operative Procedures</th>
<th>Number Requiring Supplemental Anesthesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracoplasty</td>
<td>419</td>
<td>27</td>
</tr>
<tr>
<td>Pneumonectomy</td>
<td>74</td>
<td>2</td>
</tr>
<tr>
<td>Lobectomy</td>
<td>61</td>
<td>3</td>
</tr>
<tr>
<td>Plumbage with acrylate pack</td>
<td>69</td>
<td>2</td>
</tr>
<tr>
<td>Thoracotomy</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Revision</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Decortication</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Pericardectomy</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Open pneumonolysis</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Pericardial cystectomy</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Lobectomy and thoracoplasty</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Other major chest procedures</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>677</td>
<td>36</td>
</tr>
</tbody>
</table>

A total of 677 operations was performed upon 419 patients. There were 193 males and 226 females; the ages ranged from 13 to 68 years. The maximal surgical procedures for one patient was five.

**Anatomy and Physiology**

The peridural space is a potential space whose presence can be proved by dissection or the filling of the canal with a solution as in peridural anesthesia. It extends from the foramen magnum cephalad to the sacrococcygeal junction caudad. The outside wall consists of periosteum and supportive ligaments of the vertebrae and the inner wall is the dura mater. This space contains venous and arterial plexuses, lymph vessels, adipose and connective tissues.

The presence of a negative pressure in the peridural space is an accepted fact, but whether it is constantly present or is created by entrance of the needle into the space has been clearly described by Lawrence (11). He stated that if a needle is barely inserted into the peridural space, little or no negative pressure exists as shown by a water manometer, but as the needle is further advanced the pressure increases until the dura is pierced. This indicates that the negative pressure is the result of the dura being separated from the wall of the vertebral canal. Bonnoit (12) pointed out that the negative pressure can be increased by flexing the head and kyphosing the back. It is our observation that when a patient is tense and will not relax, negative pressure does not exist, but will reappear when he again relaxes. A negative pressure is not seen in caudal approaches and this approach
is used in a form of peridural anesthesia. All of this seems to bear out
the opinion that negative pressure is the result of the separation of the
walls of this space and not a constant. By using either a water man-
nometer or by placing a drop of saline solution over the open hub of
the needle, one can demonstrate the negative pressure and identify the
peridural space as it is entered.

Sensory loss is fairly rapid and complete while motor elements are
not so greatly impaired. The muscles of respiration are active and no
direct impairment to oxygenation exists. The effect on the blood pres-
sure is fairly constant. There is usually a gradual decline over a
thirty to forty-five minute interval and methedrine in a 10 mg. dosage
has proved adequate in maintaining it at a normal level. In toxic reac-
tions from too rapid absorption or intravascular injection of the anes-
thetic solution and from massive subdural injection, the patient de-
monstrates a profound sudden collapse of the circulatory and respira-
ty systems. The use of vasopressor drugs, cardiorespiratory stimulants,
plasma, vigorous oxygenation, and other treatments for shock are in-
dicated. If the toxic reaction is demonstrated by irritation of the
central nervous system temporary de cerebration can be obtained with
an intravenous barbiturate.

Technic

The cases used in this paper were patients at the Missouri State
Tuberculosis Sanatorium where they were receiving constant medical
care. All patients were tested for procaine and pontocaine sensitivity
on the day before operation at which time peridural anesthesia was
discussed with them. A barbiturate was given the night before and on
the morning of operation. No narcotics or parasympathetic blocking
agents were administered for premedication.

Following the usual preliminaries of applying the blood pressure
apparatus and checking all emergency equipment, the patient is placed
in the sitting position on the side of the table with the neck acutely
flexed and the back kyphosed (fig. 1). This position extends the spin-
ous processes, bringing them into greater relief and widening the in-
terspace, so that the needle can approach the peridural space at ap-
proximately right angles. This is important for the greater the angle
of the needle from a right angle when it penetrates the ligamentum
flavum, the greater is the possibility of penetrating the dura.

Any interspace between the seventh cervical and the third thoracic
vertebrae may be selected. The higher interspaces are indicated for
first stage thoracoplasties and operations involving the apical-pleura
while the lower ones are satisfactory for all other thoracic operations.
The aid of a well trained assistant who is acquainted with the technic
of the block is of utmost importance. The success or failure of the
performance and result will depend on the assistant maintaining the
patient in proper position.
The anesthetic agent is dependent upon the expected duration of the surgical procedure. Procaine hydrochloride in 1.5 per cent concentration with 0.5 cc. of 1:1000 epinephrine hydrochloride is the primary agent. When a greater duration of anesthesia is needed, a 0.05 per cent to 0.15 per cent solution pontocaine hydrochloride is added to the primary agent. This combination of drugs allows up to three hours of operating time. We prefer to prepare our mixtures fresh from procaine and pontocaine crystals prior to each block, although we do not believe this a necessity.†

Fig. 1. Angle of the needle is shown when the bevel is in the peridural space at the level of the first thoracic interspace. The anesthetist is adding a drop of saline solution to the hub in order to check for presence of the "drop sign." The chin of the assistant overlies the occiput of the patient, maintaining his head in constant flexion while the assistant's hands grasp the upper arms. A well-trained assistant who keeps the patient in position and relaxed is essential for successful peridural anesthesia.

The skin is cleansed and painted with an antiseptic solution. The area is draped and a skin wheal is made with 1 per cent procaine over the selected interspace. A larger needle is used to leave an opening in the skin for the blunt peridural needle. This latter needle should be approximately 19 gauge, extremely short beveled, with no sharp edges or points, and should contain a stilet.

The angle at which the peridural needle enters the intraspinous ligament depends on which interspace is chosen but the needle is always inserted in the midline parallel to the spinous processes (figs. 2

† Since the time this manuscript was submitted for publication the authors have performed 123 peridural anesthesias for similar thoracic procedures with a 1 per cent xylocaine solution (Astra Pharmaceutical Company) replacing procaine as the primary anesthetic agent.
Figs. 2 and 3. The needle is in the peridural space. Top, posterior view; bottom, posterolateral view.

and 3). Entrance through the skin is made without difficulty because of the opening already created. In penetrating the supraspinous ligament, however, considerable resistance may be encountered owing to the bluntness of the bevel and the density of the ligament. Resist-
ance from the infraspinous ligament is definite, but considerably less than from the supraspinous ligament. The needle is advanced to the 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 at a more suitable angle. The stilet is 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 now existing in the peridural space. Gutierrez (13) referred to this as the "drop sign" (fig. 1) Two other methods are used to prove entrance into the peridural space, that is, (1) the addition of a U tube manometer or (2) the addition of a syringe filled with saline solution, applied to the hub of the needle when the stilet is removed. When the space is entered, the manometer shows a negative pressure or if the syringe is used little resistance to injection is encountered. These signs may be used in place of a drop sign; 5 cc. of normal saline solution is 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, a new interspace should be chosen and the block repeated until successful entrance into the peridural space is assured. A test dose of 5 cc. is now injected and a period of ten minutes allowed to rule out subdural anesthesia.

A 5 or 10 cc. syringe is used for injecting the anesthetic agent, 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 anesthesiologist being aware of doing so. While syringes are changed it is possible to recheck the drop sign for reassurance that the dura has not been penetrated. Sometimes it is necessary to wait between injections for the patient to relax, but when he does, the negative pressure and drop sign invariably return. After approximately 5 to 8 cc. of solution has been injected, the patient complains of pain in the shoulders, back or arms. This pain may be rather severe, causing the patient to become tense and restless. 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. It has been our custom to administer 10 mg. of methedrine intramuscularly while the anesthetic is being administered. Although the volume of the anesthetic solution varies between 20 and 30 cc., depending on the nature of the operation and the size of the individual, a total of 30 cc. is usually employed. The patient is placed in a lateral position lying on the operative side for five to ten minutes. He is then turned to the opposite side, prepared for operation and administration of fluid is started. The time con-
sumed in administering the anesthetic is from twelve to fifteen minutes. Approximately twenty minutes is used in placing the patient on his operative side, repositioning for the surgical procedure and sterile preparation of the operative field.

Observations

Difficulty in performing the peridural tap is markedly increased in patients who have varying degrees of distortion of the spinal column from previous thoracic surgery or congenital and developmental deformities. With experience, however, it is possible to handle these patients successfully.

The level of anesthesia obtained from 30 cc. of solution varies with each individual and each procedure, but usually extends from the second or third cervical to the upper lumbar nerves.

Dizziness is a frequent complaint during administration, but soon passes after the injection is completed. Nausea is not common during the operation.

In the longer lasting operations, the patients often become uncomfortable in the lateral position, but state the operation is not painful. Incisions made within twenty minutes after injection and closures in prolonged cases often cause slight discomfort, but nothing of such serious note as to indicate need for supplementary analgesia. These patients are often apprehensive until after operation is underway and then become more at ease. They readily converse with the operator and anesthetist who encourage them to expectorate their secretions. Ligation of the bronchus is sometimes irritating and results in coughing paroxysms of relatively short duration.

A fall in blood pressure occurs over a thirty to forty minute period after administration of the anesthetic. The intramuscular administration of a small dose of methedrine for the gradual decline in systolic pressure will restore the circulatory system to a relatively normal state.

The presence of mediastinial flutter, paradoxical respiration, incidental holes in the pleura, and other upsets in respiratory physiology necessitates the use of oxygen under positive pressures. Only in patients having a low vital capacity have these respiratory problems been important or resulted in distress to the patient and here again the use of positive pressures of oxygen is advisable.

Analysis of Series

In reviewing the case histories and anesthetic charts of 677 cases in which peridural anesthesia was used we have compiled the following information.

Supplementary anesthesia was necessary in 36 for an incidence of 5.47 per cent. This refers to all instances of failure, whether partial or
Nitrous oxide was the only supplementary anesthetic agent used. It is interesting to note that with increased experience with this technic we have had only 3 failures in the last 100 cases, raising the successful anesthetic rate from 94.53 per cent to 97 per cent. These 100 cases were consecutive with the exception of 2 patients. In other words we were able to perform these blocks for 100 of the last 102 operations. One of these patients had previously had a spinal fusion and the other was entirely too apprehensive. Peridural anesthesia was not attempted for these latter 2 patients.

In 1 out of every 5 cases it was necessary to approach the peridural space through more than one interspace. The most common reason for using more than one interspace was aspiration of blood or spinal fluid which appeared in 1 out of every 10 taps. This was not considered a contraindication to this technic and a lower interspace was chosen for the next attempt. It does mean that the anesthetic agent must be injected at a very slow rate so as not markedly to increase the pressure in the space which in turn would cause dissipation of fluid into the venous system or cerebrospinal fluid. In 1 case there was some spread into the cerebrospinal fluid and an immediate respiratory failure and vascular collapse resulted. Prompt artificial respiration and intravenous administration of stimulants (epinephrine and coramine) resulted in return of respiration and circulation within fifteen minutes and the operation was completed. The postoperative course was without complications or sequelae.

There were 2 deaths in this series which occurred on the operating table and might be associated with this technic. Necropsy was performed in both cases immediately after death and the pathologist made special examination of the spinal fluid for evidence of local anesthetic agents and their effects. The final diagnosis was coronary thrombosis in one and cardiac failure on the other. It is our belief, however, that in the latter case death resulted from massive subdural injection, with possibly inadequate handling of the emergency.

Since the patients had previously been tested for procaine and pontocaine sensitivity the possibility of serious toxic reactions was eliminated. The use of epinephrine slowed the absorption and relieved still another problem. The one thing that did bother us was vascular absorption resulting in numbness and headaches. These were transitory effects and were of little concern because they were over in fifteen to twenty minutes. No neurologic sequelae were noted in this series and postoperative headaches were minimal.

The extremely low incidence of postoperative spreads (1.65 per cent) is most encouraging. This can be directly attributed to the fact that the patients were able to expectorate secretions throughout the surgical procedure. Bronchoscopy is not necessary with peridural anesthesia.
There are cases in which we consider this the only indicated anesth- 
essia and one such example will be cited. A 56-year-old man, who had 
previously undergone a pneumonectomy, under peridural anesthesia, 
was in a state of cardiovascular collapse. His blood pressure was 70 
mm. systolic and 60 mm. diastolic and the pulse extremely rapid and 
almost imperceptible. Peridural anesthesia, without premedication, 
was induced as an emergency procedure. The thoracic cavity was ex-
plored and fluid and exudate removed. The pericardial cavity was 
opened and approximately 500 cc. of pericardial fluid released. Peri-
cardectomy and decortication was carried out and a total of 200 cc. 
blood was administered on the operating table. The patient left the 
operating room with a blood pressure of 110 mm. systolic and 80 mm. 
diastolic and a good full pulse. Recovery from the operation was 
uneventful.

Advantages

1. The low incidence of spreads with this technic when compared 
with the incidence in patients who have had similar operations under 
general anesthesia reveals one of its main advantages. This is attribu-
table to the constant evacuation of bronchopulmonary secretions dur-
ing surgical procedure.

2. The general well-being of these patients after operation is most 
appealing to the surgeon and the patient. The low incidence of nausea 
and the rapidity with which diets can be increased aid materially in 
helping these patients recover from the surgical procedure.

3. These patients do not lose the amount of blood during operation 
that is lost when a general anesthesia is employed in which capillary 
oozing is increased.

4. The cauterity can be safely used throughout the operation.

5. There is no impairment to oxygenation of patients.

6. This method is applicable to extremely poor risk patients who 
would not tolerate general anesthesia.

7. There is a minimal upset in body physiology.

8. Peridural anesthesia is particularly adaptable to tuberculous 
patients with low vital capacity.

Disadvantages

1. It is often stated that the conscious patient prevents liberal 
discussion of the surgical problems at hand. The consciousness of 
the patient has not interrupted our routine in any manner and this 
includes discussion, teaching and other remarks.

2. This method of anesthesia is not a familiar one and is more dif-
ficult and time-consuming than administration of a general anesthetic.

3. Coughing paroxysms occur occasionally with ligation of a 
bronchus.
PERIDURAL ANESTHESIA IN THORACIC SURGERY

SUMMARY AND CONCLUSIONS

A series of 677 peridural anesthesias for thoracic surgery is presented. The technic employed in administration of these anesthetics and the results obtained are discussed. The distribution of cases and number requiring supplemental anesthesia are listed.

Supplemental anesthesia was required in 5.47 per cent of cases and with experience we have reduced this to 3 per cent in the last 100 cases. To qualify this further, it should be noted that the majority of these anesthetics were administered by physicians who have not had training of any manner in anesthesia.

The importance of a well-trained assistant cannot be over emphasized and will definitely affect the success obtained with this method. Blood pressure falls are minimal and never as marked as with sub-dural anesthesia over the same anatomical area.

We believe this technic worthy of consideration by anesthesiologists and surgeons alike. The benefits offered the patient are numerous and the results are most favorable. These cases are unselected, consecutive, and the series is large enough in number to indicate the effectiveness of this method of anesthesia for thoracic surgery.

The low incidence of spread (1.65 per cent) is most encouraging and is directly related to the ability of the patient constantly to evacuate his secretions throughout the surgical procedure.

In some cases this type of anesthesia is the method of choice, and one such example is cited. Patients who are poor anesthetic risks and have low vital capacity, tolerate surgical procedures under this method of anesthesia, whereas general anesthesia would cause too great an upset in body physiology.

Anesthesia was successful in 94.53 per cent of the cases and with experience this percentage was raised to 97. Patients with spinal deformities or those who are extremely apprehensive present the most difficulty.

The general well-being of these patients during the postoperative period tends to popularize it with all concerned. Postoperative shock following peridural anesthesia is not as prevalent or disturbing as that associated with general anesthesia.

REFERENCES


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