PERIDURAL SEGMENTAL ANESTHESIA
WITH INTRACAINE *

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As Tovell (1) has pointed out, anesthesia should aim at three goals: (1) adequate surgical exposure with relaxation and quietude; (2) somatic and psychic comfort of the patient during the preoperative, operative and postoperative phases and (3) the minimal deviation from the normal physiology. No currently used anesthetic procedure fulfills these requirements. The high spinal, for example, advocated at the Lahey Clinic (2) meets with the surgeon’s approval but may produce sufficient cardiorespiratory reaction which not only often causes serious apprehension on the part of the anesthetist but frequently jeopardizes the patient’s safety. Preoperative medication with fixed agents, such as the barbiturates or tribromethanol, produces the greatest psychic comfort, but it must be realized that they may be dangerous drugs, particularly in the presence of hepatic or renal dysfunction.

With these considerations in mind and observations made during clinical experience with 2,000 cases, a discussion of a long neglected anesthetic procedure, the peridural segmental block, seems justified.

The method is not new and dates back to J. L. Corning (3), of New York, who in 1885 became interested in spinal anesthesia. The injection of a cocaine solution into the spine, which he described, was doubtless an accidental epidural anesthesia, for the peridural space at that time was not well known nor described. Although some writers claimed that this was a subarachnoid anesthesia, Corning makes no mention of obtaining spinal fluid. Six years later Cathelin (4) blocked the sacrococcygeal plexus by introducing an anesthetic solution into the caudal canal by way of the sacral hiatus. It must be remembered that the caudal space is definitely extradural. At first Cathelin’s method did not attract many followers and only after the work of Lawen (5), in 1910, did it acquire any popularity. In 1907 Sterzé (6) published the first definite anatomical description of the peridural space. The publications of Lawen and Hanneart were followed by attempts to block all the spinal nerve roots in order to obtain abdominal anesthesia. Their method was to force the anesthetic solution up into the lumbar and thoracic area by the sacral route. The patients were placed in the

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Trendelenburg position, and a large amount of solution was injected. These attempts were unsuccessful as were those of Pauchet (7), Stoeckel (8), Zweifel (9), et al. The few fatal results which followed caused these men to turn their attention from this form of anesthesia.

The present type of peridural anesthesia was instituted by Fidel Pagés (10), who cited 43 cases and observed that anesthesia could be achieved through introduction of an anesthetic agent into the epidural space. Somewhat later Dogliotti (11) reported the discovery of peridural segmental anesthesia. Harger (12, 21), and somewhat later, Odom (13, 14) described the clinical application of the method in this country. Earlier than this, it was widely used in South America (15, 16, 17, 18).

The method is not complex nor difficult, but it requires a knowledge of anatomy and a considerable degree of technical adeptness. It is because of technical ineptitude that it has fallen into general disuse. The advantages the procedure offers from the point of the patient's well-being as well as the production of adequate anesthesia are so great as to warrant the acquisition of the technical skill required for the correct use of this procedure.

With patience and time, the anesthetist develops his technic to such a point that he may interpret into a visual anatomical picture the different degrees of resistance encountered by his needle. Here I can best facilitate the acquisition of this technique by a word picture of some of the technical details. There is no reliable substitute in the form of a manometer for experience.

Body position is important for subarachnoid puncture: it is even more important for the successful performance of an extradural injection. Both the sitting or the lateral decubital position may be used. I prefer the latter for most of my work. For caudal extradural injections the prone jack-knife position is used routinely. When employing the lateral decubital position, the side on which the incision is to be made is usually placed downward to take advantage of the gravitation of more of the anesthetic solution to that side. The thighs are well flexed upon the abdomen. The chin is brought down onto the chest. The shoulders are pulled forward. In this manner the back is well arched with its convexity facing the operator. "Corkscrew spines" are to be avoided. In this position the distance between the spinous processes is greater, resulting in enlarged intervertebral spaces. To locate the site of puncture, I prefer to count up from the lowest palpable interspace; namely, that between the fifth lumbar and sacrum. After the interspace is located, it is marked with a wheal. The needle to be inserted should be preferably 3 to 3½ inch, 18 or 19 gage, with a sharp short bevel, and a well fitting stillet. The needle's wide diameter permits the anesthetist more easily to appreciate the varying degrees of resistance offered by the different tissues traversed. The shortness of the bevel lessens the danger of dural perforation.
The needle is grasped firmly in the right hand in a manner similar to that shown in figure 1. The supraspinous ligament is steadied with two fingers of the left hand and the point of the needle is then inserted exactly through the middle of it. The lateral approach is used only when the midline route is contraindicated, as may occur when there is too much overlapping of the spinous processes or calcification of the supraspinous ligament. This step is further facilitated by keeping the bevel parallel to the longitudinal fibers. I am convinced of the superiority of the midline approach for the following reasons: first, the epidural space is more ample (greater distance between the ligamentum flavum and the dura); second, there is less danger of injuring the endospinal veins; third, one can better appreciate the different sensations transmitted by the needle to the hand by the various anatomical structures.

The introduction of the needle exactly through the middle of the supraspinous ligament is emphasized because it enables the anesthetist to sense the position of the point of his needle. There is a sudden characteristic "give" as the needle penetrates the supraspinous ligament.
After this is felt the needle is best handled with the thumb and index finger on the hub. This delicate handling of the needle enables one to discern the first sign of increased resistance to its forward passage, which should be the compact elastic ligamentum flavum. If the resistance is absolute, the point is against bony vertebra and should be slightly withdrawn, its inclination checked, the direction accordingly changed, and again pushed forward gently seeking a rubber-like semi-resistant ligamentum flavum where the bevel is engaged.

With the bevel of the needle properly engaged, an attempt to inject saline solution (with a 2 cc. syringe) will meet with considerable resistance. If the bevel is still in the loose interspinous ligament the resist-

![Fig. 2. Author's method of advancing needle through ligamentum flavum.](http://anesthesiology.pubs.asahq.org/pdfaccess.ashx?url=/data/journals/jasa/931745/)
peridural space. Even before the entire bevel of the needle has penetrated this ligament, the liquid, which at first encounters a strong resistance, escapes very rapidly and freely into the peridural space. The needle is now in place and should not be inserted further.

After the abrupt characteristic "give" of the plunger is experienced as the needle emerges through the ligamentum flavum, it is necessary to take added precautions to verify the position of the bevel before injection of the full anesthetic dose, for inadvertent subarachnoid injections should be avoided. The syringe is removed and no spinal fluid should be obtained. Occasionally a few drops of fluid will drop out and simulate spinal fluid which can mislead the anesthetist into believing that he is in the subarachnoid space, for this merely represents a reflux of the injected saline solution. At this point the stilet should be inserted in the needle and removed to insure patency of the needle, and gentle aspiration attempted in an effort to obtain spinal fluid. If, after all these maneuvers, one still feels that the needle is not in the subarachnoid space, 5 to 10 cc. of the anesthetic solution is injected slowly; if after two or three minutes no sign of typical subarachnoid anesthesia is obtained, one may feel reasonably certain the needle is in the extradural space and proceed to inject the balance of the anesthetic solution. If the total dose at one site is 25 cc., it is better to inject it in three divided doses of roughly 8 cc. each at two-minute intervals, at the rate of 1 cc. per second. In this manner systemic toxic reactions are minimized, the anesthetic zone is prevented from spreading too far, and the nerve roots in the desired zone are better saturated.

The use of the method implies a knowledge of the anatomy of the spinal column and the physiology of the visceral and somatic afferent pathways. The somatic distribution of the cerebrospinal nerves to the parietes and its dermatomic distribution is essential. This, however, is not necessary with some technics such as employed by Odom (13, 14) and others, who make no attempt at selective segmental blocking and routinely puncture between the first and second lumbar vertebrae. This necessitates the administration of greater quantities of the anesthetic solution and implies greater toxicity. The metameric terminations of the visceral fibers in the spinal cord may be different and require separate consideration. A brief chart (fig. 3) is presented in order to facilitate a quick orientation to the various pathways.

In considering the anatomy of the spinal column, several points must be emphasized: the supraspinous ligaments, interspinous ligaments, ligamentum flavum, dura, vertebral spines and the sacral hiatus. The epidural space extends along the entire length of the spinal canal from the foramen magnum to the coccyx. Although it is frequently spoken of as the space between the dural sac and the bony vertebral canal, it is in reality between the parietal and medullary layers of the dura for at its upper end the thick cranial dura splits at the foramen magnum into two layers. The external layer lining the vertebral canal
acts as the periosteum and the thick fibrous covering of the ligaments of the spine. In the region of the coccyx it becomes continuous with the periosteum. The inner layer becomes the true spinal dura and is the tubular sac containing the spinal cord and cerebrospinal fluid.

This extradural space is present only in the vertebral column, and an anesthetic solution cannot find its way to the medullary centers of the brain.

The extradural space is filled with adipose connective tissues and a venous plexus. These tissues adhere with varying firmness to the inner surfaces of the vertebral canal and dural sac and can readily be stripped from the dura mater by the injected fluid, which can easily be distributed over wide areas depending upon the total fluid volume introduced and the speed of injection. Laterally the extradural space communicates with the intervertebral foramina, through which the peridural tissue is continuous with the paravertebral tissue. Finally, it continues to the periphery with the nerve trunks in the form of a perineural connective covering. It is by this path that an anesthetic solution introduced into the extradural space leaves the vertebral canal.

*Fig. 3. Schematic representation of the sensory fibers of viscera referred to the spinal segments at the right, and metameric cutaneous innervation at the left.*
and bathes each segmentary nerve outside the spinal canal at the point
where the nerves no longer retain their dural sheath.

The routine solution contains:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intracaine hydrochloride</td>
<td>2 per cent</td>
</tr>
<tr>
<td>Potassium sulfate</td>
<td>2 per cent</td>
</tr>
<tr>
<td>Epinephrine to make a concentration of 1:200,000</td>
<td></td>
</tr>
</tbody>
</table>

The pharmacologic evidence which forms the basis for the use of this
"potentiated" local anesthetic mixture will be the subject of a later
communication. Such solutions usually afford two hours of working
anesthesia. When prolonged operative procedures are to be under-
taken, a 2 per cent solution of intracaine base in oil may be employed
resulting in anesthesia up to six hours. No reactions from such oily
solutions have been observed.

In order to obtain maximum efficiency from extradural segmental
anesthesia with its very minimum toxicity, it is necessary to be familiar
with sensory pathways, both somatic as well as visceral. By blocking
only the necessary pathways at various levels of the cord it is possible
to obtain satisfactory anesthesia with one-half the amount of local anes-
thetic solution that would be required if only one site of puncture was
used. In this manner one avoids filling the whole epidural space.

The anatomical description of the sensory pathways can be found
elsewhere in this paper. The author feels that the utilization of strict
anatomical segmental blocking, together with the introduction of a two-
needle technic instead of trying to spread too far from one point of
injection, greatly enhances the efficiency and value of extradural anes-
thesia. By consulting the following chart one can, at a glance, find a
guide to sites of puncture and to the amount of anesthetic solution to
be injected. The amount listed in this table is not offered, however, as
a hard and fast value.

The technic for caudal puncture is well described in other publica-
tions (19). However, it is my belief that 10 to 15 cc. of a proper solu-
tion for caudal anesthesia is ample, when injected as the needle is
gradually withdrawn.

The technic of extradural injection in the lower thoracic region is
rendered more difficult because of overlapping of the cephalad inclined
spinous processes. The technic of lumbar block should be well mas-
tered before one attempts extradural puncture in this area. Occasion-
ally it is impossible to make an extradural puncture in the mid-thoracic
region even with the lateral approach.

After the nerve blocking is over, the patient is prepared on the
operating table in the proper position for the contemplated surgical
procedure. The wrists are placed in comfortable bracelets. By the
time the patient is draped and the skin prepared, usually fifteen min-
utes have elapsed which is the minimal time allotted for the block to be
effected. If the operation is a simple one, such as an appendectomy,
<table>
<thead>
<tr>
<th>Operative Procedure or Field</th>
<th>Pathways to be Blocked</th>
<th>Approximate Site or Sites of Puncture</th>
<th>Amounts of Solution (Approximate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendectomy</td>
<td>T6 to L3</td>
<td>L1–T12, T7–T8</td>
<td>$2 \times 7\frac{1}{2}$ equals 15</td>
</tr>
<tr>
<td>Upper abdomen, gall bladder, stomach, etc.</td>
<td>T5 to T12</td>
<td>T8–T9</td>
<td>15 to 25 cc. in three doses depending on patient and intention of supplementing.</td>
</tr>
<tr>
<td>Inguinal hernia, vaginal hysterectomy</td>
<td>T9 to S1</td>
<td>T12–L1, Caudal</td>
<td>$2 \times 7\frac{1}{2}$ to 10</td>
</tr>
<tr>
<td>Dilatation and curettage and transurethral resections</td>
<td>T10 to S5</td>
<td>L1–L2, Caudal</td>
<td>$2 \times 5$ equals 10</td>
</tr>
<tr>
<td>Nephrrectomy and nephrostomy</td>
<td>T9 to L2</td>
<td>T10–T11</td>
<td>$3 \times 7$ equals 21 cc.</td>
</tr>
<tr>
<td>Left sided colostomy</td>
<td>T10 to S1</td>
<td>T12–L1, Caudal</td>
<td>$2 \times 7\frac{1}{2}$ equals 15</td>
</tr>
<tr>
<td>Rectal and perineal work, i.e., vaginal plastics</td>
<td>S1 to S5</td>
<td>Caudal</td>
<td>10 to 15 cc.</td>
</tr>
<tr>
<td>Laminectomy or spine fusion</td>
<td>Depending on area</td>
<td>Depending on area—one or two interspaces above center of zone.</td>
<td>$3 \times 5$ or 7, i.e., 15 to 21 cc.*</td>
</tr>
<tr>
<td>Lower extremities, amputations, etc.</td>
<td>L1 to S4</td>
<td>L2 to L3, Caudal</td>
<td>$2 \times 7\frac{1}{2}$ equals 15</td>
</tr>
<tr>
<td>Thoracic surgery, i.e., rib resections, thoracotomy, etc. (except 1st stage thoracoplasty)</td>
<td>T2 to T12 depending on operative area and sometimes with brachial block.</td>
<td>Depending on operative site often supplemented with brachial block.</td>
<td>In lobectomies, etc., hilus is blocked to harmful viscerovisceral reflexes.</td>
</tr>
</tbody>
</table>

* Momentary pentothal complement may be necessary when working on subdural nerve roots.

or hernia repair, the skin incision can then usually be made and operation begun. If the patient complains of pain or discomfort and the anesthetist feels that the usual conversational psycho-anesthesia will not suffice, supplementary anesthesia is immediately started. If the
anesthetist, prior to the beginning of the operation, anticipates complaint from the patient intravenous pentothal sodium, just sufficient to induce sleep, will provide perfect anesthesia. However, if the nature of the operation is such that considerable visceral traction is necessary, preparation for a continuous light complementary anesthesia should be made. The manner in which this is provided is optional, with the choice of a light cyclopropane, intermittent pentothal sodium, or a well oxygenated mixture of nitrous oxide after a preliminary intravenous administration of pentothal sodium. If pentothal sodium is selected as the complementary anesthesia, we have found that a regular saline infusion to which the pentothal sodium is added periodically is practical.

**Discussion**

The almost exclusive adherence to the utilization of the supposed negative pressure in the epidural space as a means of localization, such as Gutierrez’s “sign of the drop” or the employment of some kind of manometric device is, in my opinion, the outstanding reason for the poor results previously obtained by many of our American anesthetists. Dogliotti pointed out the unreliability of this method by demonstrating marked differences in the alleged negative pressure at different areas of the vertebral canal. Furthermore, I have observed the absence of a true constant physiologic negative pressure in the epidural space and therefore infer that it is due solely to the position of the flexed body which, like opening an accordion, increases the size of the epidural space.

Another reason for poor results lies in the attempt to block all sensory pathways of the operative field from one site of injection. This is particularly true in pelvic surgery, where not only the abdominal parietes must be anesthetized, but also the visceral afferent pain pathway of the sacral plexus. Undoubtedly this is the reason for Dogliotti’s (20) preference for subarachnoid instead of epidural anesthesia in gynecologic cases. Although the epidural space of the caudal canal in the sacral area is anatomically continuous with the epidural space in the cervical, thoracic and lumbar areas, there is sometimes interference with the free flow of the injected solution at the lumbosacral area. Dogliotti (21) has pointed out that the dura mater adheres firmly to the inner surface of the vertebral canal at the lumbosacral joint where there are fibrous bands in the form of small strips of dura mater attached to the ligamentum flavum. This complex ligamentum formation does not represent a continuous barrier, but a more or less reticular arcade, that is, a firm mass between the dura mater and the vertebral canal. The reason for failure of Lawen et al. (5, 7, 8, 9) to force local anesthetic solutions into the lumbar and thoracic areas by caudal injection was probably due to such anatomical obstructions. With the patient sitting, usually a low lumbar epidural injection will
permit enough of the solution to seep down into the caudal canal and
give satisfactory sacral anesthesia. This procedure is by no means de-
pendable. In order to circumvent such anomalies, a multiple puncture
technic is suggested. In an abdominal hysterectomy one injection
(caudal) is given for visceral anesthesia, and another between T12 and
L1 is given for somatic (parietal) anesthesia.

The early technic used for an appendectomy was the injection of
about 30 cc. of solution between T9 and T10, which spread down to L2
or L3 for parietal anesthesia, and up to T5 or T6 to block the outflow
of the great splanchnic nerve in order to insure visceral anesthesia.
Quite frequently, using this technic, the cutting of the skin or picking
up of the meso-appendix would result in some discomfort. However,
it was noticed that in most upper abdominal incisions, the skin was
almost always anesthetized. Looking for an explanation of this phe-
nomenon, it was noted that the incision in the upper abdomen was in
the midzone of the anesthetized area, while the incision in the lower
abdomen was more toward the periphery of the anesthetized zone.
The possibility of lessening intensity of this block progressing toward
the periphery of the anesthetized zone occurred to us. In an attempt
to prove this, the anesthetized fields were studied both as to pin-prick
and thermal sensitivity, for Dogliotti (20) had pointed out that there
was a higher threshold for temperature sensation than for pain. It
was soon seen that the thermal anesthetic zone was considerably nar-
rower than the pain anesthetic zone. Since this seemed to support the
clinical findings, it was decided to employ another site of puncture
rather than to spread too far with one epidural injection. The technic
applied for an appendectomy was then as follows: one needle intro-
duced between T12 and L1 with 15 cc. of anesthetic solution injected,
and another needle between T7 and T8 with 10 cc. of solution injected,
the former for parietal anesthesia and the latter for splanchnic or vis-
ceral anesthesia. The results with this technic were good. No deaths
directly or indirectly attributable to anesthesia were observed.

Another reason for unpopularity lies in the use of procaine hydro-
chloride for the anesthetic agent. Two per cent procaine hydrochlo-
ride solution in the peridural space is not sufficiently effective to pro-
duce consistent anesthesia. Also, a time element is involved before
procaine penetrates to the nerve roots. This delay at this stage is
arduous to both the patient and the surgeon. Frequently a full thirty
minutes would be necessary before onset of sufficiently intense anes-
thesia to permit cutting of the skin. These disadvantages of procaine
were sufficient to warrant the introduction of the potentiated intra-
caine solution which was used in this study.

In comparison with local infiltration, regional, the method presents
the following advantages:

1. It permits complete anesthesia of the segment to be operated on
while local anesthesia, especially of the trunk, produces anesthesia only
of the abdominal wall unless recourse is had to more profound anes-
thesia of a single viscus, such as seen in some types of anterior splan-
chnic block.
2. It requires only one or two punctures in a relatively nonsensitive
region in contrast to the numerous punctures which are necessary in
local regional anesthesia.
3. It avoids any form of trophic or regenerative disturbance of the
tissue in the vicinity of the operative field.
4. It permits adequate muscular relaxation of the involved segment.
5. It does not involve the use of a specific sulfonamide inhibitor
since intracaine does not contain the para-amino-benzoic acid nucleus.
Compared with subarachnoid anesthesia it presents the following
advantages:
1. Greater limitation of the anesthesia to the segment of the body
to be operated on. For instance, in a thoracoplasty, anesthesia is
limited to the chest wall and does not extend from the toes up, to say noth-
ing of the fact that the anesthesia is practically all sensory as compared
with subarachnoid. Thus the dangers of intercostal paralysis are
practically nonexistent. Another advantage of this limitation is the
minimal interference with the venous circulation which is greatly de-
pendent on muscle tonus. When one considers the role of muscle tonus
in the pathologic physiology of the shock syndrome the advantage is
even more gratifying.
2. Absence of the more complex and severe disturbances produced
by subarachnoid anesthesia, such as nausea and vomiting during the
operation, postoperative headaches, retention, irritation of the menin-
ges, dizziness, paresthesia and the like.
3. Reduction to an absolute minimum of the grave risks associated
with spinal anesthesia, especially the marked fall in arterial pressure.
These risks can be greatly reduced by careful watching and handling
of the patient during subarachnoid anesthesia. There is sometimes a
fall in arterial pressure with peridural segmental anesthesia, even
sometimes to the same degree as in subarachnoid and not merely 20 to
30 mm. of mercury as proclaimed by previous publications on epidural
anesthesia (10, 12, 13, 14, 15, 16, 17, 18, 21, 22). Nevertheless, it does
not carry with it the same significance. First, its occurrence is due to
a more benign disturbance of the circulatory physiology, such as inter-
ference with the thoracolumbar outflow of vasoconstrictor impulses.
It is not due to profound loss of muscle tonus and cardiac anoxia result-
ing from diminished pulmonary ventilation such as is seen in partial
degrees of intercostal paralysis. These latter factors are the serious
ones which are frequently encountered under high spinal anesthesia.
4. Lacking the diffusion of the anesthetic toward the bulbar centers,
the danger of direct paralysis of the latter is avoided which occasionally
is said to occur in subarachnoid anesthesia, though most of these dis-
turbances are peripheral in nature and not central.
5. There is absence of direct contact of the anesthetic solution with the spinal cord, eliminating the possibility of producing any alteration in their nervous elements. This has been shown by recent investigation (23, 24), although permanent secondary disturbances in subarachnoid anesthesia attributable to damage of the cord are slight and exceedingly rare. Careful analysis of a large series of patients operated on under subarachnoid anesthesia has shown that in about 5 per cent of the cases there is definite evidence of such phenomena as mild pain or paresis of the inferior extremities, delay in return of muscle tone, lack of sphincter control of several days' duration, and obscure forms of hyperthermia similar to those observed after direct operation on the spinal cord and brain.

6. The postoperative course is easier due to the minimal deviation from normal physiology during the surgical procedure.

In the comparison with subarachnoid anesthesia peridural also presents some disadvantages, as follows:

1. The intensity of the block is not of the same magnitude observed under subarachnoid. This permits the patient to sense more of the operative procedure. Although the sensation is not actually painful, it admits of more psychic instability than is likely to occur with spinal anesthesia and accounts for the increased number of supplementary anesthetics administered with extradural block.

2. The abdominal relaxation with extradural block differs from that obtained under subarachnoid in that there is no actual motor anesthesia of the recti. The relaxation is effected through the interruption of the afferent protective impulses from the parietal peritoneum to the cord. This permits a conscious patient voluntarily to contract his recti and in this manner tighten his abdominal wall. However, this occurrence is not encountered often and can easily be remedied with light supplementary general anesthesia to abolish consciousness. A small dose of pentothal sodium is efficacious.

3. The technical difficulties of extradural puncture are much greater than those of subarachnoid anesthesia. This should not be considered a disadvantage because the technic is easily mastered.

**Summary**

1. The technic of the peridural regional block anesthesia is described.

2. Intracaine hydrochloride plus potassium sulfate constitutes an adequate anesthetic agent for the production of such anesthesia.

3. When prolonged anesthesia is desired, intracaine base in oil can produce the desired effect.

4. The anatomical and physiologic basis for peridural nerve block anesthesia is discussed.
REFERENCES


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