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Caudal anesthesia

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CAUDAL ANESTHESIA

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Illustrations

History

In the evolution and history of anesthesia, caudal anesthesia is a far cry from the early discov ries and uses of anesthesia. Valerius Cordus, a botanist of great promise, who was born in Prussia in 1515 and died at the age of twenty-nine, is credited with the discovery of sulphuric ether.(54)

Three hundred and some odd years later Dr. Long, noticing the effect of laughing gas on the young village sparks, administered ether by inhalation to remove a small cystic growth from a patients neck. Following this there was a great deal of experimentation done by Sir Humphrey Davey in 1800;Horace Wells, a dentist of Hartford,Conneticut, in 1844; Thomas Green Morton; and Sir James Simpson.(51) The work of these gentlemen soon making
the medical profession anesthesia conscious.

The first local anesthetic discovered was cocaine. The alkaloid was isolated in 1850 by Nieman, a pupil of Wöhler.(16) Wöhler noted that cocaine was bitter to the taste and had a peculiar effect on the nerves of the tongue, making it numb and almost devoid of sensation. Von Anrep in 1879 studied the pharmocological actions of cocaine and found that after subcutaneous injections the skin overlying the injected area became insensitive to the prick of a pin. He recommended that this compound might by useful clinically as an local anesthetic. His suggestion was not acted on, however, and credit for the

discovery of local anesthesia is usually ascribed to Freud and Köller. A popular story relates that these two investigators were searching for a morphine substitute, and in the course of their studies on cocaine Köller acciden-tally got some of the drug in his eye and fortunately noted the resulting anesthesia.

The first accounts (12), though vague and uncertain, of anesthesia produced by the introduction of a cocaine solution into the extradural space of the vertebral canal are found in the first memorable experiment by Corning. In 1855 he attempted on dogs and then upon humans to inject a solution of cocaine into the vertebral canal as a therapeutic measure without any thought of obtaining surgical anesthesia. Corning did not mention in his report the escape of cerebro-spinal fluid during the injection, prob-ably because he did not clearly distinguish between the extradural and the subarachnoid space and injected the solution into the former. He attributed the distribution of the anesthetic and the possibility of obtaining a block anesthesia of the spinal roots to the circulation of the blood and lymph as being capable of transporting the solution over some distance into the vertebral canal proper.

The first attempt of the injection of an anesthetic solution for surgical purposes into the extradural space of the sacral segment of the vertebral canal was first

made by Cathelin in 1900. He proposed the injection of normal saline into the sacral canal for purposes of allay-ing certain nervous manisfestations connected with urin-ary tract enuresis in boys and girls, tabetic crisis, etc.(33) Encouraged by some success in this endeavor he tried to induce anesthesia by injecting in a similar manner but was unsuccessful. Cathelin described the method now known as caudal anesthesia. This consists of the injection of the an sthetic solution into the sacral canal through the sacral hiatus. The method of Cathelin did not at first have many followers, and only gained many exponents after being popularized by Läwen in 1910.

The motive which has favored this form of anesthesia has been the avoidance of diffusion of the anesthetic solution in the dural sac, thus eliminating a series of disturbances which frequently follow subarachnoid spinal anesthesia. The method seemingly to date gives the best form of anesthesia for the sacral and pudendal plexuses and is a precise method for regional anesthesia of the sacro-perineal region.

Cocaine, the first drug to make local anesthesia a practical possibility, has been strongly criticized be-cause of the danger of poisoning.(19) This was due at first to the strong solution used and later to faulty technique, too rapid injection, or imperfect control of

the circulation. Cocaine, like all other anesthetizing drugs is a protoplasmic poison, forming with protoplasm an unstable combination which breaks down slowly, after which, the tissues return to their normal condition and resume their normal function. It has practically disppeared from general use.

Novocaine, discovered by Einhorn, was first clinically tested by Braun in 1905. It was widely extolled by him and soon became quite generally adopted, and it is at the present time used by a great many. It is from seven to ten times less toxic than cocaine, and it's solutions stand boiling and keep for a long time without deteriorating. This drug and other newer less toxic cocaine derivatives such as metycaine are the ones most popular in the caudal method of today.

Anatomic Characteristics

The sacrum normally is composed of the union of five sacral vertebrae which unite at times with the fifth lumbar. It is a cuneiform bone, flattened, with a marked anterior concavity. It unites in its inferior extremity with the coccyx.(12)

The anterior or the pelvic surface of the sacrum is smooth and markedly curved anteriorly. In a vertical line on the two sides about two cm. from the midline are found four to five anterior sacral openings, through which run the anterior branches of the sacral nerves.

The posterior surface of the sacrum is of special interest to the anesthetist. It is very rough and is convex in two directions, especially in the vertical axis. It presents the medial longitudinal crest, which is readily palpated posteriorly and which is formed by the fusion of the spinal processes of the sacral vertebrae. It presents three to four and, at times, five prominences representing the superior limits of the sacral hiatus and is of the most importance to the anesthetist.

On the two sides are two other vertical crests, which are less prominent and more difficult to palpate. Of these, the more external corresponds to the line of fusion of the transverse processes, the more internal to the line of fusion of the articular processes. Between one and the other are found in a longitudinal

series four or five postior sacral foramina, which are smaller than the anterior and thru which pass the posterior branches of the sacral nerves.

The sacral hiatus, or the inferior aperture of the sacral canal, is limited below, according to classical anatomic descriptions, by two sacral horns, which as a rule point downward to meet the horns of the coccyx. They are formed by the articular process of the fifth sacral and its posterior arches which have not fused in the midline. Above, the hiatus is limited by the spinous process of the fourth sacral vertebra. Usually, it has an inverted, U or V, form with margins that are more or less prominent, being closed by a fibrous layer, which is very resistent. This anatomic situation, though it has been described as common, is found in only twenty to thirty per cent of cases, and very frequently one of the following common variations is found:(12)

1. The hiatus is displaced downward, due to the fusion in the midline of the arches of the fifth sacral. In such a case it is limited above by the prominence of this fusion, and below on the two horns of the coccyx.

2. The hiatus may be displaced upward, due to lack of fusion of the fourth, third, or even the second sacral segment.

3. Rarest of all is complete lack of fusion.

The sacral canal is of prismatic form above and semilunar below, with an anterior concavity, which narrows very rapidly from above downward. Its anterior wall formed by union of the bodies of the sacral vertebree is relatively rough, while the posterior wall resulting from the fusion of the vertebral lamina is smooth. There exists, as stated, frequent anomalies of the closure of the posterior wall. Very frequently the vertebral canal presents lateral deviations and other variations of its usual curves. At times it presents a marked narrowing in the antero-posterior axis with connective-tissue septa which are dense and at times even ossified. This represents a very unfavorable condition for the penetration of the needle and the homogeneous diffusion of the injected solution.

The sacral canal contains connective tissue and adipose tissue rich in vessels, and the sacral nerve-roots, covered by finger-like digitations of the dura mater, which run downward and in a lateral direction toward the sacral foramina. The spinal ganglia are found in the canal and not in the sacral foramina.

The dural sac extends downward as low as the level of the second sacral segment, rarely lower. One may calculate that in one or two percent there is the possibility of penetration of the dural sac with the needle inserted in the sacral hiatus, even if this is not made

beyondthe third sacral segment. This condition will be observed on the occassions in which cerebrospinal fluid comes out of the needle, signifying that either the sac has been perforated or the meningeal covering of one of the nerve roots penetrated. It is very important to recognize this possibility in order to avoid the injection of dangerous quantities of the anesthetic into the sub-arachnoid space.

It can be shown by injections that colored fluids injected into the sacral canal never appeared in the spinal canal or colored the upper part of the cord, showing the complete isolation of the two parts of the canal from one another by closure of the dura mater.(33) So that although the nerves are transmitted from the spinal canal down into the sacral canal there is no other communication between the two. This fact marks the distinction between this method of securing anesthesia and that termed spinal anesthesia, in which the fluid is injected directly into the spinal canal.

Thompson(54) following experiments upon cadavers used by the University of Texas Juniors at Galveston con-ducted an experiment to determine the level reached by diffusion of a staining fluid. Fifteen bodies were used, in each case 30 c.c. of aqueous solution of eosin

was injected into the sacral canal. A needle 6cm. long was used in each case. The dissection of the sacrum and spinal canal was made immediately, and as soon as the data in this region was obtained the spinal canal and cord were exposed in the thoracic region opposite the spine of the scapula (3rd thoracic vertebrae). Roughly speakin, in every case, in half an hour, the sacral and lumbar regions of the cord were exposed, and at the end ofan houŕ the dorsal region was laid bare.

Anatomical Findings:

No. of Diss. Rm.	Lower end of Dura Mater	Upper Level of Fluid
3	3rd Sacral Vert.	3rd. Thor. Vert.
26	2nd Sacral Vert.	3rd. Thor. Vert.
7	Junct. of 2 & 3 Sac. Vert.	7th cervical
9	" " " "	6th Thor.
11	2nd Sacral	3rd Thor.
5	3rd Sacral	6th Thor.
15	2nd Sacral	1st Sacral
17	Junct. of 2 & 3 Sac. Vert.	7th Cervical
23	2nd Sacral	3rd Thor.
19	2nd Sacral	3rd Thor.
20	?	10th Thor.
13	2nd Sacral	3rd Thor.
1	3rd Sacral	3rd Thor.

	Junct. of 2 & 3 Sac. Vert.	3rd Thor.	
Dem. Body	3rd Sacral	?	

* Some students did not have time to dissect above 3rd Thoracic.

In the work of Grodinsky and Best(18) of a similar nature, it was found that the position of the body made no difference in the levels reached. This was attributed to the fact that the extradural space is filled with a loose areolar fatty tissue which absorbs some of the injected fluid and also prevents the solution flowing as through an empty cavity.

The nerve branches that descend thus from the spinal into the sacral canal are called the sacral nerves. From the sacral canal they pass through the sacral foramina out into the pelvis, forming the sacral plexus.(33) The chief divisions of the sacral plexus are the sciatic and pudic nerves.The pudic terminates in three branches; namely, (1.) the dorsal nerve of the penis (2.) the perineal nerve (3.) and the haemorrhoidal. These supply the skin, scrotum, structures of the penis, perineum, prostate and bladder, and the inner surface of the thighs posteriorly. A structure exclusively supplied by a nerve may be anesthetized by deadening that nerve, but when the structure is supplied by another nerve also, the deadening of one nerve does not suffice for anesthesia; the collateral nerve holds the tissues in a sensitive condition. This accounts for the fact that the

lower extremities are not made analgesic by anesthetizing the sciatic nerve. Collateral innervation maintains sensibility.

Physiology

Caudal anesthesia as formerly stated involves the introduction of a local anesthetic solution through the sacral hiatus into the peridural space below the point at which the dura mater closes about the filum terminale.

Thompson, Shaw, Grodinsky, and Best(54), (51), (17), (18) and others have shown that fluids deposited extradurally do not penetrate the meninges. The work of the last two investigators indicates that to act on nerves above the third sacral, an anesthetic agent deposited in the sacral canal must pass out the intervertebral foramina and come in contact with the nerves distal to the spinal ganglia, to which the dura extends.

Caudal anesthesia is, therefore, a form of regional anesthesia and is quite different from spinal anesthesia. Its advantages over other forms of regional analgesia lies in the fact that with a single needle inserted only once bilateral analgesia can be induced up to any level desired. In addition, caudal analgesia has for the relief of pain all the advantages of spinal anesthesia with none or few of the disadvantages. It produces paralysis of only the perineal muscles, however, and does not provide the abdominal relaxation attending spinal anesthesia. Lack of abdominal paralysis is of course, a disadvantage in abdominal surgery but an advantage in

obstetrical use since the patient would not lose voluntary expulsive power.

The level reached by fluid injected into the sacral canal through the sacral hiatus is largely dependent on the volume of fluid employed. Grodinsky and Best (17),(18) found a definite order in which effects are observed, an order which is also followed in the relative segmental levels attained. First to appear, and highest to extend, is hypalgesia without significant impairment of other senses. As hypalgesia progresses to analgesia, hyperthesia to touch appears. Hingson and Edwards (14), (21), (22) have confirmed these findings and have observed further that diminution of temperature and proprioceptive sensation occurs later and to a lesser extent. They found that with the exception of the muscles innervated by the last two or three sacral segments, motor weakness does not usually appear before several hours and does not become extreme. The third, fourth, and fifth sacral nerves lie within the sacral canal for several centimeters distal to their ganglia and are therefore exposed to a more intense action of the anesthetic agent. This probably accounts for the early and complete paralysis of the muscles of the pelvic floor seen with caudal analgesia.

Harris(20) shows by his experiments that the more

rapid the absorption the more toxic are the symptoms produced. The more rapid the absorption the less marked the anesthesia, for it requires a certain length of time for the drug to act. Thus he advocates the use of adrenaline with novocaine to increase the degree and duration of anesthesia. When the anesthetic solution is brought in contact with the nerve, it penetrates the nerve and interrupts or blocks the passage of nerve impulse at that point. If the nerve be a mixed one afferent impulses are blocked before efferent. If the blocking is complete no afferent impulses can travel along the nerve at that point of blocking; hence no sensations having their origins in the region supplied by the nerve blocked can be perceived. Sensations are of several kinds; touch, pain, temperature, pressure, etc. When a nerve is blocked, the sensations are not all lost at the same time. Pain is lost first, and pressure last. The prick of a pin may be recognized after it ceases to be at all painful, and pressure can usually be recognized after touch is lost.

Despite the paucity of information concerning the mechanism of local anesthesia, it is known that certain nerve fibers are more susceptible than others. As has been mentioned it is found that in a mixed nerve the sensory fibers are blocked earlier than the motor, and

when the proper concentration of anesthetic is applied to a nerve, it is possible to block completely the sensory fibers without abolishing the transmission of motor impulses.(16) It has been established that there is a definite order in which the fibers in a sensory nerve are effected by local anesthetics. The sensation of pain is the first modality to disappear and it is followed in order by the sensations of cold, warmth, and touch. Various theories have been set forth to explain this difference in susceptibility. For a long time it was thought that the phenomenon was due to a difference in the chemical constitution of the fibers. Then Gasser and Erlanger (15) noted that when pressure is applied to a mixed nerve the resulting anesthesia of the motor and sensory fibers appears in a sequence opposite to that observed after block by anesthetic drugs, namely, the motor fibers are affected before the sensory. They then demonstrated by the use of the cathode ray oscillograph that fiber size is the main factor in determining the relative sensitivity to pressure and to chemical anesthesia. After cocaine is applied to a mixed fiber, the gamma waves (from small cutaneous afferent fibers) are the firstand the alpha waves (from large fibers) the last to disappear. Inasmuch as cocaine probably acts by chemical combination with the nerve protoplasm, it is

logical that the smaller fibers which present the greatest surface per unit of volume are the first to be anesthetized. This concept receives support from the observation that if a local anesthetic is applied to the vagus nerve, the smaller efferent cardioinhibitory fibers are blocked before the larger fibers which carry afferent respiratory impulses.

The incorporation of epinephrine in the anesthetic solution for caudal anesthesia is so frequently practiced that its action should also be rightly given a short discussion. The duration of action of local anesthetics is proportional to the time during which they are in actual contact with nervous tissue. Consequently procedures which localize the drug at the nerve greatly prolong the period of anesthesia. Cocaine itself constricts the blood vessels and therefore prevents its own absorption. For this reason, the duration of cocaine anesthesia is greater than that of most anesthetics which do not cause vasoconstriction. The addition of epinephrine to local anesthetic solutions greatly prolongs and intensifies their actions. In clinical practice, therefore, the injection of a local anesthesia is usually accompanied by epinephrine or one of its suitable synthetic congeners. A concentration of 1:25,000 to 1:50,000 of epinephrine performs duel service. By decreasing the rate of absorption epinephrine not only localizes the anesthetic agent at the desired site but

also allows the rate at which the anesthetic is destroyed in the body to keep pace with the rate at which it enters the circulation. Thus a toxic concentration is not reached.

Dunlop(13), a Fellow in Anesthesia at the Mayo Foundation, became interested in the work done on the fate of local anesthetics in the body. According to the literature he compiled it was most generally accepted that the liver was the site of destruction of the local anesthetics due to work done in producing artificial injury to the liver of cats by means of phosphorous and chloroform anesthesia, and showing that these cats were rendered much more susceptible to intravenous injections of cocaine, procaine, and tutocaine than healthy, untreated animals. Dunlop in attempting to prove or disprove this assumption ran three perfusion series with procaine on normal, healthy dogs; these three were a heart-lung circuit, a heart-lung-limbs circuit, and a heart-lung circuit with the addition of the liver. The results in the heart-lung preparation demonstrated that procaine is progressively, although slowly, destroyed and converted into its end-products by the tissue present, in the absence of the liver. On the other hand, there was a decrease in successive samples of the amount of procaine present in the blood; on the other hand

there was an increase in the end-products, as can be represented by para-aminobenzoic acid. This destruction was, as stated, slow; traces of the drug persisted unchanged even after four and a fourth hours of perfusion.

The effect of adding hind limbs to the heart- lung circuit was not very marked. In all samples there was only a little less of the drug present than in the corresponding samples from the heart-lung circuit, and this could well be the result of absorption and removal of more of the drug from the blood by the extra tissue present. Inactive skeletal muscle, then, apparently takes little part in the detoxification of procaine.

The addition of the liver to the heart-lung circuit, however, gave striking results. In the three experiments conducted, procaine was entirely destroyed within one and a fourth hour, in one case within forty-five minutes. Here it was definitely not a question of the amount of tissue in the circuit, for although procaine rapidly disappeared from the blood, the end-products accumulated equally rapidly, remaining in the blood. The liver, then, although not essential, detoxifies procaine much more efficiently and rapidly than other tissues, chiefly muscle, that were studied. The question thus may be raised as to the advisability of adminis-

tering large amounts of local or regional anesthetics of the cocaine derivatives to persons suffering from severe hepatic injury.

A freshly sterilized one per cent solution of novocaine gives satisfactory results. Various additional drugs used by others such as the addition of 6 to 8 drops of adrenalin, to 1000cc, to delay absorption may or may not be of benefit, but are not essential. (49)

The injection is best made with the patient lying flat on the abdomen, with a small pillow und r the hips. Since the sacral segments are fixed, there is no advantage to be gained by the lateral position with acute flexion. The lateral position with acut flexion, however, is preferred by Hingson and Edwards in administering caudal anesthesia to obstetrics patients.(22) In obtaining results the injection of the sacral canal is more important than is that of any of the foramina, and fortunately this is the easiest of localization. In the average case the sacral cornua can be palpated with comparative ease. It will be recalled that these cornua are present as a result of the lack of fusion of the lamina of the fifth sacral segment, and the sacral hiatus or opening into the sacral canal, therefore, lies between these two landmarks. A small calibre needle of the type ordinarily used for spinal puncture serves well.

The introduction of the needle is b st preceded by the production of a d rmal wheel of novocaine with a

fine hypod rmic needle, in the mid-line and just below the level of the sacral cornua. Faulty direction of the needle is the cause of more failures than is improper location of the point of introduction. The needl is best maintained at an angle of about forty-five degrees with the skin surface until the point is f lt to penetrate the fibrous membrane covering the sacral hiatus and to strike the bony floor of the sacral canal, 2 or 3 mm. beyond. The operators end of the needle is then depressed until the shaft comes to be approximately parallel to a tangent to the curve of the sacrum at the point of introduction. As the needle is further introduced it may be necessary to slightly elevate or to further depress the end in order to avoid the point striking the roof or floor of the canal. The curve of the canal makes a tapping of the dural sac a very rare occurrance, yet it should be routine to watch for the appearance of cerebrospinal fluid during a short interval oftime between withdrawal of the stylet and injection of the novocaine solution. Dr. Davis (10), (11), (9) in his his injections preparatory to prostate operations routinely injected into the sacral canal 40 cc. This should be injected slowly, though the fluid should flow in easily, with no force upon the plunger necessary. Since the necessity for force indicates an improperly

placed needle, the ease of introduction of the fluid is an accurate index of the success of the anesthesia.

The above in the technical sense of the word constitut s caudal anesthesia, but in the urological work of Davis, (9) (10) (11), Scholl, (49), Meeker (36), Hunt (26) Judd (30), Shaw (57) the injection of the posterior sacral foramina has become part of the procedure in bladder and prostate work. The technique being practically the same among them.

The location of the posterior sacral foramina is usually more difficult. The operator is aided by the anatomical fact that the openings of the sacral foramina upon either side all be in the same straight line, and that for all practical purposes they are equidistant from one another. In the average individual the posterior superior iliac spine may be readily palpated, and the second sacral foramen located at a point about 2 cm toward the mid-line and one cm. below. The line of all five foramina may then be determined by connecting the above described point with a point located just outside of and below the sacral cornu upon the corresponding side. This latter point locates the notch for the fifth sacral nerve, the injection of which may be omitted in case the epidural injection has been successful. The division of the distance between these two points into

three equal parts will locate the sites for injection of the third and fourth foramina. The first may be located a corresponding distance above the second. Here again, the direction of the needle is of importance. Each needle should be introduced at approximately a right angle to a tangent to the curve of the sacrum, rather than perpendicular to the skin surface. Ordinary Luer needles, about 18 gauge and 2 in. in length will well serve the purpose. It is convenient to use several. The introduction of each needle should be preceded by the production of a dermal wheal with a fine hypodermic needle. A foramen is rarely located by the initial stab. It is seldom necessary, however, to make more than a single skin puncture, for the reason that it is possible to "feel" the bony surface of the sacrum as the point of the needle comes in contact at several closely related points, before finally dropping into the foramen. The not infrequent irregularity in size and direction of the posterior foramina often gives difficulty in introduction of the needle. This is a frequent case in foramina with over-hanging bony lips. The introduction of the needle into the foramen a distance of 1 to $1\frac{1}{2}$ cm. below the dorsum of the sacrum is sufficient.

Fair sized vessels accompany the nerve roots through the foramina, and it is good procedure to allow a short interval of time before injection to await the possible appearance of blood through the needle. Upon these few occassions it is possible to withdraw the needle slightly, and then make the injection with no ill-effect.

In accordance with Meekers technique (36) (30) the routine has been the injection of approximately seven, six, five, and four c.c. of one percent novocaine solution witnin the first, second, third and fourth foramina, respectively. The skin incision should be postponed for a period of not less than thirty minutes after the initial or epidural injection.

Lewis (33) cites as difficult cases for caudal anesthesia the obese,the very nervous, the hysterical, and children. Laewen after his first clinical use of this method advised against its us in the aged, but these seem to be the very cases in which it is especially advantageous. It has made operation possible in a number of cases debilitated and decrepit from advanced age and the ravages of urinary obstruction and sepsis, its freedom from shock and other depressing influences making it particularly desirable for this class of cases.

Just as with the use of drugs for any purpose and by any method, so there is a certain variability in the

effectiveness of this method for producing anesthesia. Aside from individual susceptibility, there may be other reasons explanatory of this. The capacity of the sacral canal may be large or small, requiring a greater or lesser amount of fluid to fill it and exercise the pressure-effect on the nerves that alters the effectivness of the absorption.

In referring to the toxicity of novocaine, a wide variety of typical poisoning symptoms have been listed by early workers such as Laewen. Lewis states that only rarely in his series of 85 cases in which caudal anesthesia was usedby him prior to 1916 were symptoms of nausea, sweating, anaemia, rapid pulse, frequent respiration, feeling of oppression, and haze in front of the eyes noted, and that these symptoms could be avoided by making the injections slowly.

In Germany Barbey (2) as early as 1920 began the awakening comments regarding the comparative disregard of the sacral method of anesthesia which has finally begun sweeping this country in the last five to ten years. He comments on the technic b ing simpler than nerve blocking, and the by-effects milder than with lumbar anesthesia. He was obtaining complete anesthesia in 91.8 per cent, and failure in only 2 per cent.

Caudal Anesthesia in Urology

Epidural sacral anesthesia as applied to urology or general surgery has its chief advantage in the elimination of post-operative shock and other dangers incident to the use of ether or gas. In this respect the patient is directly benefited. A second advantage of great indirect benefit to the patient, is received through the opportunity for time and deliberatness afforded the surgeon. Under local anesthesia there is no urgent indication for haste. The operator proc eds more carefully and deliberately with his dissection, he is able to avoid trauma to tissues and has the opportunity for better exposure and hemostasis. And finally, the first few post-operative days following local anesthesia are accompanied by far less discomfort and gastro-intestinal disturbances.

The disadvantag s of caudal anesthesia and the objections to its use should be also taken into consideration, for this method is not without its dangers and its remote mortality, due chiefly to the possibility of toxic absorption. Furthermore, there are patients whose mental make-up is such to entirely preclude the successful employment of local anesthesia; and th r are many operations of such extent and such anatomical relations as to ess ntially require a g n ral anesthesia.

The chief hind rance, however, to the more general adoption of local anesthesia, and to the developement of this method to a wider field of usefulness is due in a large measure to the reluctance of the average busy surgeon to devote the time and attention essential to successful application.

The advantages of this type of anesthesia in prostatectomy are obvious. Primarily this operation deals with old age; often with advanced old age with the accompanying cardio-vascular and renal changes; to say nothing of the renal injury resulting from chronic urinary r tention and infection. These patients are, therefore, doubly handicapped, and to recover must survive the combined ill effects of operative trauma, infection, and hemorrhage. The elimination of the added insult of general anesthesia is, therefore, well worth the effort.

The mortality of sacral anesthesia is a negligble factor. In a series of 120 cases reported by Davis(10) there were no ill effects whatever. He contends that the complete perineal operation may be done painlessly following the use of a single injection through the sacral hiatus, although the small percentag of cases in which imperfect anesthesia is obtained may be further minimized by supplementing this single(caudal) injection by injections through the sacral foramina; the so-called sacral block. Davis also states that sacral anesthesia

is of distinct advantage in hemostasis in minimizing the immediate hemorrhage (probably through a lowering of blood pressure), and in permitting time for the careful ligation or suture of bleeding points.

In Scholl's (49) report of sacral anesthesia used on one-hundred and fifty patients in the Mayo Clinic, one hundred and forty were considered satisfactory, the remaining ten were failures. The failures were due in 7 cases to either individual resistance to novocaine, or to errors in technique; in two cases to anatomic deformities of the sacrum, and in 1 case to the extension of a malignant process into the sacral canal.

An estimate as to the infrequency of mishap following the sacral or extradural injection may be obtained from the work of Zweifel (58), analyzing the reports of ten fatalities occuring among 4200 cases, and concluding that in only three of these was the anesthesia responsible. In these three, death was almost immediate, resulting apparently from acute procaine poisoning. The use of newer drugs such as metycaine may reduce this small percentage even further - the test of time proving or disproving this.

In all urological reports there is almost universal consensus of opinion that the numb r of failures can be reduced by applying a more careful technique with the resulting success of introducing the needle through the

hiatus into the lumen of the sacral canal. Another common error is the omission of an interval of time between the injection and the incision. Unsuccessful anesthesia will be obtained unless a period of thirty to forty minutes be allowed to elapse, which represents the time probably necessary for the pen tration of the dural sheaths of the nerves. Proper selection of cases, and pre-operative hypodermic narcosis when necessary, will largely reduce the percentage of so-called failures.

As mentioned above, th re is great satisfaction to the surgeon during the prostate operation in the knowledge that time for operativ deliberatness and hemostasis may well be afforded without danger to the patient. Consequences and complications resulting from prolonged anesthesia need be given no consideration. Of greater importance, however, is the fact that with sacral an sthesia, these patients pass through no period of post-op rativ shock. Their condition upon returning to bed, as measured by pulse, respiration, color and general appearanc , is not essentially changed from that prior to operation. To observe one of these patients reading or eating during the aft rnoon following operation is not unusual. Furthermore the sum total of post-operative discomfort and pain is less, presumably due to a p rsistent analgesic eff ct. The pain caused by the

removal of the hemostatic bag twenty-four hours later and the gauze if present is in no way comparable to the pain produced by a similar procedure following general anesthesia. In the Davis series of prostatectomies (9) the average number of days before (1) sphincter control, (2) urethral voiding and (3) closure of the perineal fistula was five, seven, and twenty one respectively. There is, therefore, no reason to believe that sacral anesthesia interf rs in any way with wound healing or with the return of the normal function of urination.

Objections to sacral anesthesia appear to be largely two in number: (1) The injection of the sacral canal requires a fair degree of technical skill and practice, and the method is time-consuming in that an interval must elapse between injection and incision. (2) There occurs the very occassional case of inexplicable failure to obtain satisfactory anesthesia.

The solution of novocaine should be made up fresh for each case. The novocaine, in combination with sodium bicarbonate and sufficient sodium chloride to give a normal salt solution, is kept in powders. Scholl (49) gives the following proportions:

Sodium Bicarbonate	0.15
Sodium Chloride	0.10
Novocaine	0.60

Thirty cubic centimeters of distilled water is brought to a boil in a glass flask over an alcohol lamp; the flask removed and the powder dropped in. The solution is then brought to a boil and allowed to cool. Six-tenths of a gram of novocaine in 30 cc of water makes a 2 percent solution. The addition of sodium bicarbonate makes a strongly hydrolyzed solution which diffuses more readily through the nerve sheaths and produces an anesthesia of gr ater intensity and longer duration than that with novocaine alone. After the addition of the powder the solution is not allowed to boil for more than a few seconds since the acid bicarbonate readily changes to the strongly alkaline carbonat which may produc gangrene.

Epidural sacral an sthesia is particularly applicable to bladder and urethra procedures. The bladd r and urethra are supplied by two sets of nerves, the sacral and the sympathetic, both of which contain afferent and efferent fib rs. The sacral branches are the most important, they form the hypo-gastric plexus which ramifies over the bladder, supplying the unstriated muscles of the bladd r, urethra and corpora cavernosa; other branches from the sacral plexus, especially the pudics, form the motor path to the striated muscle of the urethra. The sympathetic branches are of importance. They arise from the lower thoracic and upper lumbar

roots, passing through the splanchnic nerve to the inferior mesenteric ganglion, then through the hypogastric nerv s to the bladder. Blocking the sacral nerves produc s in most cases complete anesthesia of the bladder and urethra, though in an occassional case distension gives moderate pain.

One of the most satisfactory fi lds for sacral anesthesia is the anesthesia obtained in irritable, inflamed bladders, specially of tub rculous origin. The results in this class of cas s are remarkable. In contracted painful bladders which must be emptied every ten to fifteen minutes, the instrument is passed painlessly, the anesthesia permitting a distention of from 100 cc to 150 cc during the entire examination, without a tendency to discharge. There is a paralysis of the sensory arc, and the reflex spasm that often makes a complete examination impossible is absent. The patient rests quietly; the starterous breathing and the shifting bladder walls of a patient under deep narcosis is absent.

It is possibl in these cas s to add the additional ounce or two of fluid which produces a distention sufficient to flatten the folds of mucosa and expose the entire surface of the bladder. With a knowledge of the approximate duration of the anesthesia and of the absence of undesireable after-effects on the patient, the operator is able to carry out a t chnically complet examination

without the haste so often necessary when a different anesthesia is used. Bladders that hold practically nothing may readily be dilated sometimes to 150 cc. Overdistention occassionally causes the patient some discomfort, necessitating a partial emptying of the bladder. In such instances complete anesthesia of the sacral nerves is usually obtained, but the sensation of distention is carried through the sympathetic nerve to the upper lumbar roots. These minor branches to this segment may readily be blocked by injecting a small amount of cocaine in solution through the urethra into the bladder.

This type of anesthesia is ideal for the application of radium needles. The needles are inserted through the perineal tissue from 4 cm. to 6 cm. into the malignant prostate. Nearly all carcinomatous prostates are encased in a thick, resistant, fibrous, or malignant capsule. It is impossible, by local applications, to anesthetize this capsule sufficiently to allow the needles to pass through without pain, and it is also difficult to eliminate the deep pressure pains caused by the needle passing through the boardlike, malignant and fibrous tissues of the gland itself. After blocking the sacral nerves, the anesthesia of the perineal tissues, the prostate and its coverings is so complete that the needles are ofter inserted without the knowledge of the patient. More radium needles may be inserted than when a local

infiltration anesthesia is used, the radium containing tips are more accurat ly placed, and the field of operation is not obscured from the edema of the infiltrated solution.

While it is impossible to fulgurate the majority of benign papillomas of the bladder without an extensive anesthesia, there is an occassional case in which the mucosa is too irritable to permit sufficient distention or extensive fulguration. Sacral anesthesia is very satisfactory in these cases, permitting an unhurried complete operation.

Radium emanations inserted into the bladder through the cystoscope cause no pain, but an irritable cysiitis is often present, especially in cases of extensive, solid tumors, and anesthesia is necessary to permit sufficient distention forsatisfactory observation.

In case of litholapaxy, when washing out stone fragments, it is necessary to remember that the musculature of the bladder is partially paralyzed and cannot readily expel the water and particles of crushed stone. An evacuator is of satisfactory use in overcoming this difficulty.

The temporary paralysis of the internal sphincter muscles may produce a slight incontinence, disappearing with the return of sensation. This paralysis of the in-

ternal sphincter is readily seen in X-ray plates taken after the injection of an opaque medium, the cystogram resembling that seen in connection with lesions of the spinal cord. (49) In occassional cases there is also paralysis of the lower end of the ureters. Observed through the cystoscop the meati (uret ral orifices) are gaping and flacid; if touched with a ureteral catheter they contract and assume their normal appearance, but readily relax again.

Crowell and Thompson(8) give high recommendations to the use of sacral anesthesia in their series of its use in 33 consecutive prostatectomies where with one exception they found it without an unpleasant result at the time of operation or following the operation. They state its application as simple and easy, and its dangers insignificant. The influence lasts from 3 to 8 hours and does away with the gastric disturbances and pulmonary complications which frequently follow a general anesthetic. They now use it as a routine and find it very advantageous in cases of arteriosclerosis, cardiac and pulmonary complications and in cases of high blood pressure due to nephritis.

Hunt of Mayos (26) who is an advocater of supra-pubic prostactectomy gives in his 1921 report to the clinic the combined transsacral and abdominal infiltration

withnovocaine as being his ideal anesthesia.

Munger and Wrenn (41) in the Veterans Administration facility at Lincoln, Nebraska hav instigated the routine use of caudal anesthesia in all male cystoscopic examinations to do away with the fear-complex engendered by a former cystoscopy or caused by the recital of some other patient who has been through th experience and is eager to tell his friends of the extreme severity of the ordeal. Caudal anesthesia is c rtainly not always necessary for simple cystoscopic examinations. Howev-r, this is a field where we find the greatest variation in the sensib lity of patients. Where the urethra and bladder are fairly normal, simple observation of the bladder and catheterization of the ureters may be carried out with a comparatively small amount of pain under local anesthesia. If the operator remembers that the local anesthesia applies only to mucousmembrane and does not relieve the pain caused by the distension of the musculature of the posterior ur thra, he will see that local anesthesia is not as satisfactory as caudal anesthesia. The patients upon whom the caudal technique was used were not selected; they were all veterans ranging from 36 to 76 years, who presented the followingpathological conditions:

Pyonephrosis	Hunner Ulcer
Vesical calculus	Renal Tumor
Tuberculosis-renal and urogenital	Renal dystopia bilat ral
Transur thral resections	Congenital horseshoe kidney
Ureteral calculus	Obstructions of prostate, all types
Renal calculus	Diagnosis undet rmined
Uret ral Strictures	Atrophic kidney, congenital
Pyelonephritis (mixed infections)	Bifid Kidney, unilateral
Hydronephrosis	

Patients Receiving Caudal Injections

Sex	No. of patients	No. of injections	Successful	Successful%
Male	114	130	128	97.4

Unsuccessful-	%	No. of Reactions	Reactions
2	1.53	3	

The few failures illicited wer attributed to : (1) Insufficient time allowed between injection and operation(2) Too rapid injection (3) Improperly placed needle (4) Lack of using fresh solution (5) Lack of having needle high enough.

In regard to the r actions, in one case there was a marked reaction in the form of deep excitement, followed by a drop in blood pressure, cold clammy skin, and marked perspiration, with loss of motor function, dyspnea. This condition lasted but a few minut s and was promply

relieved. In two other cases there was a sign of transitory restlessness and dyspnea. All of these patients soon returned to normal condition. There were no infections and no sloughs.

A 1 percent sterile novocaine solution was used and 30 to 60 cc. were injected slowly, taking from 5 to 10 minutes. It was found that by the use of sodium amytal and morphine sulphat as a premedicant that only about one-half the amount of novocaine solution was necessary.

Johnson (28) (29) has used caudal and transsacral block anesthesia in over 900 urological cases and states he has never had a death attributable in any way to the anesthetic. Over 300of these injections were for perineal prostatectomies. His citations as to advantages, disadvantages, and technique coincide so closely with those set forth by Dr. Davis earlier in this section that their listing would be for the most part repitition.

Tuohy and Adams (55) of Mayo's substantiate the advantages and disadvantages as have be n set forth in this section on caudal anesthesia in urology. They list their preference for metycaine and have found that the 5cc. ampoule of solution of 20 per cent metycaine is useful. To the contents of this ampoule are added 95 cc. of physiologic solution of sodium chlorid , the

temperatur of which is maintained at about 37.5°C. The content of another ampoul containing 1 cc. of epinephrine 1:2600 is added to the solution of metycaine and sodium chloride. The vasopressor agent may be omitted from the solution if the patient has coronary disease, severe hypertension or thyrotoxicosis.

Campbell (4) gives an interesting report on the use of caudal anesthesi on 83 boys between the ages of 4 years and 14 years. He confined the use of the procedure to cystourethroscopic examination and trans-urethral surgery. The latter includes electro-resection of posterior urethral valves and of the bladder outlet as well as fulguration of deep urethral papillomata. The indications for, contraindications to, and administrative technique of caudal block are fundamentally alike in juveniles and adults. In a great many children the use of caudal block will eliminate general anesthesia. This is particularly desirable when the question of anesthesia delays or forbids the early establishment of the correct diagnosis and the institu-tion of adequate treatment. The majority of children over 4 years of age are cooperative. In this group the ease of administration and the results strongly recommend caudal block. In the 10 percent failure Campbell had the

blamed the failure on himself and not on the method.

The urologist, more often than any other operator, deals with persons having low kidney function. An anesthesia that will not appr ciably incr ase the ork of the kidneys, such as sacral anesthesia, is a desirable asset. As an aid to urology, sacral anesthesia, permitting examination and operations on dis ased bladders and its appendages without discomfort or risk to the patient, offers an exceptionally useful field to the urologist and deserves to be more generally employed.

Caudal Anesthesia in Surgery, Proctology

Hingson and Southworth (21) (23) state that in the U.S. Marine Hospital, Staten Island, New York, the treatment of Varicose veins has long been a problem. Their experienc indicated that phlebectomy using the Mayo stripper has been the method of choice in a particular group of their patients. This was due to the impossibility of getting their patients, who are for the most part merchant seamen, to r turn for the frequent follow-up examinations required when varicosities are treated by ligation and retrograde injection. Also, in that group of patients who have had recurrences of varicosities after ligation and retrograd inj ction, they consid red indications for phlebectomy. The technical difficulti s of phlebectomy are due largely to the necessity of working on all sides of an extremity at one sitting and at the same time maintaining the strictest asepsis. In the past this has been accomplished only by having an assistant hold the extremity in a position that is oft n awkward and strained.

Hingson and Southworth (21) due to the fact that the flexible spinal needle could be left in situ safely for long periods, tried continuous caudal anesthesia for use in phlebectomy. Because of the sel ctive affinity of the local anesthesia agents for sensory nerve roots, the patient suffers no pain but has enough

muscular control and position sense in the lower extremities to cooperate with the operator in holding his legs in positions favorable for operative procedures. They believe that this method has all of the advantages of spinal anesthesia without any of the disadvantages. Through this method they were able to get the patient to cooperate with the operator in shifting and holding positions necessary for the removal of long and tortuous varicosities that often encircle the extremity. The longest surgical procedure for which this method was used by these men was four hours and the shortest two hours. The highest dosage of the drug metycaine in a 1 percent solution was 265 cc. and this was used in the 4 hour case. The anesthesia in th patients did not extend above the umbilicus. They used the method for 20 surgical patients with satisfactory results in all of them. Most of these patients had bilat ral phlebectomies or bilateral hernioplasties. However, the procedure worked satisfactorily in an appendectomy, a prolonged operation about the anus in which plastic repair was necessary and in a vaginal hysterectomy.

The systemic effects are about the same as would be expected from an infiltration of the same amount of anesthesia locally. In some cases the blood pressure rises about 15 mm. of mercury and in other cases it

falls about the same amount. The pulse and respiration show minimum changes. The patient is able to move his lower extremities throughout the operation; some notice a diminishing muscular pow r as the agent infiltrates the anterior roots. Patients generally eat their meals on the day of operation and may receive limited amounts of water during the operation. Only rarely is a vaso-constrictor drug such as ephedrine necessary to fortify the blood pressure.

Reuther (48) of Chicago reports th use of caudal anesthesia in a series of 40 cases in which he relates he finds caudal anesthesia a satisfactory method of anesthesia for almost all proctologic op rations. His only contraindications are infections in the site of injection. He prefers the use of 2 percent metycaine as a standard technic. Procaine and metycaine wer used with two s ries of 20 cases each. Using an alkaline procaine solution, he had 55 percent failures; with a two percent solution of metycaine there were no failures.

Mentzer (39) gives a report of a series of 100 cases in which he used metycaine caudal anesthesia in proctologic surgery and found it adequat for all proctologic procedures and for many procedures in the genito-urinary, gynecologic and obstetric fi lds. He believes metycaine has proved its superiority over

novocaine in meeting the following qualifications for a perfect local anesthestic:

1. The drug must produce a diffusible, complet and lasting anesthesia.
2. Following systemic absorption it should be less toxic than cocaine in proportion to its anesthetic power.
3. It should not produce irritation and painful infiltration or cause local tissue damage but should be absorbed without after effects, such as hyper-esthesia, exudation or necrosis.
4. It should be soluble in water, and its solution should be stable.
5. It should be readily sterilized by heat, preferably in solution.
6. Unless more powerfully anesthetic, and at the same time, less toxic than any known substance, the sub-stance should be compatible in solution with adrena-line.

In his series Mentzer found metycaine used as an caudal anesthetic, produced perfect anesthesia in 90 percent of 110 proctologic cases and partial anesthesia in the remaining 10 per cent. Anesthesia was complete in an average of 11.6 minutes. The technic is simple (Mentzer cites how in the series the sacral canal was entered

by seven different physicians with no previous experience with this method.) The anesthesia is intense and prolonged and wears off gradually. The level of anesthesia produced by this method and agent is high enough to perform any anorectal operation. The only complication was nausea with occassional vomiting which occurred in 15 per cent of the cases (nausea was less frequent when ephedrine sulfate was given immediately before anesthetization was started.) The only contraindication cited is that of the often mentioned infective process over the site of the sacral hiatus.

Causey (6) who worked with Block of Chicago on many of the 2,000 cases of caudal anesthesia which were run there, cites that in Chicago and in his own practice his experience with this type of anesthesia includes anal fistula, and fissure, cryptitis, papillitis, rectinotomy, hemorrhoidectomy and procidentia (2 cases) done according to the Mikulicz technique with from 10- 12 cm. of the rectum being removed with entire satisfaction. With the proper procedure and training of the operator few failures result - between 3 - 4 %. He was impressed by the quick and complete anesthesia with a greater degree of safety. The sphincter was often completely relaxed in 3-5 min. after the withdrawal of the needle and in some cases there was an instantaneous relaxation. In this relaxa-

tion there is no need for the stretching of this muscle which might lat r result in unwanted results.

Campbell (5) of the Mayo Clinic emphasiz s the importanc of preliminary m lication in caudal and transacral block anesthesia in order to bring the patient to op ration free of fear and anxiety. He advocates the administration by mouth of sodium p ntob rbital 1½ to 3 grains on admission or several hours b fore operation. This is repeat d a half hour before operation and a hypodermic injection of morphine sulphate 1/6 to 1/4 grain is given immediately preceding removal of the patient to the operating room. He uses this method of anesthesia in operations for hemorrhoids, anal fistula, and fissure, for perineal prostat ctomy, cervical dilatation, and so on. He stat s that in his opinion regardless of weight and physical condition of the patient, this is the anesthesia of choice for operations on the anus, rectum, and erineum of the adult.

Sword (52) studied a series of between 350 and 600 caudal transsacral blocks in Grace Hospital, New Haven, Conn. and was impressed by the value of the procedure, begretting the fact that so many of the leading surgeons and anesthetists in America are satisfied with routine general anesthesia. This series has been divided roughly into three main groups:

1. The urological service, 50 cystoscopies, 150 ab-dominal prostatectomies in which abdominal field block was employed, 47 transurethral resections;
2. Surgical service, 87 hemorrhoid ctomies, 62 posterior resections, 94 fistulas and fissures, 17 Kraskes.
3. Gynecological service, 3* vaginal hyster ctomies, 48 vaginal repairs, inc luding perineorrhophies, cystocoele and rectocoele, dilatation and curettage, 27 abdominal sections with abiominal field block, 10 cases in which there was partial or complet cardiac decompensation.

These anesthetics are administered by various members of the Department of Anesthesia. Reactions wer negliblein those cases in which the needle was prop rly placed and the extra time factor was the only drawback cited in this series. It may be that the extradural technique described by Odom (44), in which novocaine is inj cted into the epidural space through the s cond lumbar vert - brae to allow higher abdominal surgery, may replace caudal transsacral block as it definit-ly saves time and limits the numb r of n edl punctur s, though for urological and rectal procedures it does not seem to give the advantageous sphincter relaxation that is desired.

Baptisti (1) on the other hand states that according to experiments conducted on cadavers with injection fluids and by clinical observation that these investigations indicate that by caudal administration the anesthetic travels

to a high level, particularly if a high caudal technique is employed or the agent is injected with a mod rat degree of pressure. Under such conditions he has been

able to produce lower abdominal and pelvic anesthesia identical with that produced by Odom (44) and others who have administered the agent into the epidural space through the second lumbar interspace. His conclusions seem more logically drawn from experiments conducted and are substantiated by the work of Hingson, Edwards (14) (22) and others.

Mentzer, Alden and Farrer (38) in a report of 327 cas s in the Jackson Memorial Hospital in Miami, Florida list metycaine as the anesthesia of choice in proctologic surgery, when given caudally; which method has proven a safe and efficient one in their hands. Caudal anes-thesia in this series was not combined with transsacral, but consisted of a single injection into the sacral canal. Preoperative sedation in the greater proportion of this series consisted of 1½ to 3 grains of nembutal, given orally and 1-6 to 1-3 grains pantopon, (or its equivalent in morphine) given hypodermically. The last 44 cases received 1-150 to 1-100 grains hyoscine in addition to the nembutal and morphine. Two strengths of metycaine

solution were used, 1 percent and 2 percent. The first 100 cases received an average of 45 cc. of a 1 perc nt

solution, as did 19 of the other 185 patients. An average of 20c.c. of a 2 per cent solution was injected 166 times in the complete series. The average time of induction until complete sensory anesthesia was obtained when 1 per cent solution was employed was 11.6 minutes; this time was 10.8 minutes when a smaller quantity of the 2 per cent solution was used. Perfect anesthesia was obtained in 91.5 per cent of the patients. Reactions attributable to the anesthetic, such as mild shock, accompanied by fall in blood pressure, nausea and vomiting, occurred in 15 per cent of patients receiving the 1 per cent solution and in 9 percent of those receiving a 2 per cent solution, with the exception of the last 44 cases. They received 1-150 to 1-100 grains hyoscine in addition to the nembutal and the morphine. There was only one reaction in this group of 44 cases.

Neely(42), (43) reports he has been using epidural anesthesia by the sacral route for abdominal operations in selected cases for four years and has had no fatalities or any serious reactions. He particularly recommends it for patients with obstructive uropathies to whom one does not wish to give anesthetics that are renal irritants. It gives wonderful relaxation of the muscles for operations on the stomach, gall bladder and bile ducts. The method gave him a satisfactory anesthesia of the entire abdomen

and lower thorax, and also of the lower extremities. the anesthesia lasted from forty-five minutes to two hours or longer. The absence of post-operative gas pains and distention was a particularly noticeable feature in his opinion. His technique varies only in that he uses 10 to 30c.c. of boiled warm 2 per cent solution of novocaine and then as much of a 0.5 per cent solution of novocaine up to 100c.c. as is necessary to produce the anesthesia for the incision and manipulations. He prefers this method due to the likelihood of more concentrated solutions giving unpleasant reactions.

Onhauser(45) of Winnipeg, Canada lists from his experience caudal anesthesia as being his first choice in both urological and proctologic procedures when they necessitate the use of an anesthetic. He states that in these particular fields of surgery this method fulfills the requirements of a good aneshtetic: (a) safety (b) efficiency (c) economy (d) no unpleasant after-effects or complications.

L. E. Moon(40) of Omaha has made caudal anesthesia a routine procedure in his proctologic practice, and states he has found it more efficacious than any other method he has tried. In proctologic procedures the maximum sphincter relaxation obtained is a highly

desirable feature. The absence of vomiting and straining, plus the cooperation of the patient, are valuable aids in avoiding the complication of post-operative haemorrhage.

Caudal Anesthesia in Gynecology

Apart from the kidney and ureter, all the organs of the pelvis derive their sensory innervation from the pudendal plexus, originating from the sacral nerves and the coccygeal nerve, to which are added contributions from the sympathetic system. The visceral branches of t he pudendal plexus, chiefly derivedfrom the 2nd, 3rd, and 4th sacral nerves, are joined by fibers coming from the hypogastric plexus and from the sacral portion of the sympathetic chain to constitute the pelvic plexus of which the hemorrhoidal, vesical, prostatic, cavernous, and uterovaginal plexus are smaller dependencies. The external genitalia receive their sensory nerve supply from the pudendal plexus by means of the pudic nerve and pudendal branch of the small sciatic which distributes filaments to the skin of the posterior aspect of the scrotum, the urethra, the greater part of the vagina, the labia majora (posterior aspect of this), and the labia minora. The labia majora is also supplied by branches of the ilioinguinal and genitocrural nerves, sometimes by the iliohypogastric nerve also. These nerves originate chiefly from the 1st and 2nd lumbar nerves. The perineum and anus also receive their sensory innervation from the pudendal plexus by way of the pudic nerve and the pudendal branch of the small sciatic nerve.

The coccygeal plexus is distributed to the posterior part of the anal region. This description of the pudendal plexus shows that it is almost solely responsible for the pain in the pelvic organs, perineum, and external genitalia, and that it can by reached by injecting all the sacral nerves. But it must not be forgotten that the surgical procedures carried out on one of the pelvic organs are unavoidably and indirectly extended to the structures to which these organs are attached. It is therefore necessary to make provisions for a much wider zone of anesthesia than is actually needed for the organs alone. The routes of approach to the pelvis must also be considered. If the perineal route is selected, the injection of the sacral nerves need not be supplemented by local infiltration or by the field block, but if the abdominal route is chosen, anesthesia of the abdominal wall is indispensable.

Robinson(47) first used a 1.0 percent solution of procaine in normal saline to which had been added five drops of adrenalin chloride. The amount injected varied from 30c.c. to 100c.c. Later he has started using 20 to 40c.c. of a 1.5 per cent solution to which has been added five drops of adrenalin hydrochloride solution. He states he had fewer reactions with a smaller amount of anesthetic solution and has observed no increase in the percentage of failures.

In operations on the cervix, the caudal block with 30c.c. of 1.5 per cent solution of procaine when successfully induced ordinarily produces a very satisfactory anesthesia. Pulls on the cervix must be gentle and gradual, so as not to give rise to too much discomfort referred to territories beyond the anesthetized area.

Anesthesia for plastic operations on the vagina are induced as are those on the cervix. For the repair of vesico-vaginal and recto-vaginal fistulae the caudal block gives very adequate results. The simultaneous anesthesia of the anal sphincter and the lower end of the rectum makes the caudal block the procedure for the repair of the most extensive perineal lesions, however, the per cent of occassional failures to produce anesthesia by means of caudal block may be reduced by its association with transsacral block.

For the excision of benign tumors of the labia majora, Robinson (47) uses the field-block procedure, by which the tumor is circum injected with the 0.5 per cent solution of procaine from several points of entrance placed around it. Operations about the meatus of the urethra and those involving the anterior portion of the genitalia are best performed after anesthesia of the vulvar orfice, including the labia majora. Anesthesia is induced in the following manner: After performing

the sacral block by injecting 30c.c. of the 1.5 solution in the sacral canal the patient is placed on the back and two wheals are raised, one on each side, over the pubic spines. Through these wheals a long needle attached to the syringe filled with 0.5 per cent solution, is passed first in a direction perpendicular to the surface of the skin, then more and more obliquely, distributing the solution in the subcutaneous tissue of the pubic eminence and genito-femoral fold, lateral to the labia majora. The pubic injections are meant for blocking the nerves approaching the labia majora from the inguinal region. The occassional failure to produce anesthesia by this means may be reduced by subcutaneous injections of 0.5 percent solution, made between the anal and vaginal orifices.

In operations for internal or external hemorrhoids, caudal block with 30c.c. of the 1.5 per cent solution gives a good anesthesia with partial dilatation of the of the anal sphincter. It has a marked advantage over local infiltration in that the injection is made at a distance from the operative field. The percentage of failures to produce caudal anesthesia by means of caudal block may be reduced by its association with transsacral block; however, this is better discussed under the sec-

tion of caudal anesthesia in urology.

In operations for uterine prolapse, cystocoele, and hysterectomy the caudal block is generally induced by an injection of approximately 30c.c. of a 1.5 per cent solution of procaine; however, these operations are usually best accomplished by the adjuvant of transsacral block. Caudal block alone is seldom adequate in an extensive operation of this type.

In other operations of the female genito-urinary system, caudal block anesthesia has been generally fairly well abandoned. In abdominal hysterectomy, operations on the bladder, adnexa and Caesarean section when regional anesthesia is desirable the injection of 0.5 per cent of solution of procaine along the line of incision is sufficient in the majority of cases.

Sims(50) has used caudal analgesia routinely on his service at the Louisiana State Uni. Medical Center since 1928 and reports that it has proven most satisfactory in his hands. In no case was it necessary to supplement the sacral injection with procaine infiltration. In four cases there were reactions which produced an increase in the pulse rate and labored breathing. These symptoms cleared up without treatment. They were noticed just after the beginning of the injection and if the procedure was delayed a few minutes the injection could be continued.

This method was used in 300 cases in the following procedures:

Dilatation and Curettage	Vesico-vaginal fistula
Conization of the cervix	Com. laceration of Perineum
Biopsies	Perineorrhaphy
Application of radium	Excisions vaginal fibroma
Cauterization of the cervix	Posterior colpotomy
Amputation of the cervix	Plastic repair of urethra
Anterior colporrhaphy	Excision vulvo-vag. gland
Excision of fistula in ano	Cauterization of chancroids
Hemorrhoidectomy	

Following the technic found so much in use in urologic procedures, many prefer a combination of caudal coupled with transsacral anesthesia in gynecological procedures. Magid and Klein(35) state their preference for this procedure for the following reasons: With the combined method the anesthesia is longer; in not a few subjects the posterior segments of the sacrum fail to close and in these cases the anesthetic is deposited in the ligament and a complete anesthesia is not obtained when the sacral block alone is employed. Again, with a transsacral block alone, it has been found that the sacrococcygeal plexus is at times not well anesthetized. This method was used by Magid and Klein in the Bronx Hospital, New York for all types of plastic gynecologic

operations such as trachelorrhapies, rectoceles, cystoceles, and rectovaginal fistulas. It has provided in every way the anesthesia desired during the procedures, and is approved as in so many reports on the favorable post-operative effects.

Wong(57) of the Department of Obstetrics and Gynecology of the Peiping, China, Union Medical College recommends the value of sacral anesthesia to those many surgeons in China who have their hands tied when they come to cases needing operations because of the lack of assistants and anesthetists. He has found caudal anesthesia a highly desirable method for gynecological procedures and has used it for the following types with great success:

Dilatation and Curettage
Insertion of radium
Cauterization of cervix
Tracheloplasty
Sturmdorff's operation
Perineorrhaphy
Plastic operation for atresia of vagina
Removal of cyst of vulva
Hemorrhoidectomy
Excision of bartholin gland abscess
Incision and drainage of perineal abcess
Excision submucous fibroid
Excision carcinoma of vulva
Excision urethral carbuncle
Cauterization of papilloma of vulva, vagina, and cervix

Caudal Anesthesia in Obstetrics

For more than thirty years single-injection caudal anesthesia has shown itself a safe and useful procedure. Lúndy(34), for instance, reports its use in more than 15,000 cases at the Mayo Clinic. In his opinion it is one of the most satisfactory technics available in the whole field of anesthesia. In spite of this and similar opinions, caudal analgesia has not been widely popularized outside the fields of urology and proctology. Largely responsible for its lack of use have undoubtedly been the rather high incidence by some users to obtain analgesia.

Hingson and Edwards(14) were impressed with the anesthesia produced by a single peridural injection into the lumbar area and in the sacral canal of 2 per cent metycaine in a series of 30 obstetrical deliveries and 200 surgical procedures. They found this single injection method of peridural anesthesia to be very satisfactory for delivery after complete dilatation, but sought to develope a procedure that would relieve the parturient of that distressing and exhausting experience throughout the early stages of labor. They decided to combine the advantage of the continous method with the safety, simplicity and effectiveness of of the extradural nerve block by using the sacral hiatus

approach to the sacral canal and the peridural space.

The Hingson-Edwards technic is applicable to all forms of surgery below the level of the umbilicus. Its only disadvantage for abdominal hysterectomy is lack of relaxation of the abdominal wall. In the field of general surgery, caudal anesthesia is eminently suited to operations on the lower extremities, including amputation. The patient is even able to hold his own leg up during the latter procedure. It gives a preveiw of the effect of alcohol injection of the lumbar sympathetics and is useful as an anesthetic procedure for alcohol injection. It may also prove valuable in the handling of war injuries of the lower extremities, in which severe pain may be a contributing factor in the onset and severity of shock.

While continuous caudal anesthesia is a distinct advance in the field of surgery, it is a complete revolution in obstetrics. Edwards and Hingson have used the method in upward of 600 deliveries. In their experience, it has the following advantages:

1. There is complete relief of pain beginning five to 15 minutes after injection and continuing as long as necessary.
2. Consciousness and voluntary motion on the part of the mother are not impaired.

3. There is no interference with uterine contractions.

4. The respiratory and other vital mechanisms of the child are not obtunded.

5. The period of labor appears to be shortened in most cases.

6. The management of unfavorable fetal positions is facilitated.

7. Postpartum hemorrhage is minimized.

8. The incidence and severity of maternal postpartum complications are reduced.

9. There is no adverse effect on the course of respiratory or pulmonary diseases.

The Innervation of the Uterus and Birth Canal in Pregnancy:

These actions of the new method can probably best be understood in the light of the innervation of the structures concerned in childbirth. Figure 1 illustrates the nerve supply of the urerus and birth canal. Cleland(7) showed that the pain of labor consists of two parts, that of uterine contraction and that of distention of the birth canal. It is evident from a study of Figure 1 that anesthesia extending as high as the eleventh thoracic roots will block all sensory impulses from the uterus and birth canal, and if anesthesia is not allowed to reach as high as the 6th thoracic roots uterine contractions will not be impaired.

FIGURE I

The sensory nerve fibers of the uterus are shown in red. They constitute visceral afferent fibers and are functionally independent of the antonomic nervous sustem although coursing through the pelvic, hypogastric and aortic plexuses before connecting with the dorsal root ganglia of the eleventh and twelfth thoracic nerves in which their nerve cells are located. The insert shows details of the connections. The sensory supply to the cervix and upper vagina travels in the sacral parasympathetic nerves shown in green. It is also functionally independent of the autonomic system. The sensory and motor supply of the lower vagina, perineum, and pelvic floor travels in the perineal and pudendal somatic nerves. All of the spinal (somatic) nerves are shown in yellow.

The motor supply of the uterus is autonomic and involves both sympathetic and parasympathetic efferent components. The sympathetic division is shown in purple with the exception of the part concerned with uterine motility which is shown in blue. Clinical evidence indicates that the motor fibers to the uterus leaves the spinal cord at higher levels than the tenth thoracic nerve whence they pass through the aortic, hypogastric, and pelvic plexuses. Visceral efferent fibers believed to be motor to the circular muscle of the lower uterine

segment and cervix and possibly inhibitory to the remainder of the uterus travel through the parasympathetic pelvic nerves shown in green.

Clinical study verifies that (1.) blocking of the sacral nerve roots abolishes the pain of distention of the birth canal, paralyzes the skeletal muscle of the perineum, and abolishes tone in the smooth muscle of the cervix; and (2.) extending the block to include the eleventh thoracic root abolishes the pain of uterine contractions without impairing their force. It suggests that extending the block to the sixth thoracic nerve or higher may impair the strength of uterine contractions.

FIGURE I ------->

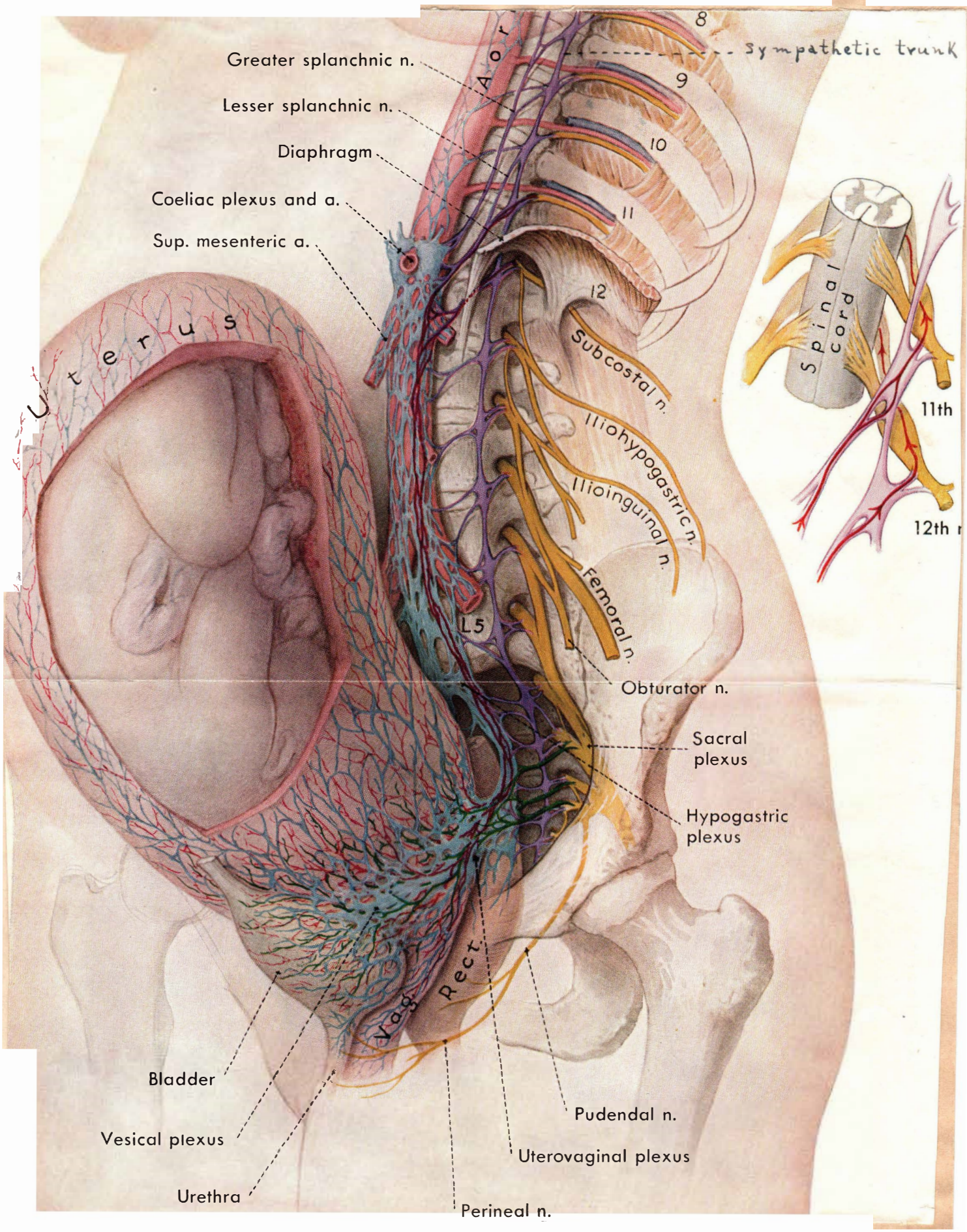
Greater splanchnic n.
Lesser splanchnic n.
Diaphragm
Coeliac plexus and a.
Sup. mesenteric a.
Aor
8
9
10
11
12
Sympathetic trunk
Spinal cord
11th
12th
Subcostal n.
Iliohypogastric n.
Ilioinguinal n.
Femoral n.
L5
Obturator n.
Sacral plexus
Hypogastric plexus
Uterus
Vag
Rect
Bladder
Vesical plexus
Urethra
Perineal n.
Pudendal n.
Uterovaginal plexus

FIGURE I

After the accoucher has made a thorough survey of the case and is convinced that the true labor pains of the first stage of labor have begun, the patient is prepared for continuous caudal anesthesia. If the patient is a primipara, and a labor of several hours is expected, the anesthesia may be started with the patient in her hospital bed. Such a course may also be selected with the multipara in whom the accoucher has found dystocia or protracted labor. Parturients who by their course and physical findings give indication of early deliveries are transferred immediately to the delivery room. No sedation is given such as barbiturates unless there is extreme nervous tension with anxiety on the part of the patient. The progress of labor under continuous caudal analgesia is somewhat different from that where this method is not used. Cervical dilatation is usually rapid in both primiparas and multiparas, and the first stage of labor is materially shortened, an effect apparently due largely to cervical and perineal relaxation. Likewise the early part of the second stage is facilitated. The end of the second stage is definitely prolonged since uterine contractions alone are seldom adequate for the final delivery. Thus precipitation

is seldom seen. While unaware of her uterine contrac-tions and lacking in any compulsion toward straining, the parturient is able to use her abdominal muscles, and spontaneous delivery is possible if she will make expulsive efforts during "pains". However, the cervix and perineal tissues are so completely relaxed that outlet forceps and if necessary episiotomy are relative simple procedures. The lack of expulsive desire is in many ways an advantage to the accoucheur, since the patient is able to cooperate fully in giving him complete control of the progress of the head over the perineum.

With this technic especial care is necessary to clear the respiratory passages of the infant at the first possible opportunity, for the babies are ready to breath the instant their noses have crossed the perineum. This quick onset of respiration is one of the striking features of the method. Fetal heart tones in the series were checked frequently and in no instance did the anesthetic effect the rate or rhythm. The babies without exception cried vigorously at birth, with no special form of resuscitation necessary. It is believed that with this method of management the incidence of anoxia and asphyxia neonatorum is definitely

reduced, since the baby is not under the influence of any narcotizing or anesthetic agent. It is believed that the reticulo-endothelial system of the mother, the placenta, and the maternal liver all serve as a triple filter to prevent any of the drug from reaching the fetus.

The rapid separation and expulsion of the placenta from the uterus without the administration of oxytocics is also remarkable. The average measured blood loss has been 30 to 90 cc. Often that loss from the episiotomy wound exceed in volume that lost from the uterus. Postpartum complications are conspicuously absent. The average length of time the Hingson and Edwards

(2) patients were under this form of anesthesia was six hours. For many of these patients including the primipara whom comprised almost two-thirds of the patients, this was the entire length of labor, since some cases were blocked early before cervical dilata-tion occurred. The average dose of metycaine for all cases was two and one-half grams. The shortest duration of anesthesia was one hour and forty-five minutes. In a case of dystocia the anesthesia was used for twenty-eight hours and thirty minutes. The labor was terminated by the use of low outlet forceps, with delivery of a vigorous, healthy infant without injury to the mothers

systemic condition. During this period over eight grams of metycaine was used. The blood pressure of the mother varied constantly between 105 and 120 m.m. Hg. over 65 and 80 m.m. Hg. During this time parturient the patient had several hours of sleep and was able to take fluids freely. In none of the cases was there an alarming fall in blood pressure. There was no evidences of systemic intolerance to the drug or of toxic reaction. A few patients did become nauseated with occassional emesis during hard contractions of the uterus. Even these cases were able to take small quantities of food and fluids during the subsequent course of labor.

In working out this procedure Hingson and Edwards (22) have used novocaine, pontocaine, eucupine, nupercaine, and metycaine in varying concentrations. They finally chose metycaine for continuous caudal analgesia because of low toxicity, rapid onset of action, and uniformity of results. For surgical procedures they use 1 percent metycaine in sterile isotonic salt solution with epinephrine added in the proportion of 1 cc. of 1:2,600 epinephrine hydrochloride per 200 cc. solu-tion. For obstetrics they employ a 1½ per cent solution without epinephrine. The latter drug tends to inhibit uterine contraction. Lundy (34) also advocates mety-

caine as the preferred solution for sacral block anesthesia because of its rapid action and prolonged duration of effect, an opinion based on an xperience of more than 15,000 cases.

The low toxicity of metycaine when us d for continuous caudal anesthetic is shown by the Hingson and Edwards data. Their average total dosage in obstetrics was 200 cc. of 1½ per cent solution or 2½ to 3 grams. This represents approximately 7.5 mg. per kilogram of body weight per hour. The largest total dosage was approximately 11 grams over a period of thirty hours. No toxic manisfestations of any description were observed in either surgical or obstetric cases. Further-more, metycaine is not incompatible with the sulphonamide group of drugs, differing from procaine and other agents containing the para-aminobenzoic acid nucleus.

This method of anesth.sia is definitely contrain-dicated in disproportions between the size of the fetus and the birth canal, in placenta previa, and in patients with gross deformities of the spine, particularly in the region of the sacrum. As has be n previously mention d, local infection around the sacral hiatus and history of sensitivity to the analg sic agent preclude the use of the method.

Complications in the Hingson and Edwards (22) series were as follows:

1. Broken needles - Early in their series of cases, this happened four times in the first 65 cases. The patients moved the hips in such a way as to bend the head of the needle back upon itself. Now special malleable needles which b nd rather than break are used and trouble from this source can be eliminated by discarding the needle after use in several cases.
2. Difficulty in Insertion of Needle into the Sacral Canal- This difficulty has be n amply discussed in the section conserning caudal anesthesia in Urology. The difficulty is proportional to the amount of deformity of the sacrum and t chnic of the operator. Hingson and Edwards believe that such a condition as to result in failure occurs in less than 1 per cent of all cases.
3. Unilateral Anesthesia - There was anesthesia on one side to the midline from the perineum to the umbilicus, but appreciation of pain on the other sid . This phenomenon in the few cases it appeared was explained by supposing that the point of the needle had deviated too far laterally, perhaps over one of the anterior sacral foramina, so that all of the anesthetic bathed more of the nerve trunks on one side. It was proven in all of these instances that by merely rotating the needle over to the opposite side all

pain was relieved. The possibility of a median fibrous raphe extending from the dura to the periosteum and ligam nts of the spinal column is to be considered.

4. Minor systemic complaints - Two patients complained of temporary headache lasting only momentarily as the first injection of anesthetic was made. Nearly all of them described vague pressure s nsations in the legs with the first inj ction. It is felt that both these complaints can be prevented if the initial injection is mad slowly over a five minute period. However, so often the labor pains are so severe that the patient would willingly tolerate this slight discomfort in order to obtain relief from the more acute pains of labor. Six patients complained of dizziness during, and for a few minutes after, the initial injection. Careful check of pulse rate and blood pressure during these episodes did not reveal anything abnormal. A few patients had cramps in the calves of the legs near the end of the period of anesthetic action of the drug. These were promply relieved by massage and a subsequent injection.
5. Backache - It is well known that women during the latter months of pregnancy do not lie on their backs because of pressure phenomena and because straighten-

ing the lumbodorsal curve causes them pain, since they gradually have assumed a hyperlumbar extension as a part of the mechanism of the "strut" of pregnancy. After injection of the anesthesia these patients can lie on their backs without pain. However, when they do assume this unnatural position for several hours they develope midback pain above the level of the upper lumbar limit. This is believed due to the stretching of the spinal ligaments. These pains have been relieved by having the patients lie on the side except for examination of fetal heart sounds and rectal examinations for advance of the fetal head. If the patients do lie on their backs for long periods the severity of the backache is reduced by a small pillow in the lumbar area to maintain the exaggerated lumbar curve.

Continuous caudal analgesia is greatly facilitated by suitable apparatics. Figure 2 shows a schematic apparatus with the needle properly placed in the sacral canal. As has been mentioned especial malleable needles are used in order to prevent breakage when the patient moves about, and which are discarded after use in several cases.

The technique for giving continuous caudal analgesia differs enough from that described in other fields in

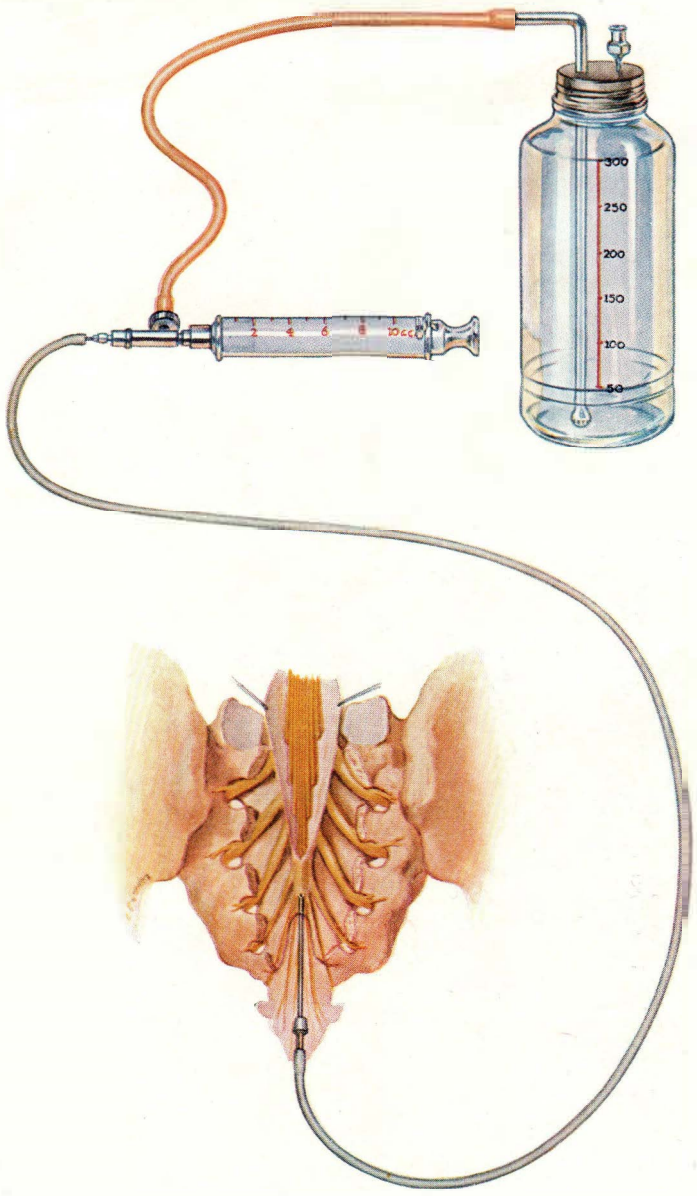

FIGURE 2—*Apparatus with needle properly placed in sacral canal.*

which caudal anesthesia is used to merit a description of this procedure. The following is the Hingson, Edwards (22) (24) technic which is fundamentally accepted and used by the majority who follow this procedure. The method is initiated only after labor is well established, cervical dilatation has begun, and the patient feels a need for relief of pain. The patients should not be given continuous caudal anesthesia while experiencing a relatively comfortable early labor. The procedure should be reserved for the relief of pain rather than of discomfort.

The only technical difficulty of the method is insertion of the special needle into the sacral canal. This is in most patients much easier than lumbar puncture, but in a few with sacral anomalies, it may be difficult or ev n impossible. The Sims position is used for the obstetrical patient; the surgical patient prone. All the precautions of surgical asepsis are taken.

The sacral hiatus is usually located 1½ to 2 inches above the tip of the coccyx, the end of the thumb readily finds the U or V shaped notch of the normal sacral hiatus. If the sacral hiatus is abnormal or cannot be palpated, an attempt at caudal injection should be made by one already experienced in the technic. When the hiatus

is found, the middle finger of the left hand changes plac wi·h the thumb and marks the spot for raising the initial skin wheal.

The metycaine for inj ction in obstetric pati nts is dissolved or dilut·d in sterile isotonic salt solution to a concentration of 1½ per cent. Ampoules "Metycaine" no. 313, containing 1 gram in 5 cc. of water, are especially well suited for this purpose. The contents of two ampoules added to 125 cc. of saline solution ayield a 1½ percent solution.

With a few cubic centimeters of this solution, skin anestnesia is obtained by raising a skin wheal with a 25 gauge needle and infiltrating to the sacrococcygeal ligament with a 2 inch, 22 gauge needle. The special malleabl 19 gauge needle is then inserted in the mid-line in the direction of the hiatus at about a forty-five egree angle with the skin. As soon as the bevel of the needle pierces the sacrococcygeal ligament, its reinforced metal collar is depressed through an arc of 1 to 3 cm. and the needle is thrust slowly and evenly into the sacral canal in the midline where its bevel should be inferior to the lowest extent of the dural sac.

A short section of tubing with a special adapter is then slipped over the collar of the caudal needle. A Luer-Lok Syringe is securely attached to the adapter,

and careful aspiration is p rformed. Crit ria for proper position of the needle are summa ized in Tabl I.

Table I.

A. Needle outside of sacral canal if:
   1. Injection of solution causes palpable swelling superficial to bones of sacral region.
   2. No relief of pain in thirty minutes after injection.

B. Needle in sacral canal but in subarachnoid space if:
   1. Spinal fluid can be aspirated.
   2. Injection of 8 cc. of solution is followed within ten minutes by some degree of both relief of pain and loss of motor power in l gs.

C. Needle in sacral canal but in blood vessel if:
   1. Pure blood is repeatedly aspirated.

D. Needle placed properly extradurally in sacral canal if:
   1. None of foregoing noted.
      Patient experiences sense of fullness or discomfort in one or both legs during rapid injection.
   3. Loss of pain sense to pin prick occurs in a progressive manner beginning at tip of coccyx and extending gradually forward on perineum and

up anterior abdominal wall. Analgesia should reach almost to umbilicus in twenty minutes.

4. Abdominal uterine cramps are relieved within five to fifteen minutes as the skin analgesia reaches the distribution of the eleventh thoracic spinal segment.

5. Sympathetic vasomotor paralysis in legs, marked by vasodilatation and flushing, cessation of sweating, and increase in skin temperature of soles of feet, is noted within five to fifteen minutes after injection. This often occurs on one side several minutes earlier than on the other side.

It should be pointed out that failure to recognize a subarachnoid position of the needle may lead to massive and possibly fatal spinal anesthesia. If there is any question of puncture of the dura, a trial injection of 8 cc. of solution (120mg. metycaine) may be made as outlined in Table I. Intravenous injection of the solution may have serious consequences. Puncture of the dura or repeated aspirations of pure blood contraindicate absolutely the use of caudal analgesia.

After it is certain that the needle is in neither a blood vessel nor the subarachnoid space, the free end of a special four-foot rubber tubing is secured over the collar of the caudal needle (see Fig. 2), all air having

been displaced from the tubing of the previously assembled apparatus with the metycaine solution. With the palm of the left hand firmly pressed over the dorsum of the sacrum, enough of the 1½ percent solution is injected to bring the told volume in the sacral canal up to 30 cc. The criteria listed under D of Table I are next watched for. In some women with unusually large sacral canals, 30 cc. may not reach a sufficiently high level to relieve the pain of uterine contraction and the injection of as much as 20 cc. additional may be necessary.

Analgesia reaches its maximum level in twenty to thirty minutes and then begins to recede. Supplementary injections of 20 cc. every thirty to forty minutes will keep the average patient free of pain. However, it is desirable to individualize dosage, and this is greatly facilitated if the level of analgesia to pin prick is followed on the anterior abdominal wall. When the level falls more than an inch below the umbilicus on either side, a supplementary injection should be made. Usually the level is higher on the side on which the patient is lying. If this difference amounts to more than one spinal segment, the patient should be turned to lie on the low side before the injection is made. The volume

or frequency of supplementary injections should be reduced if the level of analgesi reach s the xyphoid. Extension of the analgesic effect to th sixth thoracic segment or higher may weaken the force of ut rine contraction.

The mechanics of delivery can be carried out according to the pref rence of the obst trician. However, it will soon be noted that extreme relaxation of the cervix and perineum are features of caudal analgesia which greatly facilitate the handling of abnormal presentations, including occiput posterior and breech. The former frequently turns itself to anterior if enough time is given.

The patient is usually given a supplementary injection just before delivery is undertaken, regardless of the interval since the previous one. This assures adequate analgesia for any procedure that may be necessary. The needle is left in place until the patient is ready to return to her room. In some patients a final injection is given at that time, for otherwise there may be bitter complaints of afterpains from women who have been free of pain during their entire labor and delivery. In the opinion of Hingson and Edwards all of their few failures have been technical, due to failure to

deposit the metycaine solution in the peridural space within the sacral canal. Success has been uniform in all cases in which it was known the needle was properly placed.

An interesting report is published by Lahmann and Mi tus (32) in which they ran a series of 400 cases at the Milwaukee County General Hospital by the use of single injection caudal anesthesia. They inj cted an average of 25 cc. of metycaine in the sacral hiatus after labor was well under way and the cervix well dilated. The technic is the same as that described by Hingson and Edwards except the needle does not remain in place in order to facilitate subsequent inj ctions, and after the single injection the needle is removed and the anesthetizing procedure is terminated.

In this series of the first four hundred cas s in which caudal anesthesia was used, 368 were primiparas and 32 multiparas. Of the 368 primparas, 293 were delivered by low forceps and episiotomies, 8 by mid-forceps and episiotomies (including 1 Duehrssen's incision), 10 delivered spontaneously with a perineotomy, 6 were forceps deliveries without episiotomies, and 20 were breech deliveries - in 4 of which the breech was broken up and extracted. In 17 cases transverse blad s

were applied. Seven occiput post riors failed to rotate after two hours at compl te dilatation. Two of these were delivered face-to- pubis; 2 were rotat d by Kjelland forceps; 3 were turned by the Scanzoric maneuver. One primipara was delivered by a low cervical cesarean section performed entirely under caudal anesthesia. In one version and extraction, the caudal block was found insufficient and was of necessity augmented by ether. Two of those delivered without an episiotomy sustained a first d gree laceration. Two of the primaparas had twin pregnancies. Of the 32 multiparas, 9 had outlet forceps and episiotomies, 4 had a mid-forceps delivery, 3 were rotated by the Scanzonic op ration, 8 w re permitted to deliver spontaneously, 4 w re delivered by low forc ps without an pisiotomy, and 2 had assist d breech deliveries. In one pati nt, caudal was administered for a Voorhees bag insertion, and in another a low cervical c sarean section was p rformed ntirely under caudal anesthesia. In this series of 400 cases, 4 were cardiacs, 2 w re patients with moderately advanced pulmonary tuberculosis, and 2 eclamptics.

The results of this series of 400 cases are as follows:

(4 plus) Anesthesia of the perineum. Loss of con-

traction pain.

(3 plus) Anesthesia of the perineum. Pati nt aware of contraction pain.

(2 plus) Anesthesia of the perin um. Loss of contraction pain. Patient exp rienced pain when traction with forceps was applied.

(0) Complete failure.

Guided by these criteria, the results could be grouped numerically as follows:

	Cases
(4 plus)	348
(3 plus)	31
(2 plus)	10
(0)	11

Failures again are attributed to the inability to locate the sacral hiatus.

Within the first five minutes after th anesthetic is administered, the outcries of the women in labor are suddenly stilled, and the parturient who only a f w moments before had been writhing in pain, becomes quiet-ed. Since the excitomotor reflex, due to pressure of the presenting part on the perineum, is abolished, the patient loses the urge to bear down; instead, she be-comes mentally at ease and physically comforted. Yet

the rhythmic uterine contractions continue painlessly, with the same frequency and duration as before, though with a possible diminution in their intensity. Several minutes after analgesia is obtained, anesthesia of the perineum develops. In tests for the loss of cutaneous sensation, which are made by grasping the skin with an Allis forceps, the developement of anesthesia was cosistently found to begin in the region of the anus and then spread fanwise upward toward the symphysis pubis, backward over the sacrum and gluteal regions, and laterally along the inner aspect of the thighs - the sum effect being a "Saddle" anesthesia. Simultaneously, the musculature of the pelvic and perineal floors becomes completely relaxed. Even in primiparas, the lubricating examining hand can be easily admitted for such obstetrical manipulations as mutual rotations, decompositions, and the like. Such relaxation greatly facilitates the application of forceps and reduces the incidence of vault tears. Sensation in and control of the lower limbs is unaffected. There is no effect whatsoever on the fetus. Furthermore, the third stage of labor is unaltered, as in only one instance was more than a simple crede of the uterus necessary to express the placenta. The blood loss appears to be less than that accompanying a delivery under ether anesthesia,

since the relaxing effect of the ether on the myometrium is absent. The return of sensation occurs inv rsely to the direction in which it extended - beginning at the periphery of the saddle zone and advancing concentric-ally toward the anus. The postpartum period is unaltered.

In this series of 400 cases, the average quanity of solution injected was 25 cc. The average onset of anesthesia was 7.4 minutes between the time of injection and the time when the anesthesia became evident about the anal region. The average duration of anesthesia was one hour and twenty-nine minutes . No remarkable influ nce of the metycaine on the blood pressure was noted. Untoward vasomotor, respiratory, and gastrointestinal symptoms and signs such as tachycardia, palpitation, hyperpnea, pallor, nausea and vomiting were not obs rged in any of the series.

Lahmann and Mietus (32) thus conclude that caudal block offers a feasible and efficacious anesthesia for op rative obstetrics. It permits the uterus to contract painlessly; it relaxes the pelvic floor and anesthetizes the perineum. It is harmless to both the parturient and her newborn. It permits the normal separation of the placenta and involution of the pelvic organs. All the untoward side effects of inhalation anesthesia are

absent - there is no excitement stage, no nausea or vomiting, no danger of explosion. It lends itself well to the obstetrical service in which drop-eth r, possib -ly administred by an untrained interne or nurs , is the only other available anesthesia. It can be us d without fear in patients with pulmonary, cardiac, or renal complications.

Bourqu (3), who has been using novocain by the epidural route since 1923 in rectal surgery, tried caudal block in doing p rineorrhophies and in surgery of the cervix uteri. This proved so satisfactory that he tried it in a series of over 100 maternity cases wh re it proved so efficacious that it has been a routine in Lakeside Hospital for the past four y ars without a single complication. Occassionally there is not complete relief from pain, but in all cases relief has been sufficient to warrant the use of the method.

In contrast to the above glowing reports it is interesting to note the report given by Kelso (31) in 1929 in which he draws his conclusions from a seri s of 34 cases. The series seems too small to give an adequate survey of the method; Kelso admits difficulty in learning the t chnic, of which his 19 failures out of 34 cases bears out; his conclusions seem weakly sub-

stantiated by logic and clinical data, but as stat d above are interesting in the light of the enthusiasm by which this method is received by most other obstetricians who have used it for any length of time. He used from 30 to 60 cc. of ½ per cent novocaine injected in the sacral hiatus. The following conclusions were drawn from his series:

1. The administration of caudal anesthesia in ob -st trics is technically difficult and results are not uniform. It should be given only under the strictest precautions and therefore cannot be used in the aver -age home delivery.

2. There is difficulty in timing the administration, sinc it is often given too late in multiparae and too early in primiperea .

3. Caudal anesthrdia produces a certain amount of in rtia in practically every case, from a very slight reduction to a complete abolishment of the uterine contractions, necessitating operative deliveries for the completion of the labor.

4. It produced finite toxic manisfestaions in the mother and, with but littl question, is the cause of fetal distress.

5. It does not reli ve the pain from th uterine contractions when an inertia does not develops. Since

these pains ar appa ently almost as distressing as the pain from d livery of the head ov.r the perineum, adequate relief is not obtained for, the patient.

6. In the light of these conclusions caudal anes-thesia is not satisfactory for spontaneous d liveri s.

Captain Hopp (25) of th Army Medical Corps in a r view of the xt nsiv work done with caudal anesthesia sets forth the following conclusions: "It is possible to produce "painless labor" for some 6 to 10 hours by rep ated caudal block anesthesia using 40 cc. of a 2 percent procaine hydrochloride solution per injection, with as gr at or greater fetal and mat.rnal saf.ty than by any other method of obstetric analgesia, amnesia or anes-hesia. The ideal anesthetic, of course, would be one that would produce prolonged anes!hesia with single injection without loss of the safety factor. The method c rtainly des rves further employment by obste-tricians."

Poole (46) of England after a review of the litera-ture and after a series of 32 cases in which he used single injection caudal anesth sia lists his findings as follows: (1.) The use of a regional anesthetic eliminates certain of the disadvantages common to the general anesthetics and hypnotics. Sacral anesthesia

is a practical form of regional anesth sia for obstetric us . (2.) The technique of sacral anesth sia is not difficult, but practice is required for consistent success. (3.) Percaine, 25 to 45 cc. of a 1 p r cent solution, in normal saline, provides an anesthesia of satisfactory quality; such an an sthesia is adequate for internal manual manipulations or for suture of the perin um, but may be insufficient for delivery by forceps unless this is easy. (4.) The average duration of anesthesia is 4 hours. (5.) Uterine contractions following injection may decreases , but reappear strongly within half an hour provided they were strong and regular b fore injection. (6.) Ob sity is a contrainidcation, mechanical difficulties making the inj ction difficult or impossible. (7.) The method is free from complications to mother and child.

Greedy and Husseltine (27) have run a short series of 20 cases with continuous caudals in their obstetrical practice and verify quite closely the findings of Hingson and Edwards (24). They differ only in believing that the more intricate procedure s such as forceps rotation or version should not be done by this method due to the maximum uterine relaxation which they desire and which they do not believe is obtained by this

method. They acknowledge their limited experience with this method, however, and do not set this down as an absolute contraindication.

Conclusion

Caudal anesthesia, although a comparatively new method in the long history of anesthesia, is forcing a foci of attention upon its usefulness due to the remarkable results accorded it by the many surgeons and physicians who have given it a fair trial. Its usefulness and efficaciousness in the fields of Urology and Proctology has been well known and has been practiced with increasing popularity in the last forty years. Due to the age groups and debilitated condition of the patients it has proven ideal in these fields in regard to the low systemic insult and minimal post-operative effects sustained as a result of its use. With an adequate anatomical knowledge of the structures involved and a fair degree of technical skill it is a fairly simple method to apply. In general surgery it has proven equal to other methods in selected cases, giving the best results in lower abdominal surgery. Its use in abdominal surgery is only now in the pioneering stage, and more time will have to be alloted and more data accumulated before its worth in these procedures can be more fully evaluated. In Gynecology it has proven a boon to those surgeons who are hindered by lack of assistants and anesthetists. Coupled with transsacral block it has proven as adequate or more so an anesthesia as any other method

for gynecological procedures, being used by a large number of gynecologists at the present time in preference to general anesthesia and by a still larger number coupled with the use of local infiltration. Its greatest revelation has been in the field of obstetrics wherein the continuous caudal method of Hingson and Edwards has plunged the country into heated discussions of its merit with the aroused interest of the laity forcing the issue. Single injection caudals in obstetrics have long been used with only ample success as to be practiced by a minority. The results of competent men in the field of continuous caudal anesthetic have been so successful in my opinion as to warrant a more comprehensive knowledge and acquired technical skill in this field by more obstetricians. The main disadvantage of the method is the prohibitive cost of time, assistants, and equiptment which is necessary to effectively carry out this procedure; the time and facilities of most men, especially in the present war crisis, making the acquisition of the method impossible even if they desired the procedure in their obstetrical armamentarium.

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