STANDARD, SEGMENTAL AND MODIFIED SEGMENTAL EPIDURAL BLOCKADE IN OBSTETRICS

BY

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Promoter: Prof. C.F. Slabber.

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"In a word, an imperfect Epidural should therefore be a spur to the active pursuit of perfection rather than remain as an object of regretful contemplation."

Andrew Doughty, 1975.

CONTENTS

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CHAPTER I

INTRODUCTION

In 1884 J.L. Corning described the technique of epidural block for the first time. Its use in surgery was limited to isolated cases until Pages (1921) and Dogliotti (1933) reported on its large scale use for this purpose. In 1938 Graffagnino and Seyler used epidural block for the first time in Obstetrics. The use of continous epidural block in Obstetrics by utilizing plastic tubing was described for the first time in 1949 by Flowers, Hellman and Hingson. In the same year Cleland reported the double catheter technique, which is still in popular use in many centres all over the world to-day.

Epidural analgesia is an integral part of modern Obstetrics. Large series have been published to testify for its safety. (Bonica etal, 1957; Eisen etal, 1960; Hellman, 1965; Bodell Tisdall and Ansbro, 1962; Lund, Cwik and Quinn, 1961; Bonica, 1967; Moore, Murnaghan and Lewis, 1974; Crawford, 1972.) In those institutions where it is used extensively by properly trained Obstetricians or anaesthetists it is considered the ultimate form of obstetric analgesia. Therefore epidural block is very often used in the patient with a normal, uncomplicated labour.

The objective of obstetric analgesia is effective pain relief with little or no risk to the mother or the foetus. (Akamatsu and Bonica, 1975). As will be discussed in more detail in Chapter II, the standard epidural block may have possible deleterious effects on the mother and the foetus. If epidural

block is to be used extensively in normal uncomplicated labours, these negative aspects should be eliminated.

Many of these problems can be obviated by improvements in the technique of standard epidural block. One specific modification is the double catheter technique as used by Bonica (1967). Pain of the first stage of labour can be eliminated by blocking segments T10 to L2 by a catheter positioned in the region of the twelfth thoracic vertebra (T12). Pain of the second stage can be eliminated by blocking sacral segments 2, 3 and 4 (S2,3,4) and thus by a catheter placed opposite S3. Two epidural catheters are therefore needed. Therefore, in the standard epidural block a single catheter is inserted in the low lumbar region (L3 or 4) and all segments from T10 to S5 are blocked simultaneously. This requires a large volume of local anaesthetic agent. In the double catheter technique, two epidural catheters are inserted: the top one opposite T12 (ideally) and the bottom one opposite S3. This allows for selective segmental blockade during the first and second stages respectively. With this latter technique a much smaller volume of local anaesthetic agent is required. Furthermore, since a smaller number of segments are blocked at one time, the hypotensive effects are less.

The double catheter technique (segmental block) therefore offers the following advantages over the single catheter technique (Standard block):

1. It allows for a smaller total dose of local anaesthetic agent. This has advantages both to the mother and the foetus (and neonate). These will be discussed in detail in Chapter II.

2. It is associated with a lower incidence of malrotation and malposition of the foetal head. By not causing pelvic floor relaxation or paralysis during the first stage, internal rotation and maximal flexion can be completed first, before blocking the sacral segments in the second stage.

3. It is associated with a lower incidence of instrumental deliveries, since the urge to bear down can be retained to a large degree by using the lower catheter expertly.

4. It is associated with less maternal hypotension since selective nerve block allows for a smaller number of autonomic segments to be blocked at a time. The smaller the number of autonomic segments blocked, the less is the hypotensive effect. Maternal hypotension may cause foetal heart abnormalities (Zaaijman, 1976) and should therefore be avoided.

While the double catheter technique (segmental block) is therefore regarded as an improvement on the standard epidural block, there nevertheless are still some unsolved problems associated with it. Two of these problems will receive much attention in this task. Firstly, the accurate placing of the top catheter opposite T12 (the ideal position) in the double catheter technique, needs attention. It has been shown by several workers that a flexible plastic catheter when threaded into the epidural space, cannot be depended upon to travel for the required distance into the intended direction. (Bromage, 1954; Sanchez, Acuña and Rocha, 1967; Bridenbaugh etal, 1968; Moore, 1965; Doughty, 1974). If the

top catheter is inserted in the lumbar region, it needs to be threaded in a cephalad direction for 10 to 15 cm to reach the ideal position opposite T12. All the above authors have shown that the only way to accurately place the catheter tip, is by not threading it for more than 5 cm beyond the tip of the needle. Performing a double catheter block with the current technique therefore seems to be fallacious. We intend to attempt to eliminate this shortcoming in the current practice of the double catheter technique. It is proposed that an epidural catheter inserted through a needle at the level of the twelfth thoracic interspace and threaded for only 2 to 3 cm beyond the tip of the needle can be accurately placed at the optimal position opposite T12. Thoracic epidural blockade has not been used in Obstetrics to date. The disadvantages of thoracic epidural block will be pointed out in Chapter II. By this modifications it is hoped to eliminate one of the problems still associated with the double catheter technique.

Secondly, the position adopted by the parturient immediately after epidural block, still remains a problem. This is true for all forms of epidural block. This fact is well illustrated by a recent editorial article. (Marx, 1975). The supine position may cause aorto-caval compression and hypotension. The left or right lateral positions, while often (not always) alleviating aorto-caval compression, may lead to unilateral blockade. We intend to eliminate this problem by placing the patient in the kneeling position during and after the block. In this position the patient's back can be kept on a horizontal level, thus eliminating the effects of gravity upon the spread of local anaesthetic

agent through the epidural space. It is also felt that this position should eliminate aorto-caval compression and all its associated disadvantages.

By these two modifications to the current practice of segmental epidural block (double catheter technique) we hope to further improve its quality and safety.

In summary it can be said that standard (single catheter) epidural block has certain disadvantages. The currently used technique of segmental (double catheter) epidural block offers certain apparent advantages over the standard block. However, it is felt that the segmental block can still be improved. To prove this, we intend to first confirm that the segmental block has advantages over the standard block. Then we intend to use two modifications in the current technique of segmental block. This is an attempt to further improve its quality and safety. These modifications include:

1. using the low thoracic epidural space to accurately place the epidural catheter opposite T12, and

2. placing the parturient in the kneeling ("hands and knees") position during and after the block, in an attempt to eliminate aorto-caval compression, while still allowing for optimal spread of the local anaesthetic agent through the (horizontally positioned) epidural space.

Although these two modifications have not to date been used in obstetric epidural analgesia, we can see no obvious

ethical reasons why they may not be tested. We hope to produce a technique for obstetric segmental epidural block which will be associated with minimal maternal blood pressure alterations, with a lower incidence of foetal heart abnormalities, with a lower incidence of patchy analgesia and lower plasma levels of maternal and foetal Bupivacaine. In this way we hope to make some contribution towards improving the current status of epidural analgesia in Obstetrics.

CHAPTER II

REVIEW OF THE LITERATURE

In this chapter we will attempt to present a relevant review of the current status of obstetric analgesia, with specific reference to the shortcomings referred to in Chapter I. As will become apparent, most of these problems are interrelated. We will try to illustrate our motivation for this particular project.

1. HYPOTENSION ASSOCIATED WITH EPIDURAL BLOCK

A. Hypotension associated with Sympathetic Blockade

During epidural analgesia not only a part of the somatic nervous system is blocked, but also a part of the segmental outflow of the autonomic nervous system. In the Standard epidural technique, blockade extends ideally from T10 to S5 (T10 = The Tenth thoracic segment; S5 = The Fifth sacral segment; etc.) During this type of block, segmental sympathetic outflow from T10 to L2 is effected: a total of 5 segments. It is generally believed that these 5 segments carry pain sensation from the uterus and cervix.

Efferent sympathetic fibres from these segments take origin from their nerve cells in the lateral column of the grey substance. From there they emerge via the ventral nerve roots of the thoracic and lumbar nerves mentioned. The pre-ganglionic fibres travel from the mixed spinal nerves via the white ramus communicans to the sympathetic trunk. The pre-ganglionic fibre synapses in the corresponding

sympathetic ganglion or in the ganglion above or below. Alternately it may traverse the ganglion to synapse only in a more peripheral ganglion. The post-ganglionic fibre travels from the sympathetic ganglion via the grey ramus communicans to the mixed spinal nerve. Post-ganglionic fibres are distributed to blood vessels and the pelvic organs.

Afferent sympathetic fibres travel from the viscera in company with the efferent post-ganglionic fibres to the ganglia on the sympathetic trunk. (See Figure 1).

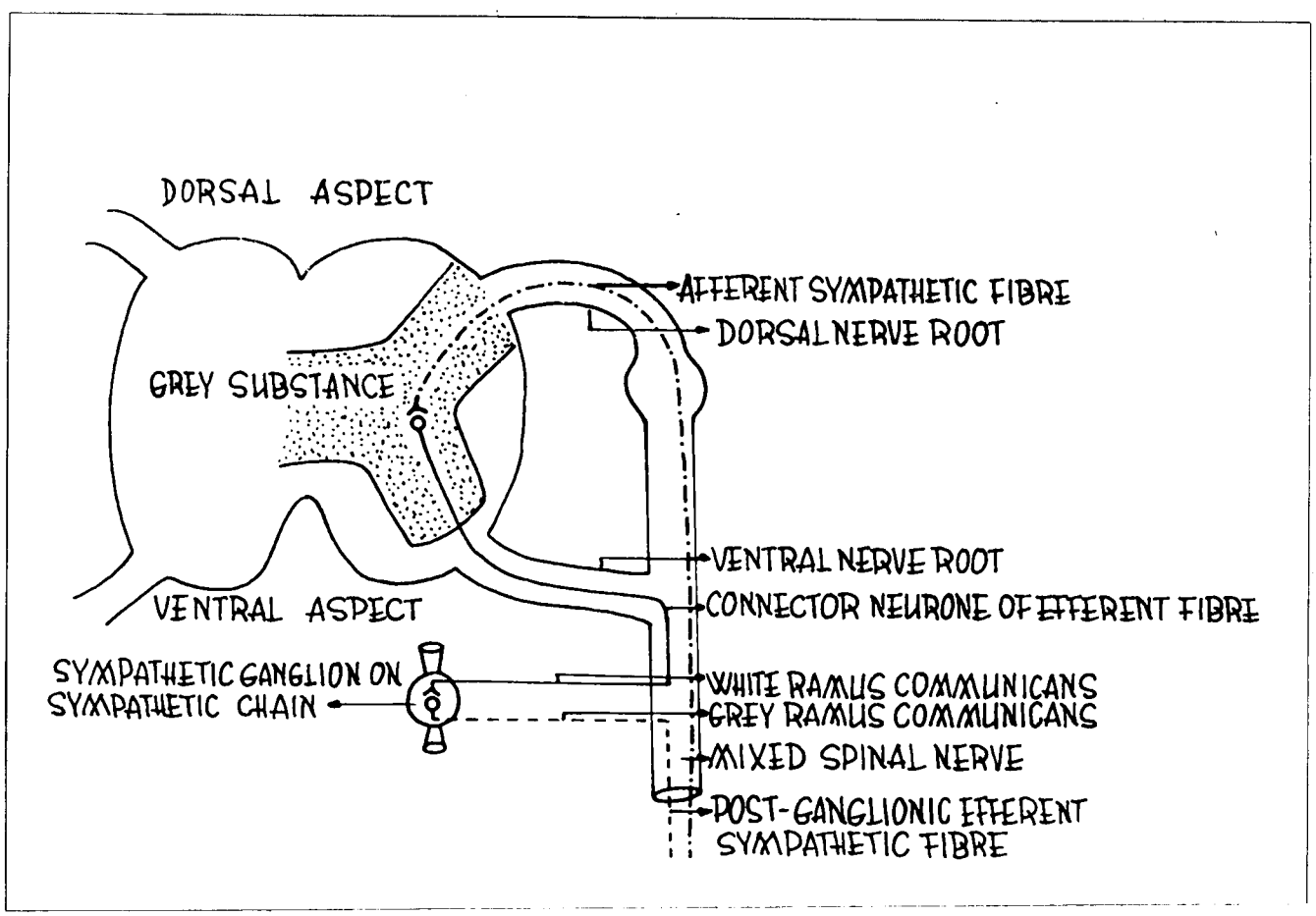

Figure 1

The Sympathetic Reflex Arc.

The sympathetic trunk also passes into the pelvis to partake in the autonomic supply to the genital organs as the pre-sacral nerves and the superior and inferior hypogastric plexuses. The mixed spinal nerve divides into posterior and anterior primary rami shortly after its formation. The posterior primary rami supply the skin of the posterior body wall in segments or dermatones. The anterior primary rami partake in the formation of the lumbo-sacral plexus and sacro-coccygeal nerve trunk. They are then distributed to supply sensory and motor supply to the lower trunk, vulva, perineum, pelvic floor and lower limbs.

While many standard textbooks of anatomy still describe pelvic visceral pain fibres to travel with the pelvic splanchnic nerves (S2, 3, 4 Parasympathetic), this is denied by Bonica in a recent publication. Akamatsu, Bonica, 1975). This forms the basis of his well tried double-catheter technique. Pain relief of the first stage is complete if the roots of segments T10 to L2 are blocked. This is done through the top catheter, the tip of which is ideally placed opposite T12 within the epidural space. The idea behind the second (caudal) catheter opposite S2 or 3 in the caudal epidural space, is to block sensory and motor somatic nerve supply to the vulva and perineum. It is not aimed at blocking parasympathetic outflow from this region. These parasympathetic fibres do not carry pain sensation and need therefore not be blocked to provide first stage pain relief. Sympathetic fibres from T10 to L2 are blocked for this purpose during the first stage. All these fibres are blocked where the nerve roots traverse the

epidural space.

Since the sympathetic outflow from T10 to L2 are blocked during epidural analgesia, a large volume of visceral and peripheral blood vessels undergo vasodilatation - because of the loss of sympathetic vasomotor tone. This effect is noticed in both resistance and capacitance vessels. (Stanton-Hicks, 1975). This results in a decrease in peripheral arterial resistance, venous pooling and a reduction in the venous back flow to the heart. The cardiac output is therefore reduced and the blood pressure drops. The more sympathetic segments blocked, the larger the total vascular bed involved, and the more marked will the drop in maternal blood pressure be. This hypotension is partially countered by spontaneous compensatory vasoconstriction in the unaffected blood vessels of the rest of the body. Therefore, the less unblocked segments left over, the less effective will this latter mechanism be in restoring the blood pressure to normal. This effect is especially marked when the segmental block reaches to above T5. (Stanton-Hicks, 1975).

The hypotensive effect of sympathetic blockade is further exaggerated by aorto-caval compression, since patients are often placed in the dorsal position to allow optimal bilateral spread of the injected local anaesthetic solution. Lateral displacement of the gravid uterus by adopting the lateral position (or by mechanical displacement) may therefore theoretically relieve the hypotension. The use of vasopressor agents, while they are likely to restore the blood pressure rapidly, is frowned upon, because they may also cause vasoconstriction of the uterine arteries.

Thereby they may be harmful to the foetus.

When sympathetic blockade extends above T5, only a small number of segments are left to effect compensation. In addition, there is also blockade of the cardio-accelerator nerves which arise from the upper thoracic and cervical sympathetic outflow. This causes a reduction in cardiac rate, in stroke volume and therefore also in cardiac output. This is therefore per se an additional factor causing hypotension during high thoracic sympathetic blockade. When epidural blockade extends to above the level of T5, there is no longer the same linear relationship between height of block and degree of hypotension. Above T5 the degree of hypotension is unpredictable - and is therefore dangerous, and should be avoided.

Although sympathetic blockade causes vasodilatation, it causes reduced visceral blood flow due to hypotension. A decrease of 7 - 11% in renal blood flow has been reported (Stanton-Hicks, 1975). There is also a reduced blood flow to the liver, the brain, the gut and the uterus. (Stanton-Hicks, 1975; Moir, 1968; Ratra, Badola and Bhargava, 1972; Matiadal and Cibils, 1976). This is due to reduced cardiac output and hypotension. This point is further illustrated by reports of reduced blood loss during major vaginal surgery done under epidural block. The blood loss may be as little as one third of that occurring with other forms of anaesthesia. (Moir, 1968).

There is also a reduced blood flow to the muscles and

skin of the lower limb, (Moir, 1968, Bridenbaugh, Moore and Bridenbaugh, 1972; Nolte, etal, 1974). Such reduced blood flow to the brain may cause cerebral dysfunction. Anoxia of the vomiting centre occurs when systolic blood pressure falls below 80 mm Hg. This causes nausea and vomiting (Ratra, Badola and Bhargava, 1972). Restoring the blood pressure and supplying oxygen usually alleviates this vomiting.

The reduction of uterine blood flow with hypotension after epidural block disturbs the chorio-decidual haemodynamics and causes relative foetal hypoxia. This may cause changes in the foetal heart rate - see section (3) below.

B. The direct action of the local anaesthetic agent upon maternal blood pressure.

Local anaesthetic agents have a direct inhibitory effect upon the smooth muscle of blood vessel walls, producing vasodilatation and hypotension. At the same time, it may cause a temporary reduction in uterine activity, both through a direct smooth muscle inhibitory effect and secondary to (hypotensive) relative ischaemia (Stanton-Hicks, 1975; Matiadal and Cibils, 1976). Rapid, direct intravenous injection of Bupivacaine may produce a temporary severe hypertension, followed by hypotension. This suggests a type of biphasic response to Bupivacaine (Stanton-Hicks, 1975; Matiadal and Cibils, 1976). When the local anaesthetic agent is injected into the epidural space, the absorption is much slower. The hypotension due to sympathetic blockade comes into play long before

that due to a direct effect. The two effects in combination will lead to a greater eventual degree of hypotension, than any one alone.

C. The Effect of Adrenaline (incorporated in the local anaesthetic agent) upon maternal blood pressure

Local anaesthetic agents are marketed in South Africa with or without Adrenaline. Bupivacaine Hydrochloride 0,5%, with Adrenaline 1:200 000, is the most commonly used local anaesthetic agent in our local labour wards. It was the drug used in all the patients in this series. The rationale behind its use, is as follows:

a. It leads to slower absorption of the local anaesthetic agent from the epidural space, because it causes vasoconstriction of the epidural vessels. Less top-ups are required and the total dosage is lower.

b. The maternal and foetal and neonatal blood levels of local anaesthetic agent are lower, as a result.

c. Adrenaline per se may to some extent counter the cardiovascular effects of epidural blockade.

d. Due to its marked systemic effects on the maternal cardiovascular system, it provides an aid in the early diagnosis of inadvertent injection of the local anaesthetic agent directly into the vein.

Whether or not it should be used as a routine or not, is an unsettled question. There are several protagonists for its routine use. These include, among others, the following: Akamatsu and Bonica, 1975; Bromage, 1969; Waters, Rosen and Perkin, 1970; Brown, Bell and Lurie, 1975; Stanton-Hicks, 1975. There are as many antogonists for its use, since it has certain potential disadvantages for the mother, such as hypotension and tachycardia - if given intravenously by accident. It may also temporarily reduce the uterine work output. (Moore, Murnaghan and Lewis, 1974; Matiadal and Cibils, 1976; Broadfield, etal, 1975; Corall, etal, 1975; Cohen, 1974; Kaiser and Harris, 1950; Reynolds, Hargrave and Wyman, 1973). Whether Adrenaline should be used in the local anaesthetic agent or not, is not a settled question yet. It is also clear that it may interfere with our ability to study the effects of plain Bupivacaine on maternal and foetal homeostatis. It is mentioned here, because it may effect the maternal blood pressure during epidural block.

Therefore, regarding blood pressure changes after epidural block, it may be influenced by the following factors:

A. Sympathetic blockade below T5 causes vasodilatation of resistance and capacitance vessels, leading to hypotension. The more segments blocked, the more marked is the hypotension. Sympathetic blockade above T5, in addition eliminates the cardio-accelerator nerves. This produces bradycardia and severe hypotension, the severity of which is unpredictable.

B. The direct smooth muscle inhibitory effect of local anaesthetic agents may worsen the above hypotension.

C. The use of Adrenaline in local anaesthetic agents may or may not mask the hypotensive effects of sympathetic blockade.

It should therefore be obvious that in Obstetric Epidural analgesia, that

a. Specific blockade of a limited number of sympathetic segments is desirable. This will ensure the least drop in blood pressure.

b. This block should not extend above the level of T5, since this may cause severe and unpredictable degrees of hypotension.

c. The smallest possible quantities of local anaesthetic agent should be used. This will have least hypotensive effects upon the mother.

To achieve the above, it is essential to ensure accurate placement of the catheter tip. This allows for accuracy in segmental blockade with the lowest quantities of local anaesthetic agent.

d. Fluid pre-loading, and

e. A position other than the dorsal should be used. (See later).

f. Adrenaline may counter the hypotensive effects of epidural block.

In this way, hypotension due to epidural block should be minimized. This is advantageous to both the mother and the foetus.

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2. HYPOTENSION AND POSTURE - THE PHENOMENON OF AORTO-CAVAL COMPRESSION

Although aorto-caval compression is not a phenomenon specifically associated with epidural analgesia, it is another cause for maternal hypotension commonly encountered during epidural block. Patients are often placed in the dorsal position after administration of the block - to allow bilateral spread of the injected local anaesthetic agent. Adopting the sitting position after the block may cause gravitational precipitation of the local anaesthetic solution in the caudal region. This position will facilitate the loss of large quantities of the solution through the large and patent anterior sacral foramina. The lateral position may cause gravitational precipitation of the solution along the ipsilateral set of nerve roots - and may thus lead to a unilateral block. This position will facilitate the loss of local anaesthetic solution through the intervertebral foramina. With the patient in the supine position, the epidural space is roughly horizontal and maximal bilateral spread, with minimal loss from the epidural space is possible. But this latter position is associated with aorto-caval compression. In a way, therefore, aorto-caval compression is relevant to epidural analgesia, and for that reason this brief review is given here.

Aorto-caval compression still remains one of the unsolved problems in obstetric patients, especially in those subjected to epidural block. This is illustrated by the fact that many recent journals still carry articles in this regard. (Marx, 1975; Marx, 1974; Weaver,

Pearson and Rosen, 1975; Scott, 1968; Moore, Murnaghan and Lewis, 1974; Holmes, 1960; Atwood, 1976;). Howard, Goodson and Mengert, 1953; Holmes, 1960; Kerr, Scott and Samuel, 1964 and 1965, as well as other authors have published extensively on the topic of "Supine Hypotensive Syndrome". They showed radiographically that pressure of the gravid uterus, in late pregnancy may almost completely occlude the inferior vena cava when the patient assumes the supine position. This effect is most marked in the last 8 weeks of pregnancy. The mechanical occlusion of the inferior vena cava causes reduced venous return to the heart, with a consequent sharp fall in cardiac output and blood pressure. The quoted incidences in the above series vary from 3% to 50%. Holmes, 1960; stated that clinical symptoms are present in only 3% of patients, but that "some degree of decrease in arterial pressure" occurs in up to 70% of patients. The severity of the symptoms and signs of hypotension due to the syndrome depends upon the adequacy of the vertebral venous collateral circulation. These collaterals are developed to a greater or lesser extent in all pregnant women. The fall in blood pressure causes a reduction in the chorio-decidual blood flow. By placing the patient in the lateral position, compression of the inferior vena cava is relieved. This simple measure usually alleviates maternal discomfort and foetal bradycardia, but not always. Although vasopressors may also relieve the hypotension, it is, in the words of D.B. Scott, 1968, "better to treat a mechanical effect mechanically rather than pharmacologically".

Later on it was realized that some degree of distal aortic

compression also occurs in the supine position. While distal caval pressure is increased in the supine position, distal aortic pressure is decreased, especially during a contraction. The combined effect is now commonly referred to as aorto-caval compression (Marx, 1974). Maternal hypotension is caused primarily by caval compression. The degree of compression and the relative absence of vertebral collaterals determine the degree of hypotension. No satisfactory explanation has yet been offered why distal aortic compression does not correct the hypotension (by its increasing the peripheral resistance). It is possible that distal aortic compression to some degree counters the hypotension due to caval compression. However, while it partially corrects the hypotension, it will per se reduce the blood flow to the placental site. Whatever the exact mechanism, it must be assumed that caval and aortic compression individually and in combination will reduce uteroplacental blood flow. The result is foetal hypoxia. Both these effects get worse with advancing labour, but aortic compression more so than caval compression. (Marx, 1974).

Another factor involved in determining the eventual degree of hypotension, is the ability of the mother to respond with compensatory vasoconstriction (Scott, 1977 a.)This depends upon an intact autonomic supply to the vessels. The relevance of this problem to epidural block is therefore illustrated again.

Yet another factor which may complicate the understanding of this problem, is the presence or absence of vasovagal overactivity. This may be present in addition to the

"hypotensive syndrome". The diagnostic feature is the presence of persistent maternal bradycardia and hypotension, the latter which does not respond to lateral positioning. (Scott, 1977 a).

In summary, therefore, there are a number of factors at play in determining the eventual effects of aorto-caval compression. These are:

1. Inferior Vena Caval Compression.
2. Distal Aortic Compression.
3. The degree of Vertebral Venous Collateral Circulation.
4. The ability of the mother to respond with compensatory vasoconstriction.
5. The presence or absence of vaso-vagal overactivity.

The treatment recommended for aorto-caval compression (with or without epidural blockade) is lateral positioning of the patient. (Scott, 1977; Marx, 1974). This is stressed again, with a certain degree of urgency by Marx, 1975. The disadvantages of the lateral position after epidural block, have been mentioned in the introductory remarks of this section. Furthermore, hypotension is not always improved by the lateral position, probably because caval compression is not completely relieved in all cases. Turning such patients to the opposite lateral side may help, but not always. In the latter group of patients, the use of vasopressors has been suggested, and will usually be effective. Unfortunately, vasopressors may also effect the uterine arteries. This is potentially harmful to the foetus. (Scott, 1977).

This form of treatment is more readily resorted to in the epiduralized patient - because the block is blamed for the persistent hypotension. (Scott, 1977; Milne and Murray-Lawson, 1973).

It is therefore obvious that the problem of aorto-caval compression in obstetrical patients has not been satisfactorily resolved. Neither the use of lateral positioning nor vasoconstrictors provide the answer in all cases. In a recent, extensive comparitive anthropological study of parturitional posture, it is concluded that "There is still a lack of knowledge concerning parturitional postures". The purpose of that paper was "not to advocate a certain delivery position; instead, its purpose was to expose the reader to the wide variability of delivery positions...." (Atwood, 1976). Although the kneeling (on-all-fours, quadrupedal) position is briefly mentioned, it has certainly not been used to any marked extent in obstetrics. It is not even a very popular position in the higher apes.

It is our contention that by placing the patient in the kneeling position (on-all-fours, hands-and-knees, quadrupedal) with her back in the horizontal plane, one will abolish aorto-caval compression in most (if not all) cases. In this position the gravid uterus is displaced forwards by gravity. This allows a free flow of blood through both the aorta and the inferior vena cava. In addition, this position, by maintaining the epidural space in a roughly horizontal position will allow for optimal spread of local anaesthetic solution in all directions equally.

No reference to the large-scale use of this position in modern labour wards could be found in the recent literature. No serious ethical objection to this position is evident, and we have therefore decided to try it in an attempt to abolish hypotension, and the associated changes in the foetal heart rate, during the crucial 10 to 30 minutes immediately after the block.

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3. HYPOTENSION AND THE FOETUS

In 1971 Popescu stated that ".... in Obstetric we are called to care for two patients, but to anaesthetize only one". This is well illustrated by the effects of hypotension during epidural block upon the foetus. Similarly, the local anaesthetic agent may itself (Possibly) adversely effect the foetus. The next two sections will deal with these aspects.

Maternal hypotension, whether due to aorto-caval compression, sympathetic blockade, or direct action of the local anaesthetic agent upon the vessel, may adversely effect the foetus. Maternal hypotension results in reduced blood flow through the chorio-decidual space. This results in hypoxia of the foetus, and may cause periods of bradycardia in the latter. Maltau, in 1975, described temporary foetal bradycardia in only 2 out of 35 patients, when 5 to 8 ml of a 0,25% or 0,5% solution of Bupivacaine was used in selective blocks. No association with maternal hypotension is mentioned. Foetal heart changes, without apparent reason, were reported by Printz and Mc Master in 1972 in 11 out of 100 cases. Wingate, etal, in 1975 reported foetal heart changes in a total of 55% of cases. Of those cases developing abnormalities of the foetal heart, 71% had hypotension after the epidural block. This happened in spite of fluid pre-loading. Comparable results were reported by Boehm, Woodruff and Growdon in 1975 and by Zaaijman and Slabber in 1976. In all of the last three series, standard epidural blocks were done. Hypotension occurred in spite of fluid pre-loading. Mc Donald, Bjorkman and Reed, 1974, reported

slowing of the foetal heart between 10 and 40 minutes after epidural block when hypotension was present. There was also a significantly increased incidence of foetal acidosis in those foeti developing bradycardia. Eckstein and Marx in 1974 blamed the combined effect of aorto-caval compression and sympathetic blockade for maternal hypotension and foetal bradycardia. Foetal bradycardia has also been reported in association with hypotension after high spinal block (Abouleish 1976). Belfrage, etal, 1977, reported temporary reduction of the beat-to-beat variation of the foetal heart in 7 out of 10 patients after epidural block where maternal hypotension was associated. Therefore, from most of these studies, there seem to be an association between maternal hypotension after epidural block and foetal bradycardia. The latter is usually temporary, and the exact effect upon the foetal well-being is not clear at this stage.

Other reported causes for foetal bradycardia during epidural block (Where maternal hypotension may or may not be present) include:

1. Direct injection of the local anaesthetic agent into the foetal head during caudal epidural block (Finster, etal, 1965). Here the foetal bradycardia was ascribed to "direct intoxication".

2. Direct injection of the local anaesthetic agent into an epidural vein (Abouleish, 1976).

3. Di Giovanni, in 1971, reported foetal bradycardia

after inadvertent intra-osseous injection of local anaesthetic agent into the sacrum during caudal block.

4. Accidental paracervical block while attempting caudal epidural block has been reported as a cause for foetal bradycardia (Abouleish, 1976).

It is therefore clear that any of the several causes for maternal hypotension during epidural block may adversely effect the foetus, albeit temporarily. Some studies have shown that such foeti are acidotic at the time of bradycardia, while others could show no correlation between foetal bradycardia and the Apgar scores.

Nevertheless, every effort should be made to avoid hypotension during epidural block. This may be made possible by:

1. Avoiding the supine position.

2. Using the lowest possible doses of local anaesthetic agent.

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4. BUPIVACAINE AND THE FOETUS

In a recent review Dubowitz, 1975 made a plea that obstetricians should be more concerned about the possible foetal effects of new drugs being introduced into the labour ward. He is especially concerned about the more subtle effects of drugs upon the "fragile" foetal and neonatal nervous systems. Bupivacaine is at present exclusively used in our labour wards for epidural analgesia. Later in the discussion it will be pointed out that some doubt still lingers about the complete safety of this drug as far as the foetus and neonate is concerned. For the present, our aim should be to use the lowest possible doses of Bupivacaine.

Bupivacaine was first synthesized in 1957 by Eckenstam, and came into popular use in the early 1960's. (Ekenstam, Egner, Pettersson, 1957). It is an Anilide type of local anaesthetic agent, with the following structure:

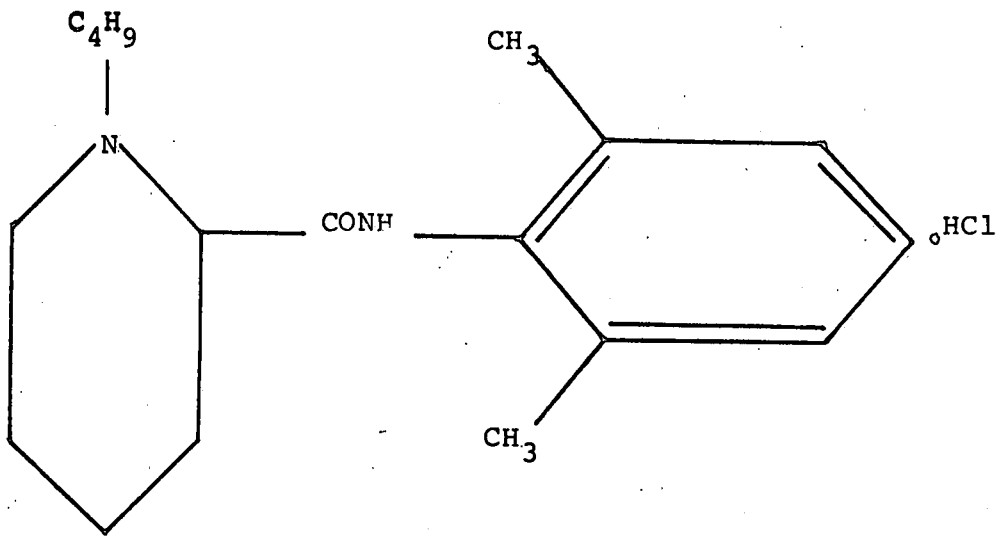

Figure 2

The biochemical structure of Bupivacaine (1-n-buty 1-DL-piperidine-2 carboxylic acid-2, 6-dimethylanilide.).

Bupivacaine is a very popular local anaesthetic agent for epidural analgesia all over the world to-day. It is highly lipid soluble, has a molecular weight of 325, and maintains a low degree of ionization. In the unbound form it therefore crosses the placenta with ease. In the protein-bound form it does not cross the placenta. In the foetus, a much lower percentage of the fraction diffuses according to the concentration gradient. The blood levels of this fraction is the same in the mother and foetus. Because of this differential protein binding of the drug in maternal and foetal plasma, the blood levels of the bound form are not the same. This gives rise to the so-called umbilical vein/maternal (UV/M) Bupivacaine ration. The foetal blood levels vary between 30 to 60% that of the maternal concentrations. This ratio is determined by total dosage, percentage saturation of binding sites and the total maternal plasma proteins. In maternal plasma, 90 - 95% of Bupivacaine is protein-bound, while the same figure in the foetus is 40 - 70%. The higher the free fraction in the mother, the more drug crosses to the foetus. (Magno, etal, 1976). Acidosis also effects placental transfer, because it encourages ionization of the drug. The more acidotic the mother, the less drug will cross to the foetus. (Finster and Pederson, 1975). Peak levels in the mother are reached at 20 to 40 minutes after epidural administration. (Magno, etal, 1976; Moore, etal, 1970). The drug is cleared from the foetus and neonate largely by renal excretion. It is rapidly cleared, and by 24 hours most neonates have no detectable levels of the drug in their circulations (Brown, Bell and Lurie, 1975). Within minutes of injection into the epidural space, the drug becomes

detectable in the foetus. Large doses given repeatedly, may cause maternal and foetal accumulation and sometimes neonatal depression.

Bupivacaine is intrinsically a longer acting drug than any of the other agents used (Moore, etal, 1970; Duthie, Wyman and Lewis, 1968; Bromage, 1969; Phillips, 1975; Wilson, 1975). Because of this, the total dose required is less, and so is the risk of accumulation and toxicity. The first symptoms and signs of maternal and foetal-neonatal toxicity become apparent at maternal blood levels of 1UG/ML or more. These levels are rarely reached in obstetric analgesia (Reynolds and Taylor, 1970; Scott, 1975). But even with less than these toxic levels, foetal heart rate changes have been reported and ascribed to Bupivacaine. Hehre, Hon and Hook, 1969, found a correlation between high foetal blood levels of Bupivacaine and foetal heart irregularities. On the other hand, Belfrage, etal, in 1975 could not demonstrate a relationship between foetal pH, foetal Bupivacaine concentrations and the foetal heart pattern. Several other authors have also indicated that Bupivacaine may not be completely harmless to the foetus and neonate. Fisher and Paton in 1974, for instance, showed that Bupivacaine exerts a Quinidine-like effect on the myocardium, that it may cause depression of the central nervous system and even convulsions in very large dosages. They showed that it may cause foetal bradycardia, acidosis and neonatal depression, due to decreased myocardial conduction velocity and decreased cerebral blood flow. Standley and co-workers in 1974, blamed

Bupivacaine for increased cerebral irritability and decreased motor maturity of the neonate. This fits in with the findings of Munson, Martucci and Wagman, 1972, that seizures could be induced in Rhesus monkeys by the intravenous injection of Bupivacaine. Seizures took place at or above blood levels of 5,5 µG/ml. This is admittedly very much higher than the ordinary therapeutic levels in man (Munson, Martucci and Wagman, 1972). But then Tahir, Adriani and Naraghi, 1975, reported four cases who developed convulsions within 30 seconds of epidural injection of Bupivacaine. The injections were presumably given intravenously inadvertently. Maternal convulsions are without doubt harmful to the foetus. If accidental intravenous injection into the mother occurs, acute systemic toxicity may result; This is characterized by temporary hypertension, tachycardia, headache, dizziness and occasionally, convulsions.

In 1974, Scanlon, etal, introduced a new technique of neurobehavioral evaluation of the neonate. They found that neonates from mothers who had epidural blocks with Lidocaine and/or Mepivacaine, had a decrase in muscle tone and strength. These changes were not detectable by doing the ordinary Apgar score. In a more recent study, the same group could not confirm these findings after epidural block with Bupivacaine.(Scanlon, etal, 1976).

At present, therefore, the complete safety of Bupivacaine for the foetus and neonate, has not been proven. More studies are required to provide clarity. One would like to hazard a guess that the direct or indirect deleterious

effects upon the foetus and neonate will be dose - related, as has in fact been suggested by some of the studies referred to above. However, it would appear from its world-wide popularity, that it must be the safest agent in use to-day. Nevertheless, for the time being it is still desirable for both mother and foetus, to use the smallest possible dosages of Bupivacaine. We hope to achieve this as part of the aims of this project.

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5. ACCURATE PLACEMENT OF THE EPIDURAL CANNULA

Up to this point we have tried to point out that maternal hypotension during epidural block can be lessened by:

1. Avoiding the dorsal position and thereby aorto-caval compression,

2. blocking the minimum number of sympathetic segments, and by

3. using the lowest possible mass (mass = volume x concentration) of local anaesthetic agent.

The latter two conditions can be best achieved by accurately placing the epidural cannula at the optimal position, namely opposite T12. In the double catheter technique two cannulas are placed into the epidural space. The lower catheter is placed into the caudal epidural space opposite S3. This catheter is used for second stage analgesia. The top catheter is usually inserted into the lumbar epidural space and is then threaded in a cephalad direction for varying distances in an attempt to place its tip opposite T12. This position theoretically allows for the lowest possible dosages of Bupivacaine. But by simply threading a catheter into the epidural space through the second or third lumbar interspace is futile. Bridenbaugh, etal in 1968 concluded that it is not possible to place an epidural catheter accurately if it is threaded for more than 5 cm beyond the tip of the needle. They pointed out that when the

catheter was threaded for more than 5 cm, that it only travelled straight in a cephalad direction (as intended) in a mere 25% of cases. Similar findings were reported by Sanchez, Acuña and Rocha, 1967, as well as by several other authors already quoted in Chapter I. The further such a flexible cannula is threaded, the less likely is it to travel in the intended direction, and the less likely is it to reach the intended position. After entering the epidural space, the catheter may apparently travel straight cephalad, or may curl up at the site of insertion, it may leave the epidural space through an intervertebral foramen or it may even be deflected to travel in a caudal direction. All the quoted authors concluded that the best way to accurately place the catheter, is by threading it for the "minimum length" into the epidural space. A catheter inserted in the low (L3 or 4) or high (L1 or 2) lumbar epidural space, would need to be threaded for 10 to 15 cm to reach the ideal position opposite T12 - that is if the catheter were to follow a straight cephalad course. It therefore seems unrealistic to attempt accurate placement of the epidural cannula to a point more than one segment cephalad to the level of insertion. It is therefore concluded that the most accurate way to place an epidural catheter exactly at T12, is to thread it in at the twelfth thoracic interspace (T12), for 2-3 cm beyond the tip of the epidural needle.

There are however, dangers attached to low thoracic epidural block. The spinal cord usually ends at the level of L1 or L2. The technique is open to criticism since it involves:

1. An increased risk of direct trauma to the spinal cord,

2. An increased risk of hypotension - if the block is allowed to extend above T5 (see (1) above),

3. An increased risk of dural puncture, because the posterior compartment of the epidural space is smaller in the thoracic and high lumbar regions, than in the low lumbar region,

4. An increased risk of total spinal block - because of the level at which subdural injection may be given accidentally.

For these reasons, thoracic and high lumbar blocks have been criticized before (Editorial Comment, Survey of Anesthesiology, 1976). But the same criticisms can for practical purposes be applied to the high lumbar block performed by Bonica, 1967. Furthermore, the technique of thoracic epidural blockade is quite commonly used to treat post-operative thoracotomy patients - especially those with poor lung function, where good post-operative coughing is essential. (Shuman and Peters, 1976; Miller, etal, 1974; Bromage, 1967; Spence and Smith, 1971). Thoracic epidural block is also used in the surgical treatment of bladder carcinoma (Brown, Arthurs and Glashan, 1974).

There is therefore no convincing reason why thoracic epidural block should not be used with safety in Obstetrics. Unfamiliarity seems te be the only real contra-indication.

It would appear to be ethically justifiable, since there are certain theoretical advantages attached to the technique, such as:

1. Accurate placement of the catheter tip opposite T12 is made possible.

2. This (1) should permit the use of minimal dosages of Bupivacaine, thereby facilitating ....(3)....

3. A lower incidence of maternal hypotension, and consequently ....(4)....

4. A lower incidence of foetal heart rate abnormalities.

5. Accurate placement should lessen the incidence of patchy analgesia, unilateral block an unblocked segments.

6. It provides some security to the operator, since he knows exactly where the catheter tip lies.

This modification has not been used in Obstetric epidural analgesia before, but it may eliminate some of the disadvantages of the current technique of segmental blockade.

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6. SUMMARY

In the above relevant review of the recent literature, we have attempted to point out some of the problems that are still encountered in epidural analgesia.

Hypotension may be caused by sympathetic blockade. In the latter both the number of segments and the site of blockade may effect the blood pressure. The direct effect of Bupivacaine may worsen the hypotension. The disadvantages of the lateral position are mainly associated with a poorer quality of block due to its gravitational effect upon the injected local anaesthetic agent. The foetus may be adversely effected by hypotension. The foetus may also be adversely effected, directly or indirectly, by large doses of Bupivacaine. The larger the dose, the more likely is the foetus to be effected directly and indirectly, secondary to hypotension or even maternal convulsions. Accurate placement of the epidural cannula should improve the quality of the block and should allow one to use only minimum dosages of Bupivacaine.

We have decided to introduce two modifications into the current technique of the double catheter epidural block.

Firstly, we intend to use the twelfth toracic interspace to insert the epidural cannula. We intend to thread the catheter just immediately beyond the tip of the needle. In this way it is hoped to place the catheter tip accurately near T12 in the majority

of patients. The potential advantages of such accurate placement have been outlined.

Secondly, we intend to place the patient in the kneeling position (hands-and-knees) with the back horizontal, before giving the injection through the top catheter. This position should eliminate the disadvantages of the lateral and dorsal positions.

Both these modifications should improve the quality of the block and should allow for a lower dose of local anaesthetic agent. There should be less hypotension and therefore a lower incidence of foetal heart rate changes.

To allow an objective evaluation of these proposed modifications, we have decided to compare the Standard, the Segmental and the Modified Segmental epidural blocks. The latter of these is to contain the 2 above mentioned modifications. Each block is to be evaluated according to the same set of objective maternal, foetal and neonatal parameters. We hope to show objectively that the Segmental block has some advantages over the Standard block. We also hope to show that by introducing the two modifications to the Segmental block, that its value can be further improved. We therefore will try to show that the Modified Segmental block is to be a better technique than any of the other, since it may still further reduce the disadvantages attached to the other two techniques. To the best of our knowledge a similar study has not been reported to date.

CHAPTER III

PLAN OF STUDY, EPIDURAL TECHNIQUES AND LABORATORY TECHNIQUES

1. GENERAL INFORMATION AND PATIENT GROUPS

The project was undertaken in an effort to improve the present standard of epidural analgesia in Obstetrics. A total of 3 patient groups were used. Each group consisted of 25 patients. Each group was subjected to a different technique of epidural block. The first was subjected to a Standard (single catheter) block, the second to a Segmental (double catheter) block, and the third to a Modified Segmental block. Two modifications on the segmental block were incorporated into the third type of block. The three groups were then compared in terms of a series of objective maternal, foetal and neonatal observations. These 75 patients were selected from a total number of 158 epidural blocks performed by the candidate personally. The patients in the three groups were evenly matched in terms of race, age, parity, body mass, ante-natal course, cervical dilatation and birth weight. The differences observed by using the 3 different blocks could therefore be ascribed to the difference in technique used.

All the patients were black South African females from the Southern Free State area. They were all healthy primigravidas. All had uncomplicated ante-natal courses and normal uncomplicated labours. All the patients had gone into labour spontaneously after a gestational period of 36 weeks (by dates and palpation) and all of them were

between 4 and 7 cm dilated at the time of the block. They all had vaginal vertex deliveries. In all cases 500 to 750 ml of a 5% Dextrose in water solution was infused intravenously prior to the block. In all cases continuous cardiotocographic monitoring was performed both before and after the block. In all cases a normal foetal heart pattern was present for at least 20 to 30 minutes prior to the block. Any changes in the foetal heart occurring after the block, could therefore be assumed to be probably due to the block. In all cases an epidurogram was performed before the block. All neonates were assessed in terms of the Apgar score, as well as by umbilical vein and arterial Astrup estimations. Maternal arterial Astrup estimations were done at the same time. The neonatal masses and sexes were recorded. Maternal and umbilical venous blood was collected at birth for whole blood Bupivacaine estimations.

Altogether 15 objective parameters were used to assess the effects of the block in each case. The results were then subjected to statistical analysis. Nine of the 15 parameters were used to perform a variance analysis on the three patient groups, in an attempt to objectively assess the three techniques in comparison with one another. All the patients partaking in the project supplied informed consent prior to the block.

GROUP A

This group consisted of 25 patients. Their ages varied between 16 and 28 years, and the average age was 21, 52 years. The body masses varied between 54,3 kg and 91,0 kg,

with an average mass of 67,66 kg. These patients were all subjected to a Standard Epidural Block. All the standardized conditions outlined above, applied to this group.

GROUP B

This group consisted of 25 patients. Their ages varied between 16 and 26 years, with an average age of 19,96 years. The body masses in this group varied between 51,5 and 89,2 kg, with an average mass of 65,99 kg. All these patients were subjected to a Segmental Epidural Block. All the conditions outlined above applied to all the patients in this group.

GROUP C

This group consisted of 25 patients. Their ages varied between 14 and 29 years, with an average age of 20,64 years. Their body masses varied between 53,0 and 96,4 kg, with an average mass of 65,56 kg. All these patients were subjected to a Modified Segmental Epidural Block. All the above mentioned conditions also applied to all the patients in this group.

Details of the 3 patient groups are given in the Addendum A.

2. EPIDURAL TECHNIQUES

In all the patients, irrespective of the type of block, the following precautions were taken:

a. A fully equipped anaesthetic machine with all the

necessary facilities for immediate intubation and intermittent positive pressure respiration was available in the labour room.

b. A pressor agent, Mephentermine Sulphate (Wyamine), was kept readily available in all cases.

c. Fluid pre-loading was carried out on all patients with 500 to 750 ml of 5% Dextrose in water solution.

d. A Spiral electrode was connected to all patients prior to the block. In all cases, care was taken that a normal foetal heart pattern was present before the block, with the patient in the position in which the block was to be performed, eg. in the full supine or in the kneeling position.

e. At least one other doctor was present in the labour room at all times, in case of a major catastrophy.

f. The Epidural Space was identified by the hanging drop technique. In addition, subdural positioning of the needle tip was excluded by injecting a small quantity of air, followed by aspiration in 4 directions. A test dose of 2 to 3 ml of the local anaesthetic solution was given 5 minutes before the therapeutic dose.

g. The blood pressure and pulse were recorded at 5 minute intervals before and after the block.

h. A change of position to the lateral was done whenever a drop of blood pressure to below 90 mm Hg systolic occurred or when a change in the foetal heart pattern was observed. If these took place before the block, the patient was excluded from the series.

A. THE STANDARD EPIDURAL BLOCK

In the Standard epidural block, the catheter was inserted in the left lateral position. A flexible plastic catheter (See Figure 3) was inserted through a number 18 gauge epidural needle at the third or fourth lumbar interspace. The catheter was threaded cephalad for 10 to 15 cm. (The catheter was marked at 5 cm intervals.)

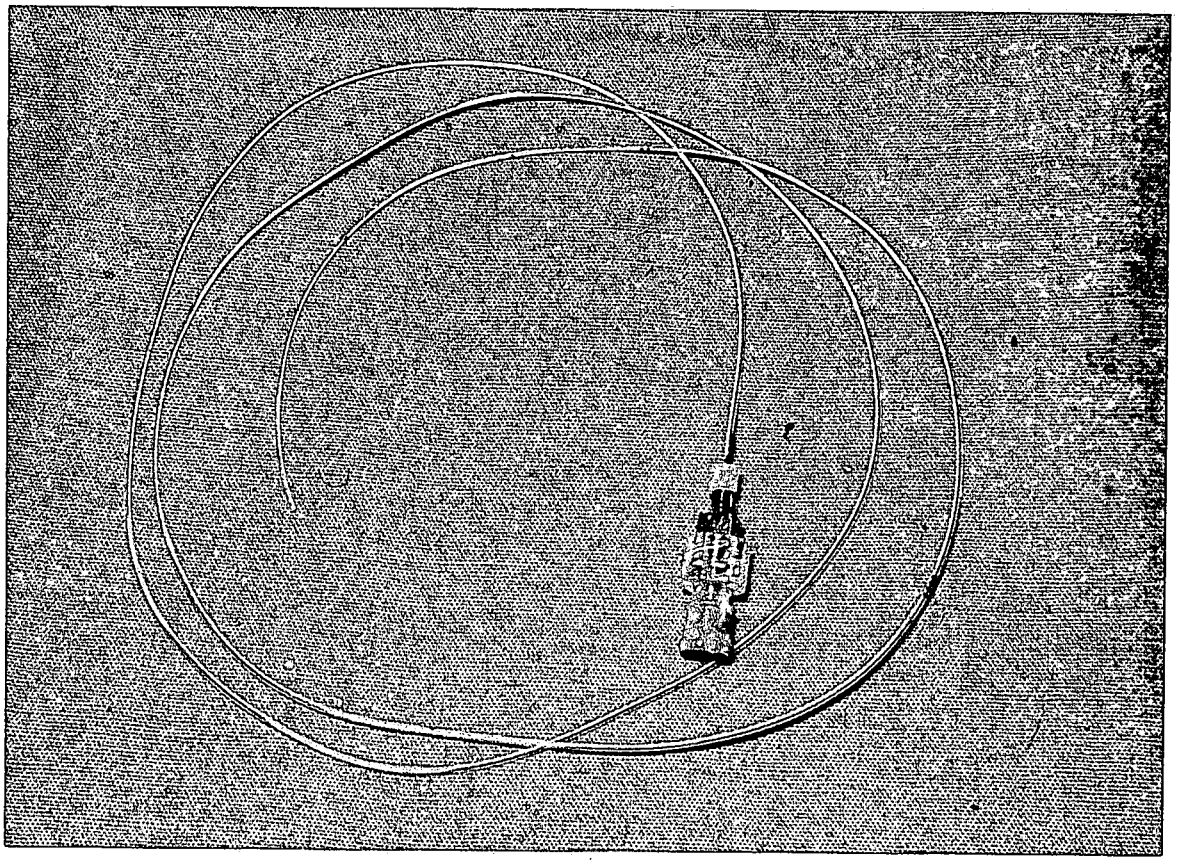


Figure 3

This type of flexible plastic catheter, with markings at 5 cm intervals, was used in all cases.

After the catheter was inserted, an epidurogram was performed in all cases. The patient was then placed in the supine position, and after a normal cardiotocographic tracing had been obtained for 20 to 30 minutes in this position, a test dose injection of 2 to 3 ml of Bupivacaine 0,5% with 1:200 000 Adrenaline was given. If no untoward reaction occurred after 5 minutes, the therapeutic dose of 10 to 12 ml of the same solution was given. The patient was (ideally) kept in this position for approximately 10 - 15 minutes after the block, to allow optimal bilateral spread of the local anaesthetic agent through the epidural space. If necessary (which was more often than not) the patient was turned into the left or right lateral position (see above). The blood pressure and pulse were taken at 5 minute intervals for at least 30 minutes after the block. The area of cutaneous hypo-algesia was assessed by the pin-prick method, and recorded.

The loss of perineal and pelvic floor tone was assessed by digital rectal and/or vaginal examination, and classified into 3 grades as follws:

Grade I : No loss of tone clinically detectable.
Grade II : Some loss of tone clinically detectable.
Grade III : Clinically flaccid.

The quality of the block, in terms of analgesia during labour, was assessed objectively by the operator. This was done by comparing the patient's response to contractions before and after the block.

Grade 0 : Obviously no pain relief at all.

Grade I : Minimal pain relief.

Grade II : Pain during contractions; patchy or unilateral block; unblocked segments.

Grade III : Complete relief of pain; sleeping between and during contractions, etc.

(In this patient population, subjective evaluation was found to be impossible. The patients were as a rule unable to express their degree of pain relief. There was also usually a language barrier. For these reasons, this attempt was made to grade the quality of the block objectively. It was based purely on clinical observation of the patient's behaviour after the block, when compared to her behaviour before the block.)

"Top-up" doses (of 5 - 7 ml) were given when analgesia became obviously inadequate. The times when and dosages given, were recorded.

The duration of the second stage, was recorded to the nearest 5 minutes. The mode of delivery was recorded.

B. THE SEGMENTAL EPIDURAL BLOCK

The general protocol for this group was the same as outlined above. In this group two epidural catheters were inserted. The top catheter was inserted through the second lumbar interspace. (L2). The catheter was threaded cephalad for exactly 10 cm, in an attempt to place the catheter tip opposite T12, the ideal position

for segmental blockade. (Akamatsu and Bonica, 1975, suggested that the catheter would reach T12 if it were threaded for only 4 cm. This is anatomically obviously impossible. For that reason we threaded the top catheter for 10 cm.) Then a second catheter was inserted into the epidural space via the sacrococygeal hiatus. This catheter was threaded cephalad, along the sacral canal, for 5 to 7½ cm. The above is the same technique as used by Akamatsu and Bonica, 1975, with the exception of the length of (upper) catheter threaded.

Epidurograms were then performed through both the upper and lower catheters. These were done to check the positions of the catheters. The patient was then placed in the dorsal position. After a normal cardiotocographic tracing had been obtained in this position, the test and therapeutic doses were given through the upper catheter. In this group the local anaesthetic agent was Bupivacaine with Adrenaline 1:200 000. The concentration used was 0,25%. The therapeutic dose was 4 to 6 ml of this solution. With the top catheter in the ideal position (T12) this dosage should block first stage pain (T10 to L2). The purpose of the top catheter was to provide pain relief in the first stage. "Top-up" doses were given as required.

Once full dilatation had been reached and internal rotation had been completed, second stage pain relief was provided through the lower (caudal, S2, 3, 4) catheter. The dosage used was 5 to 8 ml of a 0,25% Bupivacaine with Adrenaline 1:200 000. This concentration should provide adequate analgesia without producing pelvic floor

flaccidity, thereby allowing for maximal flexion, normal internal rotation, normal bearing down and a lower incidence of instrumental deliveries. Ideally, the use of the lower catheter was reserved till after internal rotation was completed, but often severe deep pelvic and perineal pain made it necessary to use this injection earlier.

The rest of the protocol was similar to that of the Standard block (See above).

C. THE MODIFIED SEGMENTAL BLOCK

This block was performed in the same way as the segmental block ((B), above), except that two modifications were incorporated:

a. The top catheter was inserted through the twelfth thoracic interspace (T12). The catheter was threaded just beyond the tip of the epidural needle. This was done to obtain more accurate placement of the top catheter opposite T12. This modification was incorporated after the results of the lumbar epidurograms were obtained. (See Chapter IV).

b. The patient was placed in the kneeling position. (See Figure 4 a, b). This was done in an attempt to avoid aorto-caval compression, while still maintaining the patient's back in a horizontal plane (allowing for obtimal, bilateral spread of the local anaesthetic agent through the epidural

space.) Ten to 15 Minutes after the block, the patient was allowed to assume any position she found comfortable. Patients were asked whether they found the position undignified and/or tiring.

The answers were recorded.

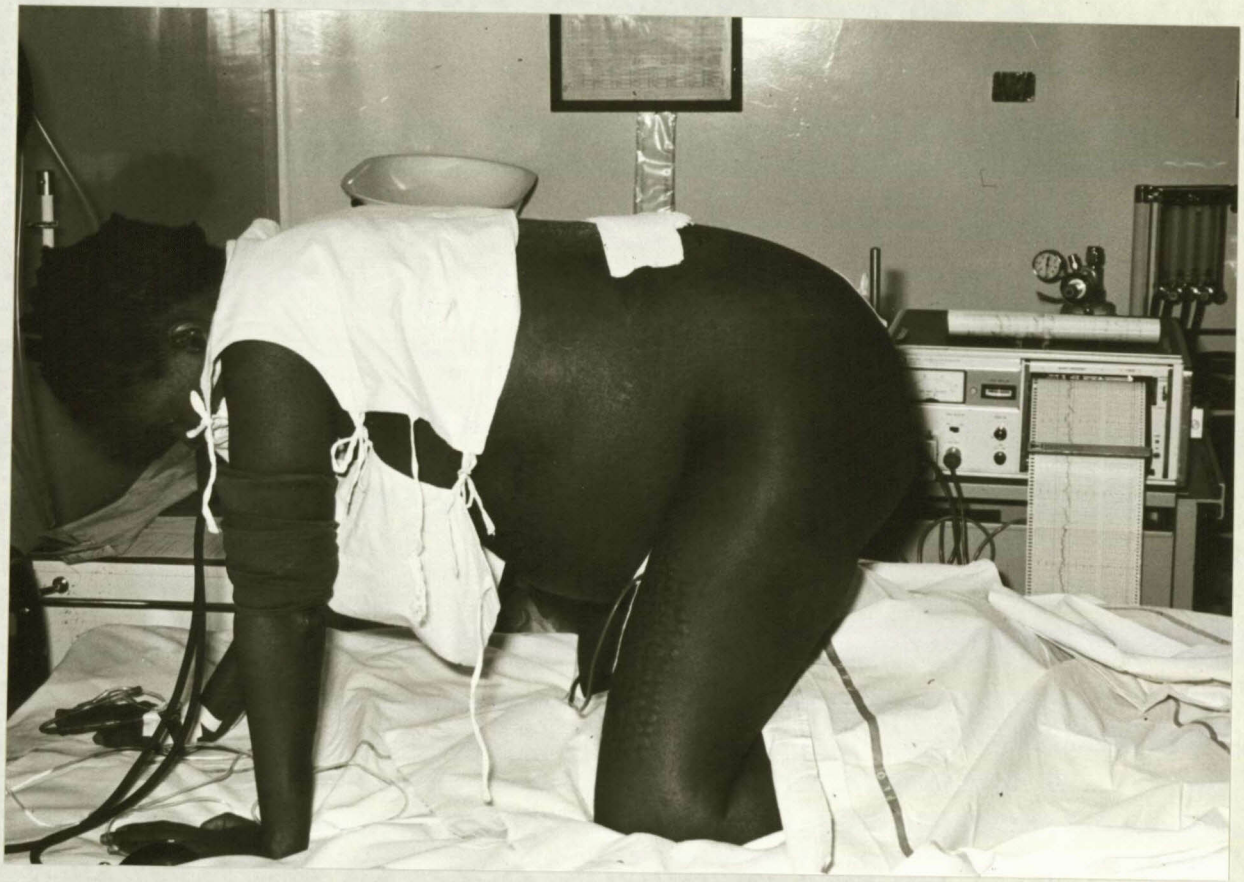
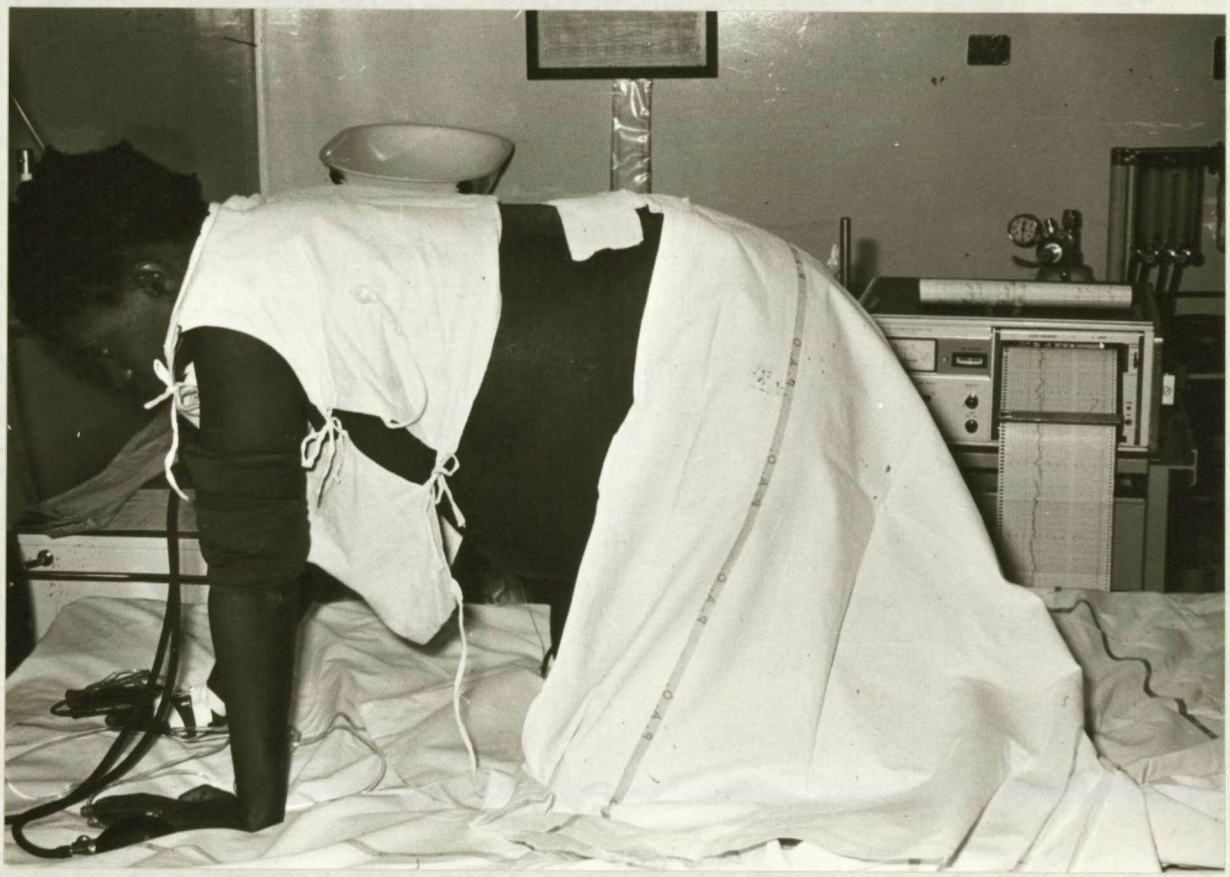


Figure 4(a)

The patient was placed in the kneeling position after the block, with the back horizontal.

Figure 4(b)

The patient's hind quaters were covered by a sheet, to avoid embarrassment.



This modification was incorporated, after the incidence of foetal heart rate changes was noted with the Segmental block. (See Chapter IV). (These foetal heart rate changes occurred in spite of the lesser degree of hypotension and the lower dosage of Bupivacaine

The rest of the protocol was the same as for the Segmental Block ((B), above).

3. THE EPIDUROGRAM

Lumbar of thoracic epidurograms were performed on all the patients in the series. Caudal epidurograms were also performed on Groups (B) and (C). These were done to establish the fate of an epidural catheter after it had been threaded for varying distances. In group C, the low thoracic epidurograms were done to prove that a catheter could be placed safely and accurately opposite T12.

A single lateral X-Ray exposure was taken of the lower thoracic and lumbo-sacral spine, after injection of radio-opaque dye through the catheter(s). The dye used was Lophendylate (Myodil). One to 2 ml was injected per catheter. The X-Rays were taken at the following setting:

160 Milli-Ampieres per second,
75 Kilovolt,
0,4 seconds,
tube to plate distance, approximately 3 foot.
These varied slightly depending on the size of the patient.

The caudal epidurogram was regarded as "normal", when the catheter could be seen within the sacral canal, often also showing spill of dye through the anterior sacral foramina. (See figure 5,a.) Both anterior and posterior

sacral displacement could be diagnosed in this way (See Figures 5 b, c). The incidences of each were recorded.

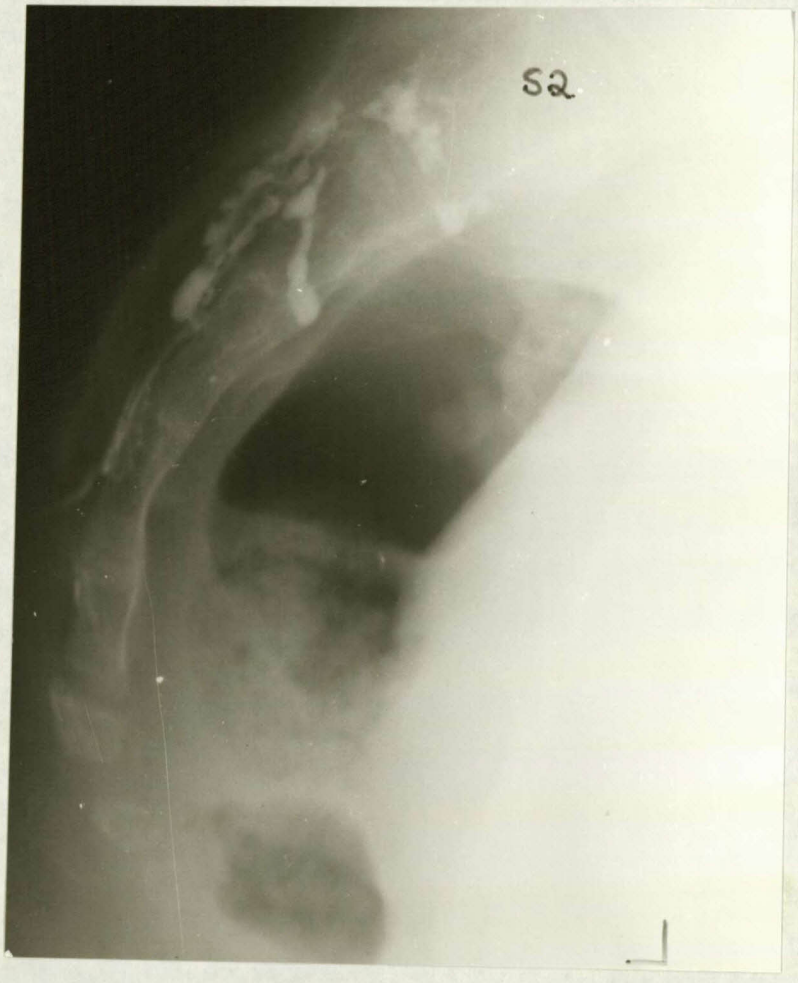


Figure 5,a

A Caudal epidurogram showing deposition of dye in the sacral canal. Dye can also be seen spilling through the anterior sacral foramina.

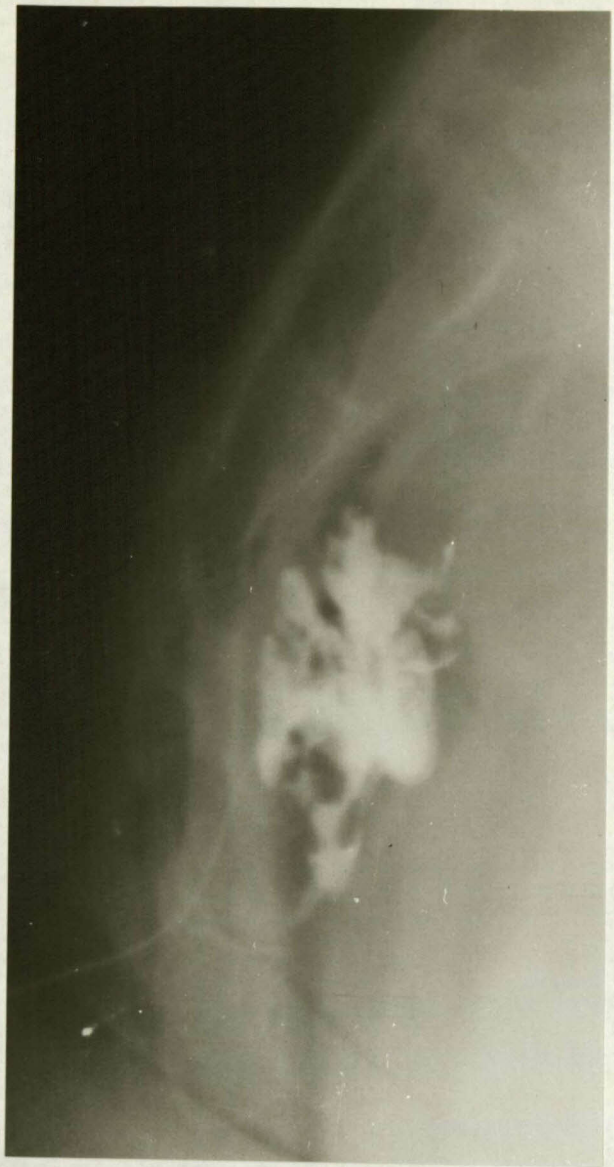


Figure 5,b

A Caudal epidurogram, showing dye deposition anterior to the sacrum.

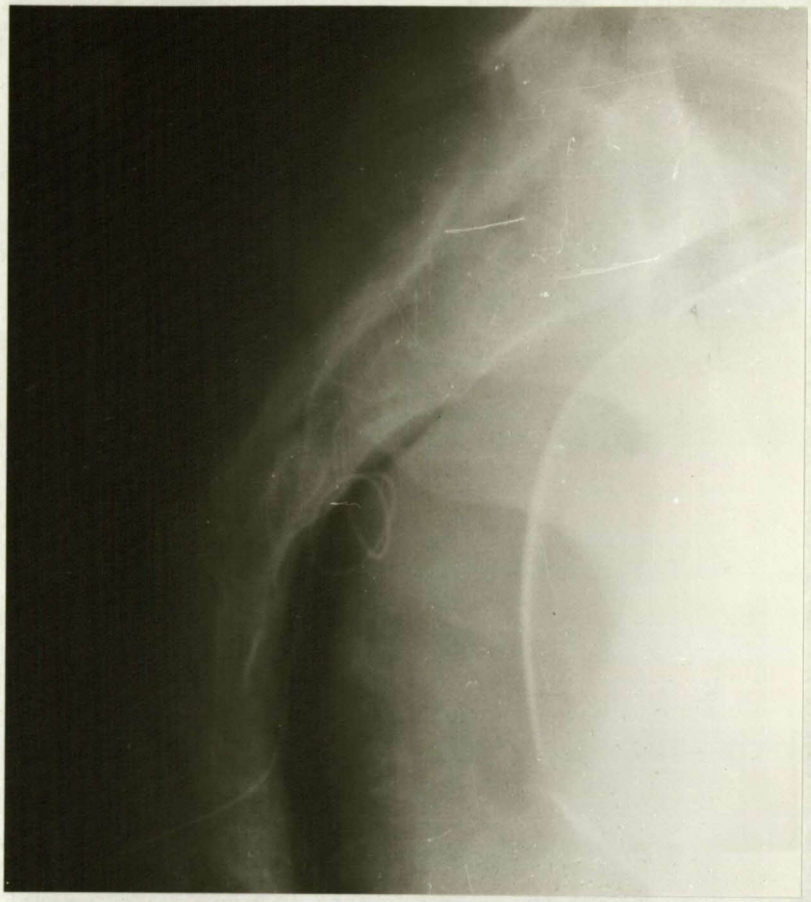


Figure 5,c

A Caudal epidurogram, showing the catheter curled up in front of the sacrum.

The low lumbar (L3, 4) epidurograms were used to determine the fate of the catheter after it was threaded for 10 to 15 cm. (See figure 6).

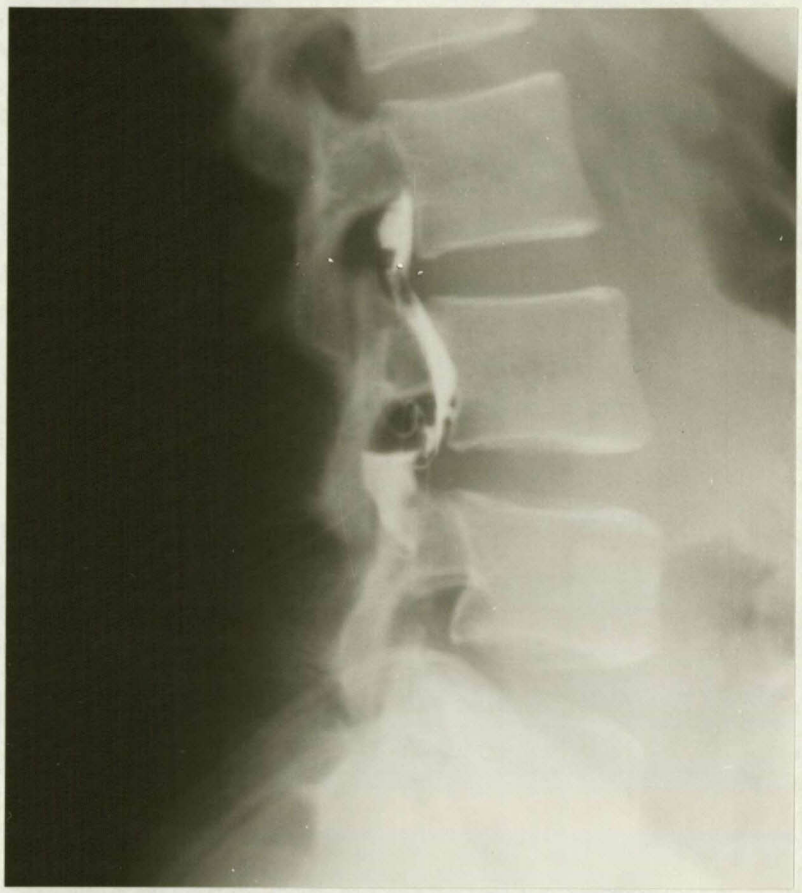


Figure 6

A low lumbar epidurogram. The catheter was inserted at L3. It is curled up at the level of insertion. Dye deposition occurs at the same level and one segment above, although the catheter was threaded for more than 10 cm.

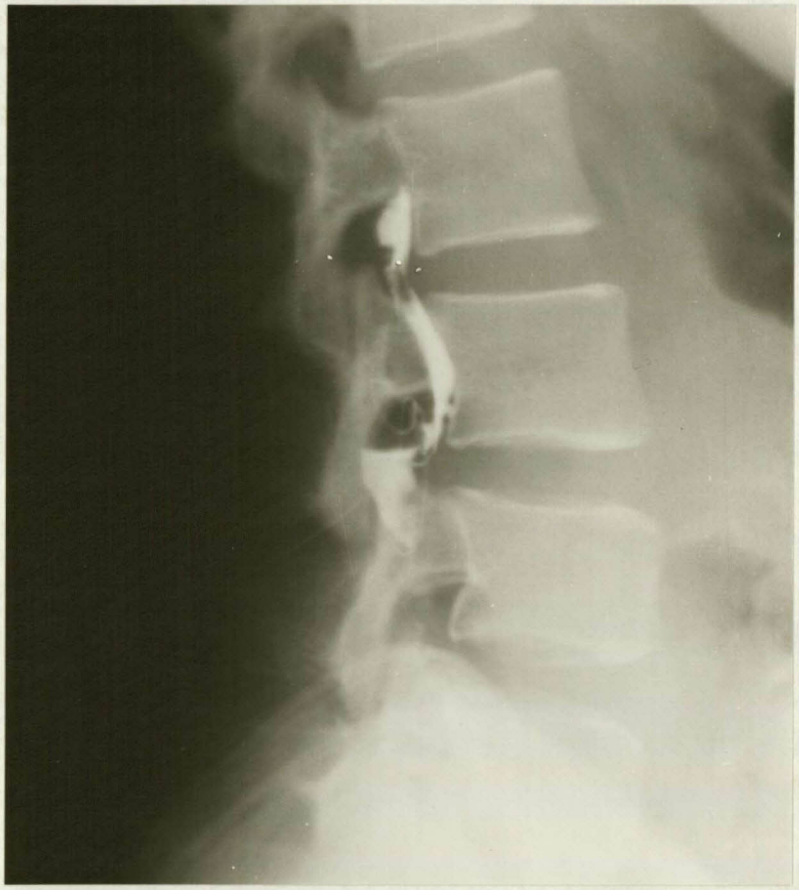


Figure 6

A low lumbar epidurogram. The catheter was inserted at L3. It is curled up at the level of insertion. Dye deposition occurs at the same level and one segment above, although the catheter was threaded for more than 10 cm.

The high lumbar epidurograms were used for a similar purpose. (See figure 7.)

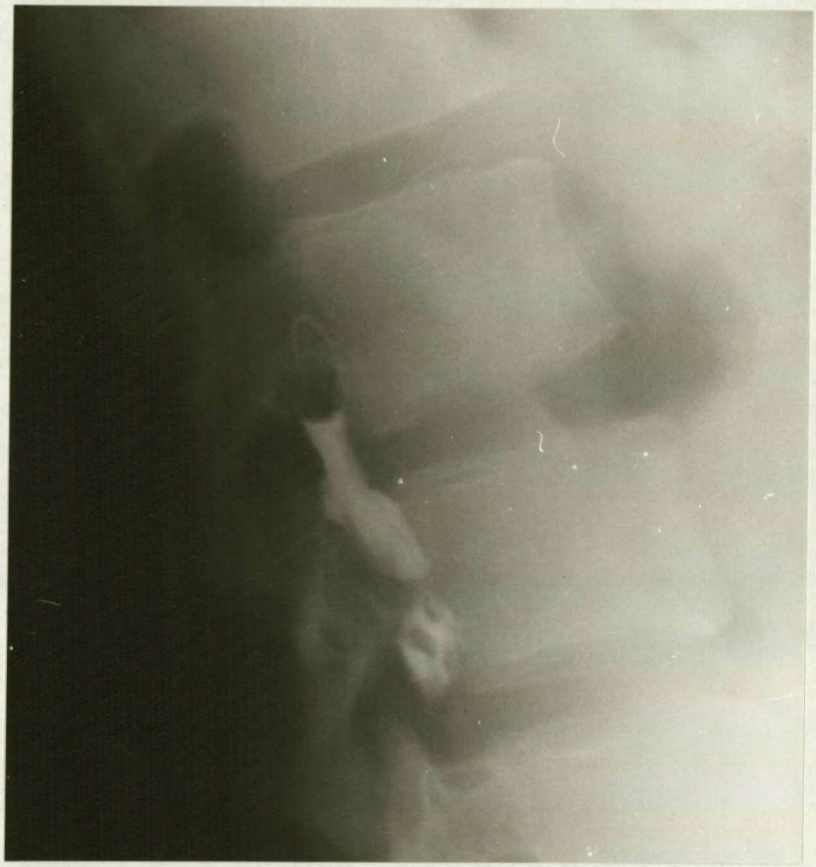


Figure 7

A high lumbar epidurogram. (L2) The catheter is curled up at the site of insertion. All the dye is deposited at the level of insertion. The catheter was threaded for 10 cm.

The thoracic epidurograms were done to show that a catheter inserted at T12, and threaded just beyond the tip of the needle, was the most accurate way of placing the catheter tip at the "ideal position".

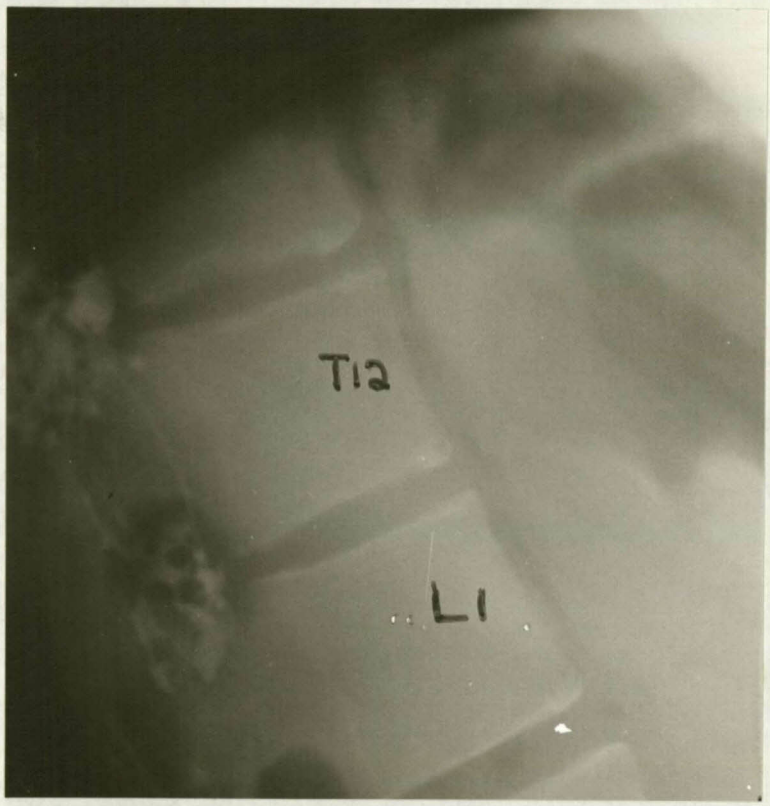


Figure 8

A thoracic epidurogram. The catheter was threaded for 3 cm. The catheter lies opposite T12. Dye deposition occurs opposite T12.

4. THE APGAR SCORE

The Apgar scores were performed independantly by both the candidate and the sister in charge of the delivery. Thereafter their seperate ratings were compared, discussed, and a final rating given. The Apgar score was taken at delivery, after 5 minutes and again after 10 minutes. For the purpose of statistical analysis, the 5 minute score was used.

5. THE CARDIOTOCOGRAPH

Every patient was monitored continuously with a cardiotocograph. (Hewlett-Packard, 8025A Recorder). The Standard technique was used employing a spiral scalp electrode and an intra-uterine catheter, flushed with a normal Saline solution. In all cases a normal cardiotocographic tracing was present for 20 to 30 minutes prior to the block. If changes occurred after the block, they could be assumed to be probably due to the effects of the block. (See Figures 9 a and b.)

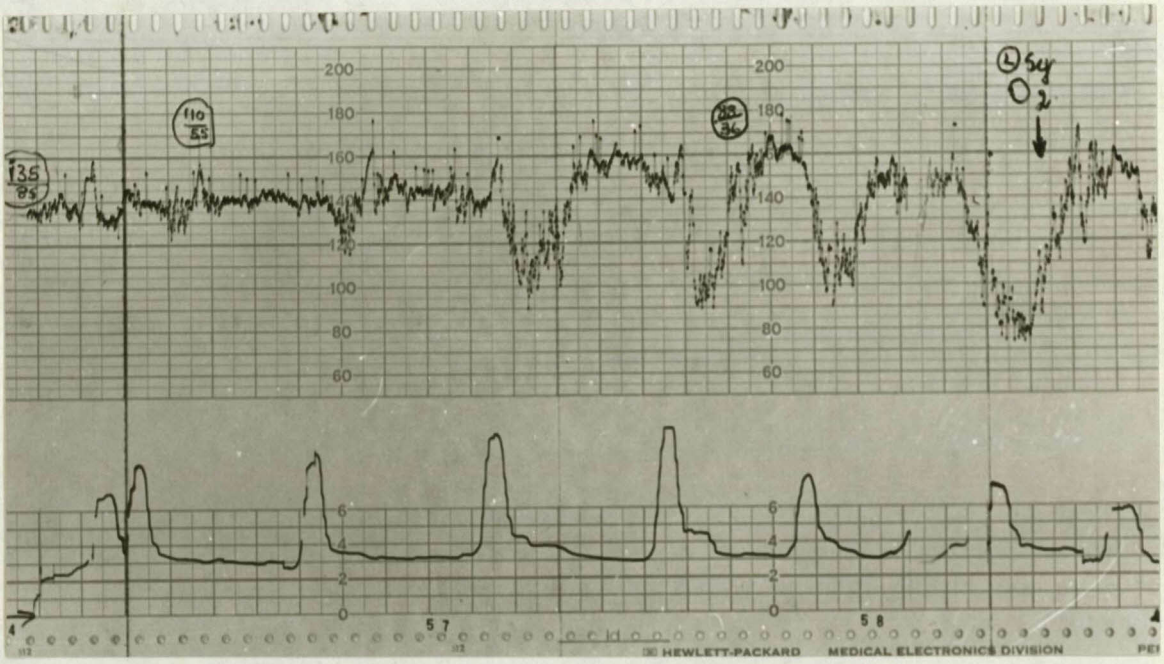


Figure 9,a

An example of late deceleration of the foetal heart occurring after Epidural Block.

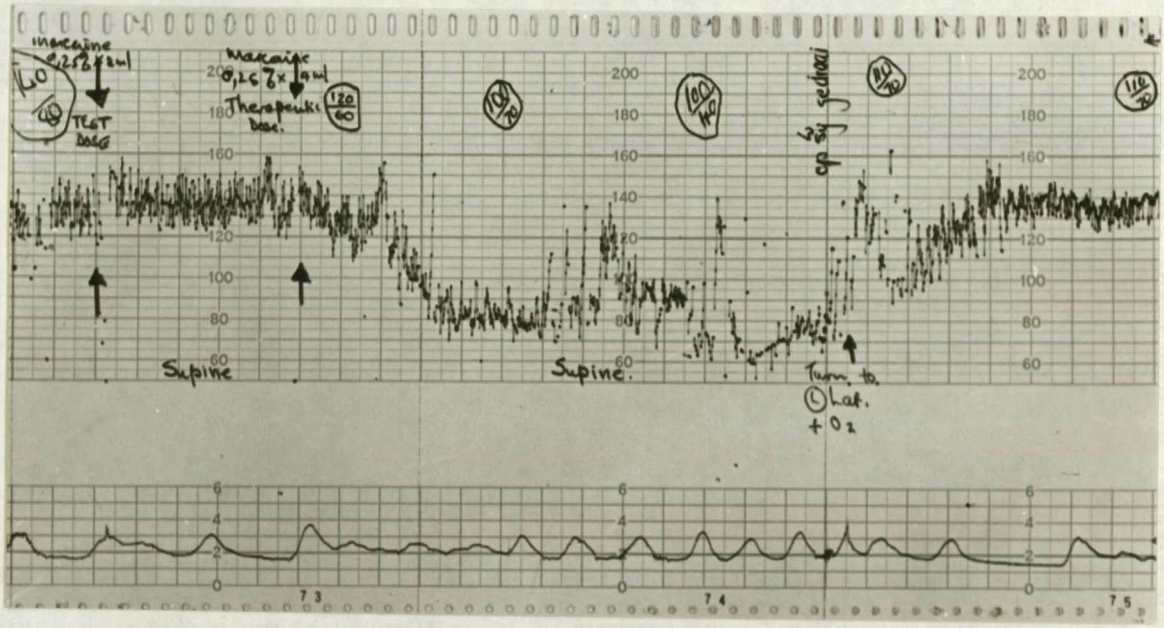


Figure 9,b

An example of severe foetal bradycardia occurring after Epidural Block.

The incidences of pathological foetal heart patterns occurring after the different epidural blocks, were recorded.

6. LABORATORY TECHNIQUES

A. BLOOD GAS ANALYSIS

Blood gas analysis was performed on all the mothers and neonates in the series.

Sample collection for maternal arterial blood gas analysis was done from the femoral artery. A 19-gauge needle was used. Blood was collected immediately after completion of the second stage. The needle was advanced until a free spill of arterial blood was obtained. One milliliter of blood was collected in a 2 ml plastic syringe, previously rinsed with Heparin.

Both umbilical artery and vein samples were collected in the same way as soon as the umbilical cord was born.

All 3 the mentioned specimens were taken to the laboratory without delay. A (the same) Radiometer ABL I Automatic Gas Analyser was used for all the specimens in the series. The apparatus performs auto-calibration with 2 buffer systems (high and low), at regular 2-hour intervals. Before the gas analyses were performed, the latest calibration figures were checked. Because of its simplicity of operation, the candidate performed all the analyses himself. The analyser was in good working order for the duration of the project. According to the calibration figures, the results were reliable. All three the mentioned specimens were subjected to analyses for pH, pCO_2, pO_2, Standard Bicarbonate and Base Excess. The results were recorded.

B. WHOLE BLOOD BUPIVACAINE DETERMINATIONS

Whole blood Bupivacaine determinations were performed on maternal and umbilical venous blood. The specimens were collected as soon as possible after the completion of the second stage. About 8 ml of each were collected in vacuum-sealed, Heparinized glass tubes. The samples were refrigerated at $4^{\circ}C$. The determinations were performed as soon as possible after collection.

The method of determination used, was based on that described by G.T. Tucker in 1970. Some modifications, developed in the local Pharmacology Laboratory, were incorporated to improve the quality and reliability of the method. All the determinations were performed by the candidate, after he had been trained in the technique by the resident laboratory staff. The work was performed under the constant supervision of the chief laboratory technologist.

a. The extraction of Bupivacaine from whole blood

Every extraction was done against two standard Bupivacaine solutions of 0,1 µg/ml and 0,5 µG/ml. These two standards, and the test specimen were then treated in the same way. To 2 ml of Heparinized whole blood in a B19 Centrifuge tube, 2 ml of distilled water was added. One ml of the Internal Standard Solution (Methadone), was added to every tube. Then 0,5 ml of a 5N NAOH solution plus 7 ml of distilled ether, were added. The

mixture was then shaken on a mechanical shaker for 30 minutes. During shaking the strong base (5N NAOH) displaces Bupivacaine from the aqueous phase to the organic phase (ether). The tubes were then centrifuged at 2 500 revolutions per minute for 5 minutes. The supernatant layer of ether (now containing the Bupivacaine) was transferred to a clean B19 Centrifuge tube containing 5 ml of a 0,1 N HCl solution. The new mixture was shaken for 15 minutes and centrifuged. During this step the Bupivacaine is displaced into aqueous phase. The ether was discarded, and to the remaining aqueous phase, 0,5 ml of 5N NAOH plus 7 ml of ether were added. After shaking (15 minutes) and centrifugation, the supernatant layer (organic phase containing ether and Bupivacaine) was transferred to a glass ampoule. The solution was then evaporated to dryness with nitrogen. During this step Bupivacaine is deposited on the side-walls of the ampoule. The deposited Bupivacaine was then dissolved with 20 to 30 microliters of Chloroform, using a 10 microliter syringe. When this solution was reduced to just less than 10 microliters, 2 microliters of it was injected through the septum of a Gas Chromatograph.

b. Gas Chromatography

A (the same) Varian 2 100 Gas Chromatograph (G.C.) was used for all the determinations. It contained a 6 ft. glass column ($^{1}/_{8}$ inch diameter).

The column packing consisted of 5% OV-17 on Chromosorb WAW - DMCS (80 - 100) (Lot No. 029-7). The column temperature was 210°C (isothermic), the injector temperature 290°C, and the Detector temperature 225°C. The attenuation was 8, and the range 10^{-11}. The carrier gas was Nitrogen, flowing at 50 ml/minute. Air flow was 50 ml/min and Hydrogen flow was 25 ml/minute. After every fourth injection, the G.C. was programmed as follows:

$210^{\circ}C \xrightarrow{10^{\circ}C/min} 270^{\circ}C$, for 30 minutes. The column was then cooled and kept isothermic at 210°C for the next 4 injections. This programming was necessary because after the fourth injection, certain peaks appeared which interfered with that of Bupivacaine. The retention time for the Internal Standard Solution was approximately 247 seconds, that of Bupivacaine was approximately 410 seconds.

A Pantos (Unicorder U-125 M, 1m Volt) recorder was attached to the G.C. An integrator (Hewlett-Packard, 3373B), was also attached to the same G.C. The latter was used in the preliminary stages of the series, but because the peak ratios were found to be less accurate than the peak heights, the integrator was only used to indicate the retention times.

c. Calculation of results

The concentration of Bupivacaine was calculated by

regression analysis, using a Model 10 Hewlett-Packard Programmable Calculator. In a previously constructed graph, the relationship of the ratio of Bupivacaine to Internal Standard (Peak Heights) against concentration was found to be a straight line. The concentrations were calculated from this graph and expressed in µG/ml. The Standard Deviation was indicated for every concentration calculated. The results were recorded.

7. STATISTICAL ANALYSIS

The statistical test used in this project was the Kruskal-Wallis One-Way Analysis of Variance. This test, first described by Kruskal and Wallis in 1952, is discussed in detail in a work by Siegel (Siegel, 1956). This is a non-parametric one-way analysis of variance. It was used in an attempt to avoid making the assumptions concerning normality and homogeneity of variance associated with the equivalent parametric test. Each time the test was applied, the necessary correction was made for the number of ties occurring in the 3 groups. (See Addendum B).

The test was applied to find out whether a statistically significant difference existed between the results obtained in each of the 3 patient groups. The following results of each of the 3 groups were tested:

a. The decrease in maternal blood pressure.
b. The quality of analgesia achieved.
c. The duration of the second stage.

d. The 5-minute Apgar score.

e. Maternal Arterial pH, pCO_2, pO_2 and Base Excess.

f. Umbilical Vein pH, pCO_2, pO_2 and Base Excess.

g. Umbilical Arterial pH, pCO_2, pO_2 and Base Excess.

h. Maternal Bupivacaine blood levels.

i. Neonatal Bupivacaine blood levels.

Other relevent results obtained that were recorded, included:

a. The Epidurograms.

b. The incidence of foetal heart abnormalities during epidural block.

c. The incidence of loss of tone of the pelvic floor musculature.

d. The incidence of malpositions of the foetal head at delivery.

e. The incidence of instrumental delivery.

f. The incidence of complications.

This latter group of results are all merely incidences, occurring in different percentages in 3 patient groups and were thus unsuitable for intricate statistical analysis.

8. COMPLICATIONS AND FOLLOW-UP

All patients were visited at least once in the first 24 to 48 hours after delivery. They were questioned and examined specifically with a view to the symptoms and signs of complications that may have arisen as a result

of epidural block. The complications were recorded. No long term follow-up of the mothers and or babies was possible on an organised basis.

CHAPTER IV

RESULTS

1. MATERNAL BLOOD PRESSURE

A. Table I illustrates the drop in blood pressure that occurred in the patients in Group A. (Standard Epidural Block). The lowest reading obtained in the 30- minute period prior to the block was taken as the initial reading. The lowest reading recorded in the first 30- minute period after the block, was taken as the final reading. The results are expressed in mm. Hg Mean Arterial Pressure (M.A.P.), where M.A.P. = (Systolic Blood Pressure) + (2 x Diastolic Blood Pressure).

TABLE I

Blood Pressure changes occurring in patients of Group A.

Case Number	Initial Reading in mm Hg M.A.P.	Final Reading in mm Hg M.A.P.	Drop in mm Hg M.A.P.
1	103	80	23
2	100	81	19
3	103	83	20
4	107	70	37
5	97	80	17
6	107	40	67
7	93	67	26
8	107	97	10
9	97	77	20
10	103	37	66
11	100	83	17
12	107	93	14
13	110	10	100
14	97	80	17
15	103	80	23
16	103	83	20
17	100	68	32
18	103	67	36
19	83	80	3
20	97	67	30
21	107	72	35
22	107	70	37
23	102	53	49
24	107	77	30
25	100	43	57

B. Table II illustrates the drop in blood pressure that occurred in the maternal blood pressure in the patients of Group B. (Segmental Epidural Block).

TABLE II

Blood Pressure changes occurring in patients in Group B.

Case Number	Initial Reading in mm Hg M.A.P.	Final Reading in mm Hg M.A.P.	Drop in mm Hg M.A.P.
1	100	77	23
2	110	95	15
3	105	93	12
4	93	73	20
5	107	50	57
6	107	80	27
7	103	100	3
8	80	77	3
9	83	70	13
10	105	87	18
11	103	93	10
12	110	90	20
13	100	80	20
14	107	93	14
15	105	85	20
16	100	80	20
17	105	77	28
18	100	90	10
19	107	92	15
20	107	72	35
21	92	87	5
22	97	80	17
23	100	87	13
24	113	87	26
25	97	90	7

C. Table III illustrates the drop in blood pressure that occurred in maternal blood pressure in patient Group C. (Modified Segmental Block).

TABLE III

Blood pressure changes occurring in patients in Group C,

Case Number	Initial Reading in mm Hg M.A.P.	Final Reading in mm Hg M.A.P.	Drop in mm Hg M.A.P.
1	83	83	0
2	110	90	20
3	107	103	4
4	73	67	6
5	73	65	8
6	107	87	20
7	103	88	15
8	73	73	0
9	103	103	0
10	100	70	30
11	93	87	6
12	110	98	12
13	110	103	7
14	100	70	30
15	110	95	15
16	103	87	16
17	103	87	16
18	103	83	20
19	93	82	11
20	102	85	17
21	97	97	0
22	100	100	0
23	97	70	27
24	103	73	30
25	97	92	5

The average drop in blood pressure occurring in each patient group is expressed in Table IV.

TABLE IV

The Average drop in blood pressure occurring in each of the 3 patient groups.

Patient Group	Average drop in blood pressure in mm Hg M.A.P.
A	32,20
B	18,04
C	12,60

It is therefore obvious that the worst drop in blood pressure was associated with the technique used in patient group A, i.e. the Standard Epidural Block. The least drop in blood pressure occurred in Group C. (Modified Segmental Block).

The data presented in Tables I, II and III, were then subjected to the Kruskal-Wallis Test. (See Chapter III). The 3 groups were found to differ statistically significantly from one another, at a Significance Level of 0,01. This confirms the impression gained from Table IV. This statistical significance existed between each of the 3 groups.

2. QUALITY OF ANALGESIA

The quality of analgesia achieved in each patient in the 3 groups, is expressed in Table V. The quality of analgesia is expressed in Grades O to III, as explained in detail in Chapter III.

TABLE V

The Quality of Analgesia achieved by the 3 different epidural techniques.

Case Number	Group A	Group B	Group C
1	III	O	III
2	III	II	III
3	III	III	II
4	III	II	I
5	III	II	II
6	III	I	II
7	III	O	II
8	III	I	II
9	III	II	III
10	III	III	III
11	III	II	III
12	III	III	III
13	III	II	III
14	III	II	I
15	III	II	III
16	III	II	II
17	II	II	III
18	III	II	III
19	II	III	III
20	III	I	III
21	II	III	III
22	III	III	II
23	III	II	III
24	I	II	III
25	III	O	II

We then awarded points for each Grade of analgesia in an attempt to numerically express the efficacy of each type of block. Grade 0 was awarded 0 points, Grade I, 1 point etc. Table VI illustrates this.

TABLE VI

The efficacy of each block expressed numerically.

Group	Effectivity of block expressed numerically
A	70 Points
B	47 Points
C	63 Points

This shows that the Standard Block was the most effective in terms of analgesia, followed respectively by the Modified Segmental and the Segmental Blocks.

When this information was subjected to the Kruskal-Wallis Test, the three blocks differed statistically at a significance level of 0,01. Upon separate analysis of Groups A and C alone, no statistically significant difference was found to exist between these two groups. Therefore, purely on statistical grounds the patients in Groups A and C experienced comparible pain relief, while those in Group B had statistically poorer pain relief.

3. DURATION OF THE SECOND STAGE

The duration of the second stage in each patient group is shown in Tabel VII, below. The time of the second stage was measured to the nearest 5 minutes, because of the inaccuracy in the exact diagnosis of the onset thereof.

TABLE VIII

The duration of the second stage in the 3 patient groups, expressed in minutes.

Case Number	Group A	Group B	Group C
1	25	30	30
2	35	20	30
3	45	20	10
4	35	15	20
5	35	30	25
6	35	20	25
7	30	30	40
8	20	35	30
9	35	40	15
10	30	20	30
11	20	20	5
12	30	20	20
13	20	35	45
14	30	15	40
15	25	25	20
16	20	20	20
17	15	45	15
18	30	15	30
19	30	50	15
20	35	20	10
21	30	20	25
22	40	15	10
23	45	40	15
24	40	20	40
25	35	20	30

The average duration of the second stage in each patient group is expressed in Table VIII, below.

TABLE VIII

Average duration of the Second Stage in minutes.

Patient Group	Average Duration of Second Stage in minutes
Group A	30.8
Group B	25.6
Group C	23.8

It can be seen that the average duration of the second stage was longest in the patients in Group A, followed by Group B and Group C, in that order. However, when all the data in Table VII were subjected to the Kruskal-Wallis test, the difference in the duration of the second stages between the 3 groups did not differ statistically significantly.

4. APGAR SCORE AT 5 MINUTES

The Apgar scores at 5 minutes of the neonates of the 3 different groups are shown in Table IX.

TABLE IX

The 5- minute Apgar Scores of the Neonates of the 3 patient groups.

Case Number	Group A	Group B	Group C
1	5	5	8
2	9	9	9
3	5	5	8
4	10	10	8
5	10	10	6
6	10	10	8
7	10	10	10
8	10	10	10
9	9	9	8
10	10	10	8
11	8	8	10
12	10	10	10
13	8	8	10
14	10	10	10
15	6	6	9
16	4	4	10
17	6	6	9
18	8	8	6
19	10	10	10
20	10	10	10
21	10	10	10
22	10	10	10
23	10	10	10
24	10	10	8
25	10	10	10

The neonates were then divided into those with an Apgar score above 7/10 and those with an Apgar score less than 7/10. This information is given in Table X.

TABLE X

The 5- minute Apgar Scores of the 3 patients groups.

	Apgar Score Above 7/10	Apgar Score below 7/10
GROUP A	20/25	5/25
GROUP B	20/25	5/25
GROUP C	23/25	2/25

From Table X it would appear that the neonates from Group C (Modified Segmental Block), had on the whole a better Apgar rating. However, when all the data in Table IX were subjected to the Kruskal-Wallis test, there was no statistical difference between the 5- minute Apgar ratings of the neonates born from the 3 patient groups.

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5. a. MATERNAL ARTERIAL pH VALUES

Maternal arterial pH values obtained at delivery are expressed in Table XI, below.

TABLE XI

The maternal Arterial pH values of the 3 patient groups.

Case Number	Group A	Group B	Group C
1.	7,29	7,40	7,42
2	7,40	7,43	7,33
3	7,39	7,35	7,33
4	7,42	7,41	7,36
5	7,40	7,38	7,41
6	7,43	7,44	7,44
7	7,47	7,34	7,44
8	7,38	7,41	7,39
9	7,40	7,40	7,45
10	7,43	7,43	7,38
11	7,45	7,41	7,41
12	7,40	7,33	7,41
13	7,30	7,36	7,39
14	7,41	7,42	7,41
15	7,30	7,47	7,41
16	7,45	7,47	7,44
17	7,37	7,40	7,33
18	7,41	7,38	7,39
19	7,37	7,44	7,36
20	7,43	7,38	7,41
21	7,33	7,30	7,44
22	7,43	7,36	7,40
23	7,49	7,33	7,41
24	7,39	7,24	7,39
25	7,42	7,38	7,30

When one studies the contents of Table XXIII, it can be seen that the average arterial pH values of the mothers in the 3 groups were the same.

All the data in this table were nevertheless subjected to the Kruskal-Wallis test. It was found that no statistically significant difference existed between the maternal pH values of the patients in the 3 groups.

5. b. UMBILICAL VEIN pH VALUES

The pH values of the umbilical venous blood obtained at delivery, are given in Table XII.

TABLE XII

Umbilical Vein pH values of the neonates of the 3 different patient groups.

Patient Number	Group A	Group B	Group C
1	7,19	7,30	7,35
2	7,32	7,26	7,35
3	7,32	7,07	7,19
4	7,30	7,36	7,27
5	7,30	7,26	7,24
6	7,28	7,39	7,35
7	7,37	7,24	7,35
8	7,20	7,23	7,24
9	7,37	7,13	7,09
10	7,32	7,27	7,32
11	7,09	7,29	7,33
12	7,31	7,33	7,36
13	7,15	7,22	7,37
14	7,30	7,38	7,27
15	7,05	7,36	7,28
16	7,22	7,41	7,22
17	7,27	7,34	7,32
18	7,18	7,30	7,27
19	7,36	7,38	7,28
20	7,33	7,31	7,40
21	7,27	7,27	7,34
22	7,29	7,27	7,38
23	7,29	7,16	7,25
24	7,27	7,20	7,27
25	7,28	7,27	7,26

The averages of these values are given in Table XXIII. After subjecting all the data in Table XII to the Kruskal-Wallis Test, it was found that no statistically significant difference existed between the umbilical vein pH values of the 3 groups.

5. c. UMBILICAL ARTERY pH VALUES

Table XIII illustrates the pH values of the umbilical arterial blood collected from the neonates of the 3 different groups.

TABLE XIII

The Umbilical Arterial pH values of the neonates of the 3 patient groups.

Case Number	Group A	Group B	Group C
1	7,10	7,23	7,12
2	7,08	7,19	7,15
3	7,22	7,07	7.07
4	7,22	7,29	7,20
5	7,29	7,18	7,24
6	7,23	7,29	7,25
7	7,23	7,20	7,30
8	7,15	7,18	7,19
9	7,19	7,09	7,06
10	7,24	7,22	7,21
11	7,09	7,24	7,25
12	7,23	7,25	7,34
13	7,02	7,17	7,27
14	7,23	7,30	7,20
15	6,99	7,31	7,24
16	7,20	7,37	7,04
17	7,19	7,19	7,27
18	7,11	7,09	7,31
19	7,29	7,24	7,20
20	7,19	7,26	7,28
21	7,19	7,26	7,30
22	7,21	7,23	7,31
23	7,25	7,14	7,22
24	7,23	7,19	7,19
25	7,23	7,22	7,16

When looking at Table XXIII it is obvious that there was some difference between the pH values of the umbilical arteries of the neonates in the different groups. On subjecting all these data to the Kruskal-Wallis test, no statistically significant difference was found to exist between the values of the 3 different groups.

6. a. MATERNAL ARTERIAL pCO2 VALUES

The arterial pCO2 values of the maternal blood taken at delivery, are shown in Table XIV. The results are expressed in mm Hg.

TABLE XIV

The maternal arterial pCO2 values in mm Hg.

Case Number	Group A	Group B	Group C
1	30,4	23,0	23,8
2	23,4	27,8	29,5
3	32,9	21,5	30,5
4	23,7	28,6	26,9
5	28,1	28,1	25,2
6	30,1	26,1	27,2
7	24,0	21,4	19,7
8	27,0	23,6	20,7
9	32,0	27,7	23,2
10	26,6	19,5	21,5
11	32,0	26,6	30,4
12	24,4	26,7	28,1
13	22,1	24,7	27,2
14	28,0	25,5	23,1
15	36,0	25,3	20,8
16	27,2	21,7	23,3
17	26,9	26,8	33,9
18	22,4	28,8	26,8
19	25,5	22,4	27,2
20	26,9	23,8	31,4
21	27,3	25,0	21,6
22	22,1	23,2	27,1
23	18,4	32,0	26,0
24	27,5	43,8	24,3
25	26,6	27,8	29,0

The average values for the 3 groups are given in Table XXIII. On statistical Analysis with the Kruskal-Wallis Test, no significant difference was found to exist between the maternal arterial pCO2 values of the 3 different groups.

6. b. UMBILICAL VEIN pCO2 VALUES

The Umbilical Vein pCO2 values of the neonates of the 3 different groups, are given in Table XV, below.

TABLE XV

The Umbilical Vein pCO2 values in mm Hg.

Case Number	Group A	Group B	Group C
1	41,4	32,5	32,3
2	42,0	49,6	32,0
3	41,8	58,8	46,3
4	40,9	33,9	37,2
5	44,1	38,9	45,3
6	42,1	32,4	38,0
7	36,0	42,6	32,9
8	58,5	55,0	42,4
9	37,2	56,2	62,7
10	43,1	43,4	32,8
11	64,0	48,2	40,0
12	30,3	39,6	37,3
13	31,5	43,7	33,7
14	32,5	33,8	38,9
15	70,6	38,6	40,8
16	56,7	28,9	39,1
17	42,2	37,2	41,7
18	39,5	38,6	44,5
19	31,5	37,8	43,5
20	34,5	38,1	32,4
21	33,1	39,0	32,2
22	38,3	33,1	34,2
23	43,8	50,6	42,3
24	38,2	40,0	43,5
25	41,6	34,6	41,0

The average values of the 3 groups are given in Table XXIII. On statistical Analysis with the Kruskal-Wallis Test, these values did not differ statistically significantly.

6. c. UMBILICAL ARTERY pCO2 VALUES

The Umbilical arterial pCO2 values obtained from the neonates of the 3 groups, are shown in Table XVI.

TABLE XVI

The Umbilical Arterial pCO2 values in mm Hg.

Case Number	Group A	Group B	Group C
1	58,3	45,1	63,8
2	46,0	56,1	65,7
3	62,5	57,0	67,5
4	52,2	44,2	48,0
5	43,1	49,5	45,0
6	53,2	40,8	42,0
7	45,4	49,0	40,2
8	65,1	64,0	48,1
9	58,8	63,6	78,8
10	48,3	50,1	42,8
11	83,0	53,0	47,7
12	45,7	51,8	39,4
13	51,4	80,4	42,7
14	56,9	44,0	44,9
15	92,0	46,7	51,5
16	64,1	33,8	51,9
17	57,9	63,8	41,0
18	57,6	78,6	39,3
19	35,4	23,1	56,1
20	56,9	38,6	52,4
21	45,5	57,5	37,7
22	47,4	49,3	44,8
23	47,8	59,6	49,8
24	59,8	49,6	57,4
25	63,4	45,1	60,0

When studying Table XXIII, there seems to be a difference between the average values in the 3 patient groups. This difference weighs in favour of the neonates of Group C. However, upon statistical testing with the Kruskar-Wallis Test, no

significant difference was found to exist between the 3 groups. This was true even after correction for ties was performed.

7. a. MATERNAL ARTERIAL pO2 VALUES

The maternal arterial pO2 values obtained, are illustrated in Table XVII, for the 3 patient groups. The results are expressed in mm Hg.

TABLE XVII

The Maternal Arterial pO2 values in mm Hg.

Case Number	Group A	Group B	Group C
1	101,0	90,8	129,2
2	104,3	108,0	113,9
3	60,8	118,4	85,5
4	82,8	98,5	98,8
5	88,9	95,2	85,1
6	92,0	91,6	84,7
7	95,0	121,5	126,5
8	101,4	100,7	128,1
9	115,8	130,7	102,0
10	107,7	85,5	98,2
11	93,5	91,4	126,7
12	102,5	103,4	102,6
13	139,8	134,3	87,1
14	99,8	97,1	94,3
15	75,0	84,7	61,5
16	114,8	97,7	124,6
17	91,7	87,9	78,8
18	112,0	78,0	82,3
19	93,7	101,0	129,5
20	105,6	94,2	75,0
21	86,5	92,0	124,4
22	88,7	78,1	88,3
23	82,0	89,6	96,7
24	79,6	84,6	93,7
25	108,2	92,8	86,0

From Table XXIII it is clear that some difference exists between the 3 patient groups, once again in favour of Group C. However, upon statistical analysis with the Kruskal-Wallis test, using all the individual values given in Table XVII, no significant difference was found to exist between the maternal pO2 values of the 3 patient groups. A further separate test between Groups B and C was carried out, but there was once again found to be no significant difference between the maternal arterial pO2 values of these 2 groups.

7. b. UMBILICAL VEIN pO2 VALUES

Table XVIII illustrates the umbilical vein pO2 values of the neonates of the 3 patient groups. The results are expressed in mm Hg.

TABLE XVIII

The Umbilical Vein pO2 values in mm Hg.

Case Number	Group A	Group B	Group C
1	32,9	42,9	37,6
2	17,0	20,5	33,3
3	28,5	12,4	29,6
4	30,4	31,4	76,8
5	22,3	85,0	52,3
6	23,3	33,2	30,0
7	34,4	21,6	105,7
8	18,0	23,0	107,1
9	38,0	22,1	11,6
10	26,0	32,6	31,3
11	15,6	18,1	40,3
12	36,7	48,0	31,5
13	32,9	27,0	38,1
14	27,5	35,6	25,0
15	21,8	29,1	71,8
16	15,0	34,5	42,0
17	19,4	29,2	74,5
18	29,0	43,9	46,0
19	37,1	28,7	27,6
20	31,5	20,5	28,8
21	34,8	38,0	45,8
22	35,9	36,6	30,6
23	20,6	27,0	30,5
24	34,9	24,0	24,8
25	27,6	24,6	50,0

From Table XXIII it is clear that some difference exists between the values of the 3 groups. Upon analysis with the Kruskal-Wallis Test, there was found to exist a statistically significant difference between the 3 patient groups. Since the pO2 was highest in the neonates in Group C, this points at a difference in favour of the Modified Segmental Block, when compared with the other 2

techniques. This difference was present at a significance level of 0,001, both before and after correction for ties was performed.

7. c. UMBILICAL ARTERIAL pO2 VALUES

Table XIX below illustrates the Umbilical arterial pO2 values of the neonates of the 3 patient groups. The results are expressed in mm Hg.

TABLE XIX

The Umbilical Arterial pO2 values in mm Hg.

Case Number	Group A	Group B	Group C
1	21,5	25,3	17,8
2	13,0	14,1	6,8
3	11,0	11,0	17,4
4	23,7	20,4	16,5
5	21,8	60,7	24,3
6	18,5	21,6	20,5
7	19,5	20,1	30,3
8	17,0	13,0	26,0
9	14,7	17,4	6,5
10	18,8	24,0	24,3
11	7,0	17,7	22,1
12	22,4	21,8	30,4
13	16,1	19,4	26,7
14	15,8	23,1	18,3
15	10,8	22,9	15,8
16	11,4	27,2	32,3
17	19,0	14,4	30,2
18	17,0	22,4	22,5
19	22,3	46,5	13,4
20	12,2	21,2	18,3
21	24,4	18,3	31,7
22	32,4	20,9	17,7
23	13,2	20,6	18,5
24	19,2	14,9	15,4
25	13,3	15,1	11,0

Although some difference was present between the average values of the 3 groups (See Table XXIII), there was no statistically significant difference when the Kruskal-Wallis Test was applied. The latter was applied in this case separately to compare Group B and C alone, but even then no statistically significant difference was found to exist.

8. a. MATERNAL ARTERIAL BASE EXCESS VALUES

Maternal arterial Base Excess values are shown in Table XX. The results are expressed in millimols per liter.

TABLE XX

The Maternal Arterial Base Excess Values in millimols per liter.

Case Number	Group A	Group B	Group C
1	-11,1	- 8,9	- 7,4
2	- 7,6	-13,8	- 9,2
3	- 4,3	-10,0	- 8,9
4	- 7,7	- 5,5	- 8,8
5	- 5,9	- 5,6	- 6,8
6	- 2,0	- 5,1	- 5,6
7	- 4,0	-13,7	- 9,3
8	- 7,6	- 8,9	-12,1
9	- 4,2	- 9,8	- 6,8
10	- 5,1	- 9,1	-12,1
11	- 1,0	- 6,6	- 4,2
12	- 8,1	-10,7	- 5,7
13	-14,4	-10,1	- 7,5
14	- 5,0	- 6,2	- 8,3
15	- 6,0	- 5,0	- 9,8
16	- 4,4	- 6,3	- 6,5
17	- 8,8	- 7,2	- 7,2
18	-13,5	- 7,2	- 7,2
19	- 9,4	- 6,8	- 8,8
20	- 5,3	- 9,8	- 3,7
21	-10,2	-13,0	- 7,4
22	- 7,6	-11,5	- 6,8
23	- 6,0	- 8,3	- 6,7
24	- 6,9	- 8,7	- 8,5
25	- 6,9	- 7,7	- 2,0

A statistically significant difference was found to exist between the 3 Groups, in favour of the mothers in Group A (Standard Epidural Block). This difference was present at a significance level of 0,001.

8. b. UMBILICAL VEIN BASE EXCESS VALUES

The umbilical vein Base Excess values of the neonates of the 3 patient Groups are shown in Table XXI. The results are expressed in millimols per liter

TABLE XXI

The Umbilical Vein Base Excess values in Millimols per liter.

Case Number	Group A	Group B	Group C
1	-12,3	- 9,6	- 7,0
2	- 4,0	- 5,9	- 7,0
3	- 4,9	-16,5	-10,9
4	- 6,5	- 5,5	- 9,4
5	- 5,4	- 9,3	- 9,5
6	- 6,5	- 4,5	- 3,9
7	- 3,9	- 9,7	- 6,8
8	- 6,7	- 6,0	- 8,2
9	- 3,6	-11,9	-12,5
10	- 4,4	- 7,0	- 8,3
11	- 8,0	- 4,1	- 5,1
12	-10,2	- 5,0	- 4,2
13	-17,7	-10,3	-12,2
14	- 9,6	- 3,5	- 9,1
15	-11,6	- 3,3	- 7,4
16	- 6,1	- 4,7	-11,4
17	- 7,7	- 5,3	- 3,9
18	-12,8	- 7,0	- 6,6
19	- 6,8	- 2,6	- 6,4
20	- 7,0	- 6,9	- 4,9
21	-11,1	- 8,0	- 7,4
22	- 7,9	-11,2	- 4,1
23	- 5,9	-11,9	- 8,9
24	- 9,0	- 9,0	- 6,8
25	- 7,5	- 6,7	- 8,0

Upon subjecting these data to the Kruskal-Wallis Test, no statistically significant difference was found to exist between the umbilical vein Base Excess Values of the 3 patient groups.

8. c. UMBILICAL ARTERY BASE EXCESS VALUES

Table XXII illustrates the Base Excess Values that were present in the umbilical arteries of the neonates of the 3 patient Groups. The results are expressed in millimols per liter.

TABLE XXII

The Umbilical Artery Base Excess values in millimols per liter.

Case Number	Group A	Group B	Group C
1	-12,7	- 9,2	- 9,7
2	-20,0	- 8,0	- 8,4
3	- 4,3	-15,9	- 9,0
4	- 7,2	- 5,4	- 9,9
5	- 6,0	-10,4	- 9,0
6	- 7,4	- 6,9	- 9,0
7	- 9,0	- 9,7	- 9,0
8	- 5,6	- 6,0	-10,5
9	- 7,5	-12,3	-11,1
10	- 7,3	- 8,0	-10,8
11	-10,0	- 5,5	- 6,6
12	- 9,0	- 3,6	- 4,3
13	-19,0	-12,0	-12,5
14	- 4,9	- 5,2	- 9,8
15	-13,0	- 3,5	- 6,5
16	- 5,1	- 4,9	-14,1
17	- 7,6	- 5,6	- 4,8
18	-14,4	- 5,7	- 6,3
19	- 9,0	- 7,7	- 7,4
20	- 8,1	- 9,6	- 6,0
21	-11,0	- 3,2	- 7,5
22	-10,0	- 7,8	- 3,8
23	- 6,8	-10,5	- 8,1
24	- 4,2	- 9,5	- 7,6
25	- 2,9	- 6,4	- 9,0

These values were <u>not statistically significantly different</u> when subjected to the Kruskal-Wallis Test.

9. AVERAGE VALUES

We have tried to summarize the data of the blood gas studies presented above. We calculated the average values of each patient group of 25 patients, and they are presented in Table XXXIII, below.

TABLE XXIII

Average Values of the different parameters in the 3 patient groups.

Parameter	Vessel	Group A	Group B	Group C
a) pH	Maternal Artery	7,39	7,39	7,39
	Umbilical Vein	7,27	7,28	7,29
	Umbilical Artery	7,19	7,22	7,21
b) pCO2 (mg Hg)	Maternal Artery	26,85	26,05	25,94
	Umbilical Vein	42,22	41,00	39,48
	Umbilical Artery	55,91	51,78	50,34
c) pO2 (mm Hg)	Maternal Artery	97,04	97,91	100,14
	Umbilical Vein	27,34	31,58	44,90
	Umbilical Artery	17,44	22,16	20,57
d) Base Excess (milli-mols/ liter)	Maternal Artery	-6,92	-8,62	-7,49
	Umbilical Vein	-7,88	-7,42	-7,59
	Umbilical Artery	-8,88	-7,70	-8,43

10. WHOLE BLOOD BUPIVACAINE LEVELS

A. GROUP A

The whole blood Bupivacaine Levels found in the Maternal and Umbilical Veins at delivery, in the patient Group A, are shown in Table XXIV, below. The Umbilical Vein/ Maternal vein (UV/M ratio is given in the third column of each patient. The Bupivacaine levels are expressed in µG/ml, while the UV/M ratios are expressed in percentage.

TABLE XXIV

Maternal and Umbilical Vein Bupivacaine levels of Group A patients in µG/ml. The Umbilical Vein/Maternal ratios are shown as a percentage in the third column.

Case Number	Maternal Vein	Umbilical Vein	Ratio UV/m
1	0.171 (± 0,015)	0.161 (±0.003)	(94%)
2	0.184 (± 0,010)	0.029 (±0.002)	(16%)
3	0.324 (± 0.016)	0.092 (±0.005)	(28%)
4	0.069 (± 0.006)	0.004 (±0.001)	(6%)
5	0.081 (± 0.006)	0.012 (±0.002)	(15%)
6	0.247 (± 0.083)	0.032 (±0.027)	(13%)
7	0.227 (± 0.015)	0.032 (±0.003)	(14%)
8	0.219 (± 0.023)	0.012 (±0.003)	(5%)
9	0.206 (± 0.022)	0.041 (±0.005)	(20%)
10	0.068 (± 0.018)	0.014 (±0.003)	(21%)
11	0.169 (± 0.038)	0.004 (±0.006)	(2%)
12	0.205 (± 0.044)	0.057 (±0.016)	(6%)
13	0.444 (± 0.090)	0.100 (±0.024)	(23%)
14	0.097 (± 0.049)	0.048 (±0.035)	(49%)
15	0.393 (± 0.040)	0.182 (±0.019)	(46%)
16	0.090 (± 0.021)	0.011 (±0.004)	(12%)
17	0.091 (± 0.021)	0.005 (±0.005)	(5%)
18	0.241 (± 0.241)	0.069 (±0.017)	(29%)
19	0.163 (± 0.033)	0.052 (±0.014)	(32%)
20	0.212 (± 0.041	0.011 (±0.004)	(5%)
21	0.091 (± 0.016)	0.029 (±0.006)	(32%)
22	0.119 (± 0.021)	0.015 (±0.013)	(13%)
23	0.084 (± 0.013)	0.005 (±0.003)	(6%)
24	0.108 (± 0.016)	0.045 (±0.004)	(42%)
25	0.126 (± 0.018)	0.031 (±0.001)	(25%)

B. GROUP B

The whole blood Bupivacaine levels found in the Maternal and Umbilical Veins at delivery in the patients of Group B, are shown below in Table XXV. The units used are the same as in Group A, above.

TABLE XXV

Maternal and Umbilical Vein Bupivacaine levels of Group B patients in UG/ml. The UV/M ratios are expressed as percentages in the third column.

Case Number	Maternal Vein	Umbilical Vein	Ratio UV/m
1	0.120 (± 0.020)	0.052 (± 0.007)	(43%)
2	0.085 (± 0.013)	0.044 (± 0.005)	(52%)
3	0.146 (± 0.025)	0.056 (± 0.007)	(38%)
4	0.088 (± 0.014)	0.076 (± 0.011)	(86%)
5	0.066 (± 0.009)	0.046 (± 0.005)	(70%)
6	0.108 (± 0.011)	0.093 (± 0.009)	(86%)
7	0.220 (± 0.020)	0.053 (± 0.006)	(24%)
8	0.047 (± 0.006)	0.006 (± 0.002)	(13%)
9	0.086 (± 0.009)	0.006 (± 0.001)	(7%)
10	0.049 (± 0.006)	0.008 (± 0.002)	(16%)
11	0.184 (± 0.039)	0.111 (± 0.010)	(60%)
12	0.196 (± 0.035)	0.068 (± 0.021)	(35%)
13	0.173 (± 0.065)	0.129 (± 0.047)	(75%)
14	0.142 (± 0.040)	0.052 (± 0.140)	(37%)
15	0.132 (± 0.048)	0.107 (± 0.037)	(81%)
16	0.081 (± 0.010)	0.015 (± 0.003)	(19%)
17	0.118 (± 0.013)	0.055 (± 0.007)	(47%)
18	0.098 (± 0.011)	0.012 (± 0.002)	(12%)
19	0.060 (± 0.007)	0.005 (± 0.002)	(8%)
20	0.077 (± 0.009)	0.054 (± 0.007)	(70%)
21	0.042 (± 0.005)	0.029 (± 0.003)	(69%)
22	0.034 (± 0.004)	0.023 (± 0.003)	(67%)
23	0.050 (± 0.006)	0.026 (± 0.003)	(52%)
24	0.045 (± 0.005)	0.016 (± 0.002)	(36%)
25	0.107 (± 0.013)	0.035 (± 0.004)	(33%)

C. GROUP C

The whole blood Bupivacaine levels found in maternal and umbilical veins at birth in the patients of Group C, are shown in Table XXVI, below. The units used for expression, are the same as for Groups A and B above.

TABLE XXVI

The Maternal and Umbilical Vein Bupivacaine levels of the patient Group C, expressed in µG/ml. The UV/M ratios are expressed as percentages in the third column.

Case Number	Maternal Vein	Umbilical Vein	Ratio UV/M
1	0.076 (± 0.019)	0.014 (± 0.006)	(18%)
2	0.254 (± 0.117)	0.039 (± 0.012)	(15%)
3	0.197 (± 0.015)	0.022 (± 0.018)	(11%)
4	0.093 (± 0.038)	0.058 (± 0.015)	(62%)
5	0.101 (± 0.038)	0.013 (± 0.036)	(13%)
6	0.061 (± 0.042)	0.056 (± 0.012)	(92%)
7	0.434 (± 0.055)	0.069 (± 0.021)	(16%)
8	0.101 (± 0.023)	0.063 (± 0.011)	(62%)
9	Undetectable	Undetectable	-
10	0.129 (± 0.019)	0.063 (± 0.017)	(49%)
11	0.067 (± 0.017)	0.001 (± 0.003)	(2%)
12	Undetectable	Undetectable	-
13	0.139 (± 0.028)	0.045 (± 0.018)	(32%)
14	0.102 (± 0.030)	0.034 (± 0.015)	(33%)
15	0.123 (± 0.024)	0.033 (± 0.015)	(27%)
16	0.107 (± 0.031)	0.063 (± 0.032)	(59%)
17	0.083 (± 0.026)	0.017 (± 0.012)	(20%)
18	0.117 (± 0.033)	0.050 (± 0.019)	(43%)
19	0.166 (± 0.044)	0.097 (± 0.029)	(58%)
20	0.203 (± 0.032)	0.072 (± 0.024)	(35%)
21	0.101 (± 0.028)	0.021 (± 0.008)	(21%)
22	0.058 (± 0.017)	0.022 (± 0.008)	(38%)
23	0.218 (± 0.058)	0.064 (± 0.019)	(29%)
24	0.191 (± 0.051)	0.014 (± 0.006)	(7%)
25	0.153 (± 0.041)	0.031 (± 0.011)	(20%)

The average whole blood Bupivacaine levels found, are shown in Table XXVII, below. The results are expressed in µG/ml.

TABLE XXVII

Average Bupivacaine levels in µG/ml.

VESSEL	GROUP A	GROUP B	GROUP C
Maternal Vein	0,177	0,102	0,131
Umbilical Vein	0,043	0,047	0,038

These different values presented in Tables XXIV, XXV and XXVI above were subjected to the Kruskal-Wallis Test, and the Maternal Venous Bupivacaine levels were found to differ statistically significantly in the 3 patient groups. This difference was present at a significance level of 0,001. The same test was applied to the Bupivacaine levels in the umbilical vein, but no statistically significant difference was found to exist. The same test was also applied to the UV/M ratios, in an effort to explain the higher average umbilical vein levels in Group B than in both the other groups. A statistically significant difference was found to exist between the UV/M ratios of the 3 patient groups.

The highest UV/M ratio was present in the patients of Group B, followed by Group C and Group A in that order. This difference was present at a significance level of 0,01. The average UV/M ratio in Group A was 22,36%, 45,44% in Group B and 33,09% in Group C.

11. EPIDUROGRAMS

The results of the Epidurograms are shown in Table XXVIII, below.

TABLE XXVIII

Results of the Epidurograms

Site of Entry into Epidural Space	Ideal Position Reached		Curled up site of Entry		Caudal Deflection		Other
	Out of 25	Percentage.	Out of 25	%	Out of 25	%	
Low Lumbar (Group A)	10	40%	12	48%	2	8%	1
High Lumbar (Group B)	7	28%	10	40%	6	24%	2
Thoracic (Group C)	25	100%	-	-	-	-	-

This shows that the ideal position for the catheter tip was achieved in 100% of cases by using the technique employed in Group C. These figures were unsuitable for statistical analysis, but the results speak for themselves.

12. FOETAL HEART RATE ABNOMALITIES

The incidence of foetal heart rate abnormalities occurring after the epidural blocks performed on the 3 patient groups, are shown in Table XXIX, below. A detailed list of the tipe of foetal heart rate abnormalities encountered in all the patients, is presented in Addendum C.

TABLE XXIX

The incidences of Foetal Heart Rate Adnormalities occurring after each type of block.

Patient Group	No change observed		Pathological Pattern after block	
	Out of 25	Percentage	Out of 25	Percentage
A	13	52%	12	48%
B	14	56%	11	44%
C	25	100%	-	-

Out of the total of 23 patients in whom a pathological foetal heart rate was observed following the block, 18 patients responded favourably upon lateral positioning, while the other 5 did not. This indicates that lateral positioning does not always relieve abnormal foetal heart patterns. Because these results were mere incidences, they were unsuitable for statistical analysis. They do, however, speak for themselves.

13. PELVIC FLOOR TONE IN SECOND STAGE

The loss in Pelvic floor tone occurring in the 3 patient groups, is shwon in Table XXX, below. The grading system is explained in Chapter III.

TABLE XXX

The loss in pelvic floor tone.

PATIENT GROUP	GRADE I		GRADE II		GRADE III	
	Out of 25	Percen-tage.	Out of 25	Percen-tage	Out of 25	Percen-tage.
A	0	0%	1	4%	24	96%
B	15	60%	9	36%	1	4%
C.	13	52%	7	28%	4	16%

These results illustrate the very high incidence of pelvic floor flaccidity occurring after Standard Epidural Block. Since these results were only incidences per Group, they were not statistically analysed. (In Group C, only 24 patients were included).

14. POSITION OF THE FOETAL HEAD AT DELIVERY

Table XXXI, below, illustrates the incidence of occipito-posterior positions occurring with the 3 different epidural techniques.

TABLE XXXI

The incidence of persistent occipito-posterior positions in the 3 patient groups.

Patient Group	Occipito-Anterior		Occipito-Posterior	
	Out of 25	Percentage	Out of 25	Percentage
A	20	80%	5	20%
B	22	88%	3	12%
C	21	84%	4	16%

A slightly higher incidence of persistent occipito-posterior position of the foetal head at delivery was encountered in the patient Group A (Standard Epidural Block). These results were unsuitable for statistical analysis.

15. METHOD OF DELIVERY

Table XXXII, below, illustrates the incidence of instrumental delivery in the 3 different patient groups.

TABLE XXXII

The incidences of instrumental deliveries in the 3 patient groups.

Patient Group	Normal Vaginal	Ventouse	Forceps	Total incidence of Instrumental Deliveries	
				out of 25	%
A	6	2	17	19	76%
B	19	3	3	6	24%
C	13	6	6	12	48%

These results were also unsuitable for statistical analysis, but it is clear that a much higher incidence of instrumental delivery was present in the patients of Group A.

16. MAJOR COMPLICATIONS

The following major complications were encountered in the 3 patient groups. (See Table XXXIII, below).

TABLE XXXIII

Major complications occurring in the 3 patient groups.

Patient Group	Complication
Group A	Dural Puncture with post-spinal headache : 1 Patient
Group B	Dural Puncture with low spinal block ; 1 Patient
Group C	Dural Puncture with low spinal block : 1 Patient

One Major complication was encountered in each patient group. There seems to be no one type of block which is particularly prone to any one type of major complication.

CHAPTER V

DISCUSSION

I have carried out a study in which we compared three different techniques of Epidural Block. The study was undertaken because many shortcomings are associated with the techniques in current use. This project was an attempt to obviate some of these shortcomings. The candidate has personally performed more than 750 epidural blocks of various types over the past 4 years. After initially using the Standard Epidural block exclusively, we have recently switched to the Segmental Epidural block. Although it appeared to have some advantages over the former, we felt that there was still room for improvement. Two modifications were therefore incorporated into the Segmental block. In a provisional clinical trial, we found the Modified Segmental block in some aspects superior to both the other types. But these were mere clinical impressions, and we felt that it was essential to approach the problem on a more scientific basis.

I started out by doing an extensice survey of the available Obstetric and Anaesthesiologic literature on this topic. We concentrated particularly on publications that have appeared in the past 10 years. It became clear that numerous other authors were equally concerned about the shortcomings of the Standard block. Many publications, which will be referred to later in this chapter, have appeared to confirm our own clinical impressions regarding aorto-caval compression and hypotension after the block. Much concern was found regarding the quality of the block. Many authors refer to

"patchy" blocks, unblocked segments and unilateral block. More recently a number of studies have appeared to assess the effects of epidural block upon the maternal, foetal and neonatal acid-base status. The incidence of loss of pelvic floor muscle tone, the associated high incidence of malpositions, the loss of urge to bear down in the second stage, are mentioned in almost every publication. These factors contribute to the high incidence of instrumental deliveries. More recently Bupivacaine has recieved attention. Although it is to-day generally regarded as the best drug for epidural analgesia, its absolute safety has not been proven beyond doubt. Several pleas were encountered in the literature to keep the dose of Bupivacaine as low as possible. Several reports on foetal heart rate changes were found. The accuracy with which an epidural catheter can be placed exactly, has been questioned. Several complications are mentioned in every reported study.

It is therefore not surprising that various workers have also moved away from the use of the Standard Block. The modern trend is towards the use of some or other form of Segmental Epidural block. According to all the authors mentioned below, it is said to provide the following advantages over the Standard Block:

1. Less hypotension occurs after the block.
2. The incidence of pelvic floor paralysis and malpositions is less.
3. The incidence of instrumental delivery is lower.
4. The levels of maternal and neonatal Bupivacaine are lower.

5. There is less loss of uterine motility.

6. There is minimal or no loss of the urge to bear down in the second stage.

Reference to at least three basic forms of Segmental Block was found in the literature.

1. The Double Catheter technique

This block was used in the present project. It has been described in detail in Chapter III. It is similar to the double catheter technique described by Akamatsu and Bonica (1975).

2. The Single Catheter Segmental Block, as used among others, by Jouppilla, etal (1977) and Maltau (1975). In this block a single lumbar epidural catheter is used. The catheter is threaded cephalad for varying distances with the aim to block those segments carrying pain sensation to the uterus. The stress in this type of block is upon selective segmental blockade of the segments T10 to L2. Various concentrations, varying between 0,25% and 0,5% Bupivacaine are used. The above authors used small volumes of 0,25 or 0,5% Bupivacaine. The tone of the pelvic floor remains unaffected. The second stage is apparently managed without analgesia. The block is said to offer the advantages listed above.

3. The Single Catheter Segmental Block, with Nerve Fibre Selective Blockade.

Selective blockade of the thin autonomic fibres (carrying

uterine pain sensation) only, is provided. This selectivity is achieved by using very low concentrations of local anaesthetic agent, usually 0,125% Bupivacaine. The thin autonomic pain fibres are blocked. The thicker somatic sensory and motor fibres are relatively unaffected. No motor loss is therefore experienced. Although considerable volumes can be used, the total dosage of Bupivacaine is kept to a minimum. For second stage pain relief, a higher concentration is used with the patient in the sitting position. This position allows for gravitational deposition of the local anaesthetic agent in the region of the sacral outflow. While one catheter is used, the principle is different from that in (2) above. A concentration of 0,125% Bupivacaine was used for example by Geerinkx, etal,(1974), and Vanderick, etal (1975). The latter author suggested (by his conclusions) that this concentration also blocks somatic sensory fibres. A variation of this same technique was used by Maltau and Anderson (1975). They used 0,25% Bupivacaine. This was claimed to block autonomic as well as somatic pain fibres, without causing motor block. Complete pain relief was achieved in 93% of cases. Only 15% of patients required instrumental delivery.

It was clear from the literature that Segmental Blocks had certain advantages over the Standard Block. This impression was epitomized by the closing remarks in the article by Akamatsu and Bonica, 1975: "The double catheter technique, properly done, is the ultimate for analgesia-anaesthesia for labour and vaginal delivery".

But in spite of these optimistic conclusions, we still encountered some problems with the Segmental block, especially with regard to hypotension and foetal heart rate abnormalities. It therefore became obvious to us that an area for further research existed. We started using a Modified Segmental Block. The two modifications, mentioned in Chapter III, were introduced, because it seemed theoretically possible to thereby reduce the incidence of hypotension and foetal heart rate changes. Accurate placement of the top catheter opposite T12 would allow for minimal dosage and optimal selectivity of blockade. The kneeling position was our solution to aorto-caval compression, without the risk of unilateral block (as often occurs in the lateral position). This position was to be maintained for a period of 15 to 20 minutes after the block, during the early critical phase of binding of Bupivacaine to nerve roots. The kneeling position seemed to offer the theoretical advantages of allowing for optimal bilateral spread as well as that of avoiding aorto-caval compression. After a provisional trial, the Modified Segmental block was used in this project in comparison with the Standard Block and the Double Catheter Segmental block as described before. Our results with the comparison between the 3 blocks will now be discussed and compared with the information available in the literature.

1. The Blood Pressure

Hypotension is commonly encountered after epidural block. This is partially due to sympathetic

blockade which causes vasodilatation and a reduced peripheral resistance. In addition, aorto-caval compression plays a role. The paralysed vessel walls are unable to respond by compensatory vasoconstriction. The more segments blocked, the worse this effect. The less segments left unblocked the less vessels to effect compensatory vasoconstriction. The exact quantitative and temporal relationships per unit dosage are poorly described. Zaaijman and Slabber (1977) reported a moderate (11-30 mm Hg Mean Arterial Pressure) or severe(30 mm Hg M.A.P.) drop to occur in 55,6% of 63 patients. In that series, hypotension was experienced in all cases within 25 minutes after the block. A drop in blood pressure to below 90 mm Hg was reported to occur in 29% of patients (Holdcroft and Morgan, 1976). A "moderate" drop of blood pressure was said to occur in "most" patients (Matiadal and Cibils, 1976). Other similar reports include the following: Boys (1977), Scott (1977 (a) and (b)), Scott, etal, 1977; Akamatsu (1975), Akamatsu and Bonica (1975), Stanton-Hicks (1975), Cohen (1974), Marx (1974 and 1975), Editorial Comment : Drugs and Therapeutics Bulletin (1976).

One of the aims of this project was to use an Epidural Technique which would reduce the incidence of hypotension after the block. In the present series, a decrease in blood pressure to some extent was experienced in 100% of patients in Groups A and B. In Group C, some degree of hypotension was

observed in 80% of cases (See Tables I, II, III). The severity, however, was significantly worse in Group A than in Groups B and C. The hypotension was also significantly worse in Group B than in Group C. This is reflected in the average drop in blood pressure occurring in each group.(Table IV).

The only difference between Group A and B that could cause the difference in hypotension, was the dosage (See Addendum A, Tables A and B). The degree of hypotension was therefore already statistically significantly reduced by simply reducing the total dosage of Bupivacaine given. In Group C, the dosages were comparible with those in Group B. (See Table C, Addendum A). In Group C the patients were in the kneeling position. Yet again there occurred a statistically significant decrease in the severity of hypotension. This suggests that the kneeling position was responsible for preventing the same severity of hypotention as occurred in Group B. We can therefore conclude that,

1. Hypotension of some severity occurs in at least 80% of all patients after epidural block.

2. By reducing the dosage alone, a statistically significant lesser degree of hypotension may be expected.

3. By reducing dosage <u>and</u> by using the kneeling position, a further highly significant

reduction in the severity of hypotension may be expected.

The kneeling position probably relieves aorto-caval compression optimally. Ideal placement of the top catheter allows for minimal dosages of Bupivacaine and blockade of the minimum number of autonomic segments. The lateral position is associated with a loss of quality of analgesia. Hypotension has been associated with foetal heart rate changes. Those effects of the Modified Segmental block upon blood pressure may therefore yet prove to have very difinite clinical implications in future.

2. QUALITY OF ANALGESIA

The phenomenon of "unblocked segments" was first described by Bryce-Smith (1954) and is still reported in most large series. Crawford (1972), complained that ".... the unblocked segment continues to be a major source of concern". Many other authors are also dissatisfied with the relatively high incidence of this problem. The average reported incidence varies between 7 and 9% of all patients. Ducrow (1971) reported an incidence of 6,7% while Caseby in 1974 reported an incidence as high as 21%. Other reports on unblocked segments are legion, for example: Usubiaga, Dos Reis and Usubiaga, 1970; Singh, 1967; Shanks, 1968; Moir and Willocks, 1968.

In the present series, the quality of the block was assessed on a point system. The quality of analgesia produced by the 3 blocks was found to differ significantly. In

Group A there were 4 patients (16%) who did not have complete analgesia. These had "patchy" blocks with unblocked zones. This incidence would fit in with those referred to above. The Standard Epidural block (Group A) nevertheless produced the best quality of analgesia of all the blocks. By looking at Table VI, the Modified Segmental block appears to be the next best. But no statistically significant difference existed between the analgesic quality provided by Block A and C. There was, however, a 54% incidence of some late first stage pain. (See Addendum F). For this reason, it was clinically less satisfactory than the Standard block. It was less satisfactory in terms of complete pain relief, even though this was not reflected in the statistical analysis: The Segmental Block (Group B), was in its turn significantly less effective than both the Modified Segmental and the Standard Blocks. The Segmental Block was also associated with some late first stage pain in 88% of cases. (See Addendum F).

These results were somewhat disappointing. There are a number of explanations for this:

1. Per incidental observation it was found that a total of 22/25 (88%) patients in Group B and 12/22 (54%) in Group C, experienced pain towards the end of first stage after having experienced adequate pain relief for the greater part of the first stage. (See Addendum F, Table I). The pain was not caused by unblocked uterine pain fibres, because all these patients had adequate pain relief in the early parts of the first stage. The pain was neither produced by not giving adequate top-ups. The pain was present in these patients before full dilatation, and in a number of cases was associated with a premature

urge to bear down. The pain was therefore most likely produced by the well engaged head (before full dilatation) pressing down on the pelvic floor and stretching the perineum. In the early part of the series we thought that this pain was due to a particular inadequacy in the technique. But this was not so. Towards the end of the series we started to use the caudal injection at an earlier point, using 0,25% of Bupivacaine. This type of pain could be eliminated effectively. We tried in most cases to reserve the use of the caudal catheter until after full dilatation had been reached, to avoid flaccidity of the pelvic floor and malposition of the foetal head. The result was that a short period of pain, from sacral segmental origin, was experienced in the latter parts of the first stage. This pain was responsible for the unsatisfactory results presented in Tables V and VI. With more experience in the correct use of the caudal catheter, especially with regards to proper timing, this shortcoming may well be eliminated. We are satisfied that the pain was not due to a particular shortcoming of technique, because the early part of the first stage in all these cases was pain-free. With minimum doses of 0,25% Bupivacaine at the earliest sign of this late first stage pain one may well be able to keep the patient painfree without producing pelvic floor paralysis.

2. We have pointed out, that although no statistical difference existed between Groups A and C, that the overall quality produced in Group C was not quite that produced in Group A - on clinical grounds. This may

reflect a shortcoming in our scoring system used for this project. The Modified Segmental block did nevertheless produce analgesic quality which was statistically superior to the Segmental block. This confirms the overall clinical impression. Although the same phenomenon (of late first stage pain) was also observed in Group B patients, they, in addition, had a poorer quality of pain relief. This is almost certainly associated with the inaccurate placement of the top catheter, as demonstrated by Epidurogram. (See Table XVIII). In Group C patients, the catheter tip was ideally placed (opposite T12) in 100% of cases. In Group B patients it was ideally placed in only 28% of cases. The overall poorer quality of analgesia in Group B patients (Than in Group C) can almost certainly be explained by the less accurate catheter placement.

We did, therefore, in this series, not achieve the same quality of pain relief with the Segmental blocks as we did with the Standard Block. This is disappointing if one considers that Vanderick, etal, (1974) and Maltau and Anderson (1975) independantly reported completely pain-free labour (using Segmental Block with 0,125% Bupivacaine!) in 93% of patients. Nevertheless, as pointed out above, we hope that with a combination of accurate placement

of the top catheter and more experience in the proper use of the caudal catheter, that the full advantage of the Modified Segmental Block will be reaped. We are satisfied that the superiority of the Modified Segmental Block over the Segmental Block was adequately demonstrated by the above results. Further experience with it should enable one to obtain analgesic quality like that of the Standard Block.

3. DURATION OF THE SECOND STAGE

Many reports have been published, which indicated that the second stage of labour is prolonged in epiduralized patients, and especially so in primigravidas. (Moir, 1977; Akamatsu and Bonica, 1975; Crawford, 1972; Crawford, 1974). The present series was not compared with an unepiduralized controll group. The absolute duration of the second stage is therefore not relevant now. From Tables VII and VIII in Chapter III, it is clear that the average duration of the second stage was shortest in the Modified Segmental Group, followed respectively by Group B and A. The results were not statistically significant and no definite conclusions can therefore be drawn. The trend nevertheless tends to slightly favour the Modified Segmental Block.

4. APGAR SCORE AT 5 MINUTES

In a survey of the literature no specific evidence could be found to suggest that the Apgar score is significantly affected in either direction by an epidural block. Moore, Murnaghan and Lewis (1974), for instance, reported an average Apgar score of 7,7/10 at 1 minute and 9,5/10 at 5 minutes. They concluded that neither the timing of the last injection, nor the total dose of Bupivacaine affected the distribution of the Apgar score significantly. Similarly, in a series by Printz and Mc Master (1972) only 1% (of 100) babies born after epidural block had an Apgar rating of less than 7/10. If anything, this should increase the popularity of Epidural block. By comparison, using Segmental Epidural blockade, Vanderick, etal, in 1974 reported an Apgar score of 10/10 in 85,35% of neonates. Only 2,35% of their neonates had an Apgar score of less than 8/10. But unfortunately, the reliability of the Apgar score has been questioned with regards to more subtle neurological and cardiovascular abnormalities. Scanlon and co-workers in 1974 described a ".... new more refined tool....", a clinical evaluation system of their own, with which to assess neonates. Using their scoring system, they described neonatal depression after epidural block with Lignocaine (Scanlon, etal, 1974). They picked up abnormalities that were not detected by the Apgar

scoring system. The same group could not confirm these results after Epidural block with Bupivacaine in 1976. Standley, etal, 1974, also described a series in which they picked up decreased neonatal maturity and increased neonatal irritability after epidural block. They also used an alternative scoring system to the Apgar score. Any report using the Apgar score as the sole indicator of neonatal well-being, may therefore be fallacious in a percentage of neonates. (Apgar, 1953).

Nevertheless, because of lack of a working knowledge of a better system, we used the Apgar score. In 20% of neonates in Groups A and B, the Apgar score was less than 7/10. The corresponding figure in Group C was 8%. Although the results were not statistically significant (when taking absolute values) they tend to favour the Modified Segmental block. When comparing the results with those reported by Vanderick (1974), (see above) they are less satisfactory. Nevertheless, when comparing the 3 groups, one would be tempted to favour the Modified Segmental Block.

5. MATERNAL AND NEONATAL ACID-BASE STATUS

Several studies were found in the literature, suggesting that epidural block is not harmful to the mother, foetus or newborn. For instance, Thalme Belfrage and Raabe in 1974 reported less metabolic acidosis in mothers, foeti and neonates

after epidural block than after conventional obstetric analgesia. They were satisfied that epidural block was not harmful to neonates. Pearson and Davies (1974) concluded that "..... the infant closely follows the changes observed in the mother", and that ".... the infant of a mother who has had an epidural block begins the second stage of labour less acidotic than the infants of women who have conventional analgesia, a consequence of the smaller degree of metabolic acidosis seen in such mothers...." Similar encouraging studies were reported by Magno (1973) and by Jouppilla and Hollmén (1976).

In the present study, no unepiduralized controll group was used. One can therefore not compare the maternal and neonatal acid-base status with the "normal". One can only compare the acid-base status of the mothers and neonates in the 3 different groups, representing 3 different epidural techniques. Looking at the average values in Table XXIII it is obvious that the average maternal pH, pCO2 and Base Excess were very close in the 3 different blocks. The average maternal pO2 was higher in the Modified Segmental Group, but not significantly so. Regarding the umbilical artery values in the 3 groups, similarly no differences were observed. However, in the umbilical vein, a statistically significantly higher pO2 was present in the neonates of the patients subjected to the Modified block. Therefore looking at the average values, it can be stated that there was no definite indication that any one

of the 3 blocks was metabolically harmful to mother or neonate. It can also be stated that for some reason or other, the umbilical vein was significantly better oxygenated in the neonates born after the Modified Segmental block. While the average values were much the same in the 3 different groups, the Modified Segmental Block is to be slightly favoured because of the better umbilical vein pO2. This can only be relatively advantageous to the foetus. One may speculate that the prevention of aorto-caval compression produces a more constant placental perfusion pressure. The temporary hypotension is avoided and the temporary insult to the foetus is avoided. These factors may in combination be responsible for the superior oxygenation of the foetal blood in the umbilical vein. Even if for this reason alone, the Modified Segmental Block needs to be favoured.

6. WHOLE BLOOD BUPIVACAINE LEVELS

Moore, Bridenbaugh, etal, 1970, refer to 24 reports in the literature suggesting that Bupivacaine is safe for the mother, the foetus and the neonate. Although Bupivacaine is therefore at present regarded as the best drug for epidural blockade, its absolute safety for mother and foetus has not been proven beyond all doubt. This aspect has been discussed in some detail in Chapter II. Like several other authors we therefore feel that the levels of Bupivacaine should be kept as low as possible in the mother and in the foetus. We have tried to achieve this by using the Segmental Block. It was also hoped

that one would be able to even further reduce the blood levels by using the Modified Segmental Block. At present, the following range of blood levels are being reported in the literature:

Reynolds Hargrave and Wyman (1973): Plain Bupivacaine: Average Maternal levels 0,54µG/ml (± 0,05); Bupivacaine with Adrenaline : Average maternal levels 0,36 µG/ml (± 0,03). The average Umbilical Vein levels with plain Bupivacaine was 0,14 (±0,015), while it was 0.088 (± 0,009) with Bupivacaine with Adrenaline.

Moore, etal (1970), mention levels of 0,4 µG/ml and above in 30 patients who received doses of 150 - 225 mg.

Thomas, Climie and Mather (1969). Fifteen to 30 minutes after 50 mg of Bupivacaine was administered, blood levels of 0,22 µG/ml up to as high as 0,60 µG/ml were reported.

Wilkinson and Lund (1970). After 150 mg of Bupivacaine with Adrenaline, blood levels of 1,14 µG/ml were found at 30 minutes and 2,23 µG/ml when the dose was increased to 225 mg of the same solution.

Reynolds and Taylor (1970) reported maximum maternal levels of 0,76 µG/ml and maximum umbilical vein levels of 0,14 µG/ml at birth.

It is obvious that a wide variation of average values have been reported. Because the total dosage and patient body masses are not always indicated, it is difficult to compare notes. Nor are the periods of time over which such doses were given regularly indicated. The detail regarding laboratory technique, quality controll etc., is hardly ever satisfactorily reported. For these reasons it is difficult to compare our results with those reported in the literature. Furthermore, regarding the Umbilical Vein/Maternal Vein Ratios (UV/M Ratios), just as widely varying results are being reported, for example:

Cohen (1974) : 0,31 - 0,44
Finster and Pederson (1975) : 0,14 - 0,44
Thomas, Clinie and Mather (1969) : 0,14 - 0,86
Fisher and Paton (1974) : 30 - 40%
Thomas, etal, (1976) : 0,237 (± 0,137).

For the abovementioned reasons it would be unscientific to compare our results directly with the above and try to draw conclusions safely.

In our series, the aim was to reduce the Bupivacaine levels to a minimum. In Group A, the average maternal level was 0,177 µG/ml. In Group B it was 0,102 and in Group C 0,131. The highest average neonatal blood levels were found in Group B, which was surprising. It was surprising that the difference between the blood levels were highly statistically significant, while this was not the case in

the corresponding neonatal levels. The highly significant difference between the maternal blood levels can probably be explained on the basis of the difference in total dosage administered (See Addendum A, Tables A, B, C.) That the average maternal levels in Group C should be higher than those in Group B, is also surprising, but then the period of time over which the latter group received their total dosage, was slightly longer than was the case with the patients in Group C. Assuming that the laboratory technique was sound and knowing that no statistically significant difference existed between the acid-base status of the different patient groups, these results are difficult to explain. The results of the maternal blood levels are explicable and acceptable. But the neonatal blood levels are not. There was a much lower average UV/M ratio in Group A than in the other two groups. This may possibly reflect a lower placental perfusion pressure, resulting in a lesser proportion of the maternal Bupivacaine crossing to the foetus. The grosser degree of post-block hypotention in this Group may be associated with this lower UV/M ratio. It would be difficult to explain the disparity between the other two groups on a similar basis. The other possible explanation may be that a difference existed between plasma protein levels of the mothers. The lower the maternal plasma protein levels, the higher the unbound fraction of Bupivacaine available for placental transfer to the foetus. As we did not do maternal plasma proteins on these patients, this remains merely a speculation. All

that one can conclude with safety from these results is that both the segmental blocks were associated with maternal levels that were significantly lower than those associated with the Standard Block. This represents fulfillment of part of the aim of this project. It is unfortunate though, that relatively more Bupivacaine managed to reach the foeti in Groups B and C.

7. EPIDUROGRAMS

Reference has already been made to the inaccuracy of the technique of threading a catheter into the epidural space and hoping that it will reach the ideal position. It has been pointed out in the literature that threading a catheter for more than 5 cm and hoping that it will reach T12, is futile. (Doughty, 1974; Bromage, 1954, Sánchez, Acuña, Rocha, 1967; Bridenbaugh, Moore, Bagdi, etal, 1968; Moore, 1965;). A plastic catheter can not be relied upon to travel for the intended distance in the intended direction to reach the intended position.

Our results in the present study have confirmed these findings of the above authors (See Table XXVIII). By threading the catheter for 10 cm or more, the intended position was reached in only 40% and 28% respectively in Groups A and B. By the technique used in Group C, we were able to place the catheter accurately opposite T12 in 100% of cases. The clinical implications of this were not clearly demonstrated by the results of the present study,

except that the quality of analgesia obtained in Group C was significantly superior to that in Group B. Furthermore, knowing exactly where the catheter tip lies, and knowing that the success in placing it there is repeatable, offers a degree of security to the operator. It also provides for a more scientific approach to studies of this nature in future. This technique of catheter placement is an integral part of the Modified Segmental Block. These results therefore in a way prove the superiority of this particular technique of Epidural blockade.

8. FOETAL HEART RATE ABNORMALITIES

Changes in the foetal heart rate after Epidural Block have been reported frequently in the literature. Printz and Mc Master (1972) reported foetal heart changes in 19/100 cases. The average time at which they took place was at 11,7 minutes after injection. Their average duration was 7,2 minutes. Hypotension was present in 10% of these patients. Wingate, etal, (1975) reported an association between maternal hypotension and a temporary period of foetal bradycardia in 55% (of 37) cases. No conclusions regarding the effects of this temporary period of bradycardia and the neonatal status were drawn from the study. Similar results were reported by Boehm, Woodruff and Growden (1975) and by Mc Donald Bjorkman and Reed (1974). In the latter study a statistically significant increase was reported in foetal acidosis where such a temporary period of bradycardia had occurred. Eckstein and Marx (1974) and

Zaaijman and Slabber (1977) also found an association between maternal hypotension and temporary foetal bradycardia.

In the present series, a temporary period of a foetal heart rate abnormality occurred in 48% and 44% of cases in Groups A and B respectively. (See Table XXIX, Chapter III, and Addendum C). Out of a total of 23 patients in the entire series in whom a pathological foetal heart rate pattern was observed after the block, 18 responded swiftly to lateral positioning and the administration of oxygen. In Group C (Modified Segmental Block) no pathological foetal heart changes were observed after the block. This compares excellently with the results reported by Vanderick, etal (1974). In his series 7/156 patients developed late deceleration of the foetal heart after the use of segmental blockade. In the patients in Group C, there was least hypotension. The aorto-caval compression was presumably avoided by the kneeling position. We therefore conclude with confidence that this particular technique of Modified Epidural blockade, is not associated with pathological foetal heart rate patterns after the block, in spite of minimal to moderate degrees of hypotension. This of course does not take into account the possible hazards of the caudal block. Severe foetal bradycardia has been reported after caudal block. (Finster, Poppers and Sinclair, 1965; Abouleish, 1976; Di Giovanni, 1971.) In this particular series, hypotension and/or pathological foetal heart was definitely associated

with caudal block. We are satisfied, therefore that we have tried a technique of epidural block which seems to almost guarantee that foetal heart rate changes will not follow after the block, even where moderate degrees of hypotension may still occur.

9. PELVIC FLOOR TONE AND POSITION OF THE FOETAL HEAD IN SECOND STAGE; THE TYPE OF DELIVERY

The Standard Epidural Block is associated with paralysis of the pelvic floor, an increased incidence of malrotation and an increased incidence of instrumental delivery. An "increased incidence" of persistent occiput-posterior position was reported by Raabe and Belfrage (1976). They however pointed out that the incidence of posterior position in any epidural series is falsely high, because these are usually the patients with very painful labours who require epidural block. Therefore occipito-posterior position cannot be taken as an accurate parameter in the assessment of the effects of epidural blockade. Using segmental blockade, Maltau and Anderson (1975) reported a decrease in the incidence of occipito-posterior positions when the segmental block was used.

In the present series occipito-posterior position occurred in 20% of cases in Group A. (See Table XXXI). In the same group pelvic floor flaccidity occurred in 96% of cases (Table XXX) and the incidence

of instrumental delivery in this group was 76%. (Table XXXII). In Groups B and C, the corresponding figures were 12%, 4%, 24% and 16%, 16%, 48%.

A correlation seems to exist between pelvic floor tone, malposition and instrumental delivery. From the literature this seems to be true as well. An increase in instrumental delivery with the Standard type of block was also reported by the following authors:

Moore Murnaghan and Lewis (1974)	: 86% in primigravidas 62% in multiparas.
Printz and Mc Master (1972)	: Overall 67%
Crawford (1972)	: 54,8% in primigravidas 31% in multiparas.

It is clear from the results of our present series mentioned above, that the Standard Type of block is associated with a higher incidence of pelvic floor flaccidity and a higher incidence of instrumental delivery. When using the segmental blocks, our incidences of instrumental delivery were reduced to much lower levels. (24% and 48% for Groups B and C, respectively). These incidences compare well with that reported by Vanderick, etal (1974), who used Segmental Blockade, namely 34,45%. The Segmental blocks therefore seem to be associated with lower incidences of pelvic floor flaccidity, malpositions and instrumental deliveries. For this,

among other reasons, the Standard block is presently being avoided.

It should also be mentioned at this point that although a decrease in the urge to bear down is commonly ascribed to pelvic floor flaccidity, this was not our experience in this series. Loss of the urge to bear down appeared to be more specifically related to the loss of pain on the perineum, rather than with the loss of tone. Patients, with the Segmental block, would have a reasonable to strong urge to bear down at the onset of the second stage, but as soon as perineal analgesia was provided, the urge would be reduced or even lost completely, even though the perineal tone was still normal or nearly so. This was an incidental observation, and therefore the information is presented in Addendum E, Table H. It can be seen that this observation was made in 8/23 patients in Group B, (34,78%) and in 10/20 patients in Group C (50%). We feel that this factor may have contributed to the incidence of instrumental deliveries in the Segmental Blocks. Nevertheless, the incidence of instrumental deliveries was still much lower in the Segmental blocks to make them preferable to the Standard block.

10. COMPLICATIONS

In this series, we encountered accidental dural puncture in 1 patient in each group. This is an incidence of 4% per group. The following is a list of a number of recent publications indicating the

incidence of this particular complication.

Moir and Willocks (1968)	: 1%
Mandlekar (1970)	: 2,5%
Crawford (1972)	: 3,2%
Moore, Murnaghan and Lewis (1974)	: 0,8%
Kalas and Hehre (1975)	: 2%
Holdcroft and Morgan (1976)	: 1,7%

The incidence of dural tap in the present series is therefore slightly higher than in those series mentioned above. But it is also true that this complication was not particularly associated with any one type of block. From this point of view, there is no advantage of the one block over the other.

11. DISADVANTAGES OF THE MODIFIED SEGMENTAL BLOCK

a. No specific disadvantages were found to be associated specifically with the thoracic epidural block. No increase of disadvantages or complications were associated with it.

b. Tiredness was produced by the kneeling position (See Addendum D, Table G). Sixty percent of patients complained that they found the position tiring. This is probably so because the greater part of the weight of the trunk, including the pregnant abdomen, is supported on the hands and knees. This disadvantage would make the block less acceptable for prolonged use.

We therefore changed the patients back to the lateral position as soon as the block had taken effect properly. The time spent in this position was usually about 15 to 20 minutes after the block, and about 20 minutes before the block.

c. We thought that patients may find the position undignified. Only 20% of all the patients responded positively on direct questioning. At present, this shortcoming is not common enough to contra-indicate the further use of the technique.

12. CONCLUSION

When one considers the above discussion, the following conclusions can be made regarding the 3 different techniques in comparison with one another:

a. At least 80% of all patients subjected to any one of the 3 blocks will experience at least some degree of hypotension. If the dosage of local anaesthetic used is reduced and the position of the patient is kept unchanged (dorsal), the severity of hypotension can be significantly reduced. If, in addition, the kneeling position is assumed during the block, the severity of hypotension can be further reduced by another statistically significant margin..

The Modified Segmental block is associated with the lowest total incidence and the least severity of hypotension.

b. If the dosage is thus reduced, it is associated with slightly reduced analgesic quality. The Modified Segmental block provides statistically significant better analgesic quality than the Segmental block. Standard and Modified Segmental blocks provide statistically comparible results.

c. Generally speaking, neither maternal nor neonatal acid-base status at delivery is significantly influenced by any of the 3 blocks. A statistically significantly higher umbilical vein pO2 and a slightly higher maternal pO2 seem to be associated with the Modified Segmental Block.

d. The duration of the second stage is not significantly influenced by using any one of the 3 blocks. From the present no comparison with unepiduralized patients was possible.

e. By inserting a catheter through the twelfth thoracic interspace, and threading it to just beyond the tip of the needle, the ideal position of the catheter tip opposite T12 can be reached in 100% of cases. This technique is repeatable and reliable in producing this result. It opens up future research possibilities, on a more scientific basis.

f. Pelvic Floor flaccidity can be significantly reduced by using the Segmental blocks. The incidence of occipito-posterior position may be reduced by using Segmental blockade. The incidence of instrumental delivery can be greatly reduced by using Segmental blockade. In this regard there is no difference between the Segmental and the Modified Segmental blocks.

g. The differences in 5- minute Apgar score between the neonates of the 3 groups were not significant, but tend to favour the Modified Segmental block slightly.

h. No foetal heart rate changes seem to follow Modified Segmental block, as is the case with the other two types of block. This is almost certainly associated with the avoidance of aorto-caval compression. For this reason alone (if for nothing else), the Modified Segmental block is preferable to the other types of block.

i. It is possible to achieve reasonable analgesia by a decreased dosage of Bupivacaine. Significantly lower maternal blood levels can be achieved by using the Segmental and Modified Segmental Blocks. A higher UV/M ratio seem to be associated with both the Segmental blocks. Proportionally more Bupivacaine seem to reach the foetal circulation in these 2 types of block. It is speculated that the reduced

placental perfusion pressure associated with the hypotension after the Standard block may explain the differences. These lower maternal blood levels were not obviously associated with any definite clinical advantages in this small series. It is nevertheless regarded as important that the maternal Bupivacaine levels be kept as low as possible.

j. No one of the 3 blocks seems to be prone to any one particular major complication.

k. The Modified Segmental block has the disadvantage that the patients find the kneeling position tiring. A minority of patients find the position undignified.

When considering the above, it would appear that the Segmental block, as described in the preceding Chapters, has advantages over the Segmental and Standard blocks, The main Advantage is the drastic reduction in foetal heart rate abnormalities associated with it. Other important advantages include the lesser severity of hypotension and the low maternal Bupivacaine blood levels associated with it. It is associated with very accurate catheter placement. We are satisfied that the Modified Segmental block is superior to any other currently used epidural technique.

"The distress and pain which women often endure while they are struggling through a difficult labour are beyond description and seem to be

more than human nature would be able to bear under any other circumstances. It is our duty as well as our privilege to use all legitimate means to remove the physical sufferings of the mother during parturition."

(Sir James Young Simpson, 1848)

CHAPTER VI

SUMMARY

A project was carried out to compare 3 different techniques of epidural block. The project was motivated because many shortcomings were noted in the techniques in current use. These include a high incidence of hypotension after epidural block. This incidence was found to be higher than what is usually reported. The incidence and severity of hypotension was reduced by using lower dosages of Bupivacaine and by at the same time avoiding aorto-caval compression. The latter was achieved by placing the patient in the kneeling position.

The quality of analgesia achieved by using Segmental blockade was inferior to that achieved by Standard Epidural blockade. On the other hand, the Modified Segmental block produced results which were statistically comparible with the Standard Block. This was not a true reflection of the clinical experience, and may indicate an inadequacy in our scoring system. Although we were unable to improve the analgesic quality by Segmental blockade, this may be merely a factor of inexperience at the present time, or due to inaccurate catheter placement.

The duration of the second stage, is commonly reported to be prolonged by epidural blockade. Although we were able to shorten the second stage by using Segmental blockade, the difference was not significant.

The Apgar scores of neonates born after epidural block have not been reported to be negatively influenced by epidural block. We found a higher incidence of slightly reduced Apgar scores in the Standard and Segmental blocks, but acceptable results after Modified Segmental blockade.

The Acid-base status of mothers and neonates is not known to be negatively influenced by epidural blockade. Our study confirmed this. In fact, we found that the umbilical vein pO2 values to be significantly higher after the Modified Segmental block when compared with the other two techniques.

Bupivacaine is to-day regarded as the best drug for epidural block. It is however not completely without danger to mother and foetus. It is important to keep down the dosage of the drug. We used Bupivacaine with Adrenaline 1:200000. We found our blood levels to be lower than those reported in the literature. By using the Segmental blocks, the maternal blood levels were reduced significantly when compared with those of the Standard Block.

Because it was reported in the literature that epidural catheters were difficult to place accurately,we performed Epidurograms to determine the fate of epidural catheters. When catheters were threaded for 10 cm or more, accurate placement was achieved in unacceptably low percentages of patients. By using the technique of Modified Epidural block, accurate catheter placement was achieved in 100% of cases. The technique of placement was safe, repeatable and reliable. It allows for a more scientific approach to epidural blockade.

Foetal heart rate abnormalities are commonly associated with epidural blockade. This was confirmed by the present series - in the first 2 groups. By employing the Modified Segmental Block, we were able to reduce the incidence of foetal heart rate abnormalities to nill. This alone has made the project a worth while undertaking to us.

Flaccidity of the pelvic floor, malposition of the foetal head and a high instrumental delivery rate are commonly reported after epidural block. These were confirmed by our Group A. By using the Segmental Blocks, the incidences of all these were greatly reduced.

The incidence of major complications in this series was not greatly elevated above the incidence commonly reported in the literature. None of the 3 blocks tested was prone to any particular type of complication.

Although the Modified Segmental block was found to have some disadvantages, these were outweighed greatly by its advantages.

We introduced two modifications into the current practice of Segmental Epidural blockade.

i. We placed the top catheter at T12, after entering the epidural space in the thoracic region.

ii. We placed patients in the kneeling position during epidural block.

By these two modifications we hope to have made some contribution to the present status of epidural blockade. We are satisfied that this Modified Segmental Blockade has many advantages over the other techniques in use presently. We hope to do a further large study using this technique, to confirm the findings of the present (small) series.

ADDENDUM A

In the following 3 Tables (A, B and C), a detailed list of all the patients used in this project is given. Tables A, B and C respectively represent Groups A, B and C. All the patients were primaparas and in all cases Epidural block was administered at a cervical dilatation of between 4 and 7 cm.

TABLE A

Group A patients

Case Number	Age in years	Body mass in Kg.	Total Dose of Bupivacaine used in mg.	Time over which total dose was administered in hours (Nearest ½ hour) before delivery.
1	26	76,4	60 mg	1
2	28	70,0	60 mg	2,5
3	22	62,3	100 mg	1
4	19	67,0	70 mg	3
5	19	66,2	75 mg	2,5
6	23	63,5	115 mg	3,5
7	26	59,2	75 mg	2,5
8	25	54,3	75 mg	1
9	19	58,0	75 mg	2
10	19	57,0	70 mg	5
11	16	83,3	100 mg	3
12	17	64,3	75 mg	1,5
13	22	54,5	80 mg	1
14	24	78,4	75 mg	2
15	16	55,0	80 mg	1
16	17	84,45	70 mg	2
17	20	81,6	80 mg	1
18	17	72,3	75 mg	2,5
19	28	80,0	80 mg	3,5
20	19	74,5	75 mg	4
21	26	55,0	100 mg	1,5
22	27	91,0	80 mg	2
23	19	65,0	100 mg	6
24	24	62,3	100 mg	3
25	20	55,0	75 mg	2
Averages	21.52	67,66	80,8mg	2,4

TABLE B

Group B patients

Case Number	Age in years	Body Mass in Kg.	Total Dose Bupivacaine used (mg).	Time over which Total dose was given to nearest ½ hour.
1	19	61,4	38,75	9
2	17	63,9	30,0	2
3	18	55,0	45,0	8
4	19	70,0	22,50	3,5
5	23	80,0	27,50	1
6	21	76,4	35,0	2,5
7	15	71,1	27,50	4
8	18	59,7	40,0	6
9	19	75,0	27,5	1,5
10	22	80,0	43,75	1,0
11	21	51,5	26,50	1
12	16	51,5	23,75	2,5
13	26	65,0	45,5	7
14	21	63,0	30,0	2
15	16	58,0	30,0	3
16	19	57,4	42,5	5
17	19	53,7	35,0	4
18	26	75,0	30,0	1
19	23	78,1	30,0	4
20	19	54,8	27,5	1,5
21	17	72,0	27,5	4
22	25	66,1	30,0	1,5
23	21	52,0	45,0	4
24	20	89,2	45,0	3,5
25	19	70,0	30,0	1
Averages	19,96	65,99	33,43	3,7

TABLE C

Group C Patients

Case Number	Age in years	Body Mass in Kg.	Total Dose of Bupivacaine used in mg.	Time over which total dose was given to nearest ½ hour.
1	23	53,2	42,5	2
2	29	96,4	22,5	3
3	17	66,7	35,0	1,5
4	29	58,7	35,0	1
5	25	74,4	47,5	5
6	23	75,3	35,0	3
7	23	63,0	35,0	3,5
8	18	53,0	30,0	3
9	17	64,5	32,5	5
10	14	56,1	35,0	3,5
11	24	62,3	22,5	1
12	22	63,2	20,0	1
13	15	65,5	37,5	4
14	17	61,3	35,0	1,5
15	27	66,3	30,0	2
16	20	73,5	45,0	9
17	19	60,0	21,5	4,5
18	20	62,0	40,0	5
19	22	71,5	21,5	2
20	19	57,0	27,5	4
21	19	84,0	41,25	4,5
22	17	80,0	27,5	1
23	18	57,4	15,0	2
24	18	56,6	28,75	8
25	21	57,0	32,5	1
Averages	20,64	65,56	31,82	3,24

ADDENDUM B

In this addendum we would like to present a detailed account of the Kruskal-Wallis One-Way Analysis for Variance. This was the test used in all those data-tables subjected to statistical analysis.

1. When 3 Groups of data were compared, the first step was to rank the values in each column from the lowest to the highest. The lowest value in the column was given the rank of 1. If the same value was shared by more than one result, an average rank was given. For example, if 2 maternal pH values happened to be 7.32, and these occurred at rank 2 and 3, the rank of 2,5 would be awarded to each. If rank no. 19, 20, 21, 22 and 23 were shared by 5 maternal pH values, the rank number applied to each was 21, which is the average of the 5 ranks mentioned. This sharing of rank position is referred to as a tie. (See later).

2. The sum of each column of ranks was then calculated. These sums were referred to as R1, R2 and R3. The number of ranks within each group was referred to as n. In our case the value of n was 25, because each group had 25 ranks. The total number of ranks was referred to as N, which in our case was 75. The Variable (H) was then calculated from the following formula:

$$H = \frac{12}{N\ (N + 1)} \times \sum_{j} \frac{(Rj)^2}{nj} - 3\ (N + 1).$$

(j refers to the number of columns of data compared.
$\sum$ = sum of.)

3. When H was calculated, its value was corrected for the number of ties occurring in each test, by using the following correction factor.

$$\text{Correction Factor} = 1 - \frac{\Sigma T}{N^3 - N}$$

$T = t^3 - t$

t = the number of values in each tie.

For example, if 3 groups of ties occurred, containing respectively 2, 3 and 4 values per tie, we could express the relationship between t and T as follows:

t =	2	3	4
T =	6	24	60

By then applying the above formula for correction for ties, we find that the.....

$$\text{Correction Factor} = 1 - \frac{90}{(75)^3 - 75}$$

$$= 1 - 0{,}000213$$

$$= 0{,}999787$$

4. Having calculated the correction factor in each case, the corrected H was calculated from the following formula.

$$H \text{ (corrected for ties)} = \frac{\frac{12}{N\,(N+1)} \sum \frac{(Rj)^2}{nj} - 3\,(N+1)}{1 - \frac{\sum T}{N^3 - N}}$$

$$\text{or,} \quad = \frac{\text{Uncorrected H}}{\text{Correction Factor}}$$

4. When H (corrected for ties) had been calculated, its value was applied to a Table of critical values to find whether H indicated a significant difference between the 3 groups. The level of significance was then determined from this table. A significance level of 0,01 means that in assuming a significant difference between groups, one stands a 1% chance of error. Similarly, at a significance level of 0,001, the chances of incorrectly assuming a significant difference between groups is 0,1%, etc.

(Refer Siegel, 1956).

ADDENDUM C

In this Addendum a summary is given of the foetal heart rate chances (if any) occurring after epidural block in each of the 75 patients used in the project. Tables D, E and F represent respectively Groups A, B and C. In all cases, the foetal heart rate pattern was acceptable as normal before the block. Those foetal heart rate patterns that were regarded as pathological, are indicated as such in brackets.

TABLE D

Foetal heart rate patterns observed after Standard Epidural Block (Group A)

Case Number	Foetal Heart Pattern after Standard Epidural Block
1	No change (shallow early decelerations before and after) (Physiological)
2	Variable deceleration (Path.)
3	Early deceleration before and after (Physiological)
4	Severe bradycardia (Pathological)
5	No change
6	Severe bradycardia (Pathological)
7	Shallow late decelerations (Pathological)
8	Bradycardia (Pathological)
9	Late decelerations (Pathological)
10	No change
11	Shallow late deceleration (Pathological)
12	Gradual slowing (?Physiological)
13	Severe bradycardia (Pathological)
14	Late deceleration (Pathological)
15	Variable deceleration (Pathological)
16	No change
17	No change
18	No change
19	No change
20	No change
21	No change
22	No change
23	Late deceleration (Pathological)
24	Gradual slowing (?Physiological)
25	Severe Bradycardia (Pathological)

TABLE E

Foetal heart rate patterns observed after Segmental block (Group B).

Case Number	Foetal Heart Pattern occurring after Segmental Epidural Block.
1	Variable deceleration (Pathological)
2	Gradual slowing → Late deceleration (?Pathological)
3	Late deceleration (Pathological)
4	Deep Early deceleration (?Pathological)
5	Severe bradycardia (Pathological)
6	No change
7	No change
8	Early decelaration
9	Late deceleration (Pathological)
10	"Silent"pattern (Pathological)
11	No change
12	Early deceleration
13	Severe bradycardia (Pathological)
14	Variable deceleration (Pathological)
15	No change
16	No change
17	Variable deceleration (Pathological)
18	Late deceleration (?Pathological)
19	"Silent" pattern (Pathological)
20	Late deceleration (Pathological)
21	No change
22	No change
23	No change
24	Severe bradycardia (Pathological)
25	No change.

TABLE F

Foetal heart rate patterns occurring after Modified Segmental Block. (Group C).

Case Number	Foetal Heart Pattern occurring after Modified Segmental Block.
1	No change
2	No change (⟶ "Silent" pattern when turned to lateral)
3	No change
4	No change
5	No change
6	No change
7	No change
8	No change (⟶ Bradycardia when dorsal position assumed)
9	No change
10	No change (⟶ Variable deceleration in lateral position)
11	No change (Shallow early deceleration before and after block)
12	No change
13	No change
14	No change
15	No change (Shallow Early deceleration before and after)
16	No change
17	No change
18	No change
19	No change
20	No change
21	No change
22	No change
23	No change
24	No change
25	No change (⟶ Variable deceleration in dorsal position for vaginal examination)

ADDENDUM D

Table G illustrates the incidences of positive responses of the patients in Group C on the following questions:

Question 1 : Do you find this position tiring?

Question 2 : Do you find this position undignified?

The questions referred to the kneeling position during and after epidural block.

TABLE G

Incidence of positive responses to above 2 questions of patients in Group C

Positive Response to Question 1 :	Out of 25	Percentage
	15	60
Positive Response to Question 2 :	5	20

ADDENDUM E

Table H illustrates the incidence in Groups B and C of the observation that a loss of urge to bear down occurred after perineal pain was removed, while the tone of the pelvic floor was still intact or only minimally reduced.

TABLE H

Incidences of the loss of urge to bear down after perineal pain was removed while pelvic floor tone was still normal.

	Loss of urge to bear down after perineal analgesia	
Group B	Number of patients 8/23	Percentage 34,78%
Group C	10/20	50%

Those findings suggest that the loss of urge to bear down may be partially caused by removal of pain.

ADDENDUM F

The incidence of pain late in the first stage in the patients in Groups B and C, is expressed in Table I, below.

TABLE I

The Incidence of late first stage pain in patients of Groups B and C.

	Number of Patients	Percentage
GROUP B	22/25	88%
GROUP C	12/22	54,54%

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