

Thoracic Combined Spinal-Epidural (CSE) Anaesthesia

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ABSTRACT

The experimental delivery of spinal anaesthetics to the desired heights in the body, even above the termination of the spinal cord (thoracic level), has been shown to be potentially very valuable. Since there is no blockade of the lower extremities, little caudal spread, a significantly larger portion of the body experiences no venal dilation, and may offer a compensatory buffer to adverse changes in blood pressure intra-operatively. Further, the dosing of the anaesthetic is exceedingly low, given the highly specific block to only certain nerve function along a section of the cord. Thirdly, the degree of muscle relaxation achievable without central or peripheral respiratory or circulatory depression is superior to that with general anaesthesia.

Results from Magnetic Resonance Imaging (MRI) studies indicate that the spinal cord lies anteriorly within its thecal boundaries in the apex of the thoracic curve. Intrathecal injections, therefore, at thoracic levels may have a greater absolute margin of error before needle contact with neural tissue - although the consequences of inadvertent contact are possibly more disastrous.

The thoracic CSE technique has been practised in twelve patients with cardiovascular and/or pulmonary problems. Despite bad haemodynamic situations and/or severe end-stage lung problems, abdominal surgery (i.e. cholecystectomy, bowel and vascular surgery) could be performed successfully with the thoracic CSE method, with low impact on the patient. Anaesthetic care of the patients would have been more difficult, with consequently larger impacts on haemodynamic and pulmonary function, should these surgeries have occurred under general anaesthesia - the usual anaesthetic technique of choice.

CSE techniques can be used in the thoracic region in patients who otherwise would receive general anaesthesia. High risk patients, with limited cardio-respiratory reserves, present challenges to the anaesthesiologist. Using the thoracic CSE technique in the thoracic space is extending the boundaries of regional anaesthesia.

Introduction

It is often undesirable to use general anaesthesia for surgery, and many indications exist for regional techniques. Negative side effects of the drug, relatively longer recovery times, contraindications for certain patients (elderly or those with heart conditions), safety and cost all limit the usefulness of general anaesthesia.¹⁻⁴ Indeed, some recent studies indicate that, besides pre-existing medical complications, time under anaesthetic-induced sleep and the degree of intra-operative hypotension may be important indicators of postoperative mortality.⁵ Not surprisingly, there is significant and renewed interest in the use of regional anaesthesia techniques for a number of common surgeries.^{6,7} Some of the most versatile and well-known regional techniques for surgery are spinal and epidural anaesthesia, although recent innovation of their employment in the operating room has been limited.

Anaesthesiologists are unwilling to perform spinal anaesthesia above the termination of the spinal cord, largely due to direct threats to the spinal cord from the needlepoint. Nevertheless, in the past neurologists performed subarachnoid myelographic injections at thoracic and cervical levels.⁹ Even high spinal anaesthesia has been employed for craniotomies.¹⁰ MRI and other imaging techniques have since rendered these myelographic procedures largely obsolete, although it is clearly possible to inject radiopaque or anaesthetic agents into the

subarachnoid space at the thoracic level. The experimental delivery of spinal anaesthetics to the desired heights in the body, even above the termination of the spinal cord (thoracic level), has been shown to be potentially very valuable.^{11,12} Benefits to the patient include that common surgeries of the abdomen may be performed with the lowest possible drug dosing, and the advantage of leaving the lower extremities un-anaesthetised. The last point enables compensatory reactions to adverse changes in blood pressure inter-operatively, one of the major risks identified in surgery. Safe administration of thoracic CSE anaesthesia may facilitate the option that common surgeries, usually requiring prolonged hospital stays, may be performed on an outpatient basis - or that at-risk patients can be more safely anaesthetised.¹²

Anatomy

Recent investigations into the anatomy of the spinal canal have uncovered new insights into the anatomy pertinent to neuraxial anaesthesia.¹³⁻¹⁸ The information garnered by new methods such as cryomicrotome sectioning, epiduroscopy and magnetic resonance imaging (MRI) reveals more about the mechanism of neuraxial blockade and enables the development of new techniques. Considering CSE techniques at thoracic level, it is relevant to note the margins that are available to the clinician administering the spinal bolus. To this end, the anatomy of the spinal cord and surrounding tissues is revisited.

Boundaries and contents of the epidural space

The posterior longitudinal ligament binds the epidural space anteriorly. The ligamenta flava and the periosteum of the laminae encompass the space posteriorly, whilst the pedicles of the spinal column and the intervertebral foramina encompass it laterally. (Elizaga, A.M. Illustrated notes in regional anaesthesia: Anatomy of the epidural space. October 1998. Available <http://depts.washington.edu/anesth/regional/epiduralspaceframes.html> (Accessed 12/12/2007). Figure 1 is an excellent preparation in the medial sagittal plane, showing the relevant anatomy. The epidural space communicates freely with the paravertebral space by way of the intervertebral foramina. Loose areolar connective tissue, semi-liquid fat, lymphatics, arteries, an extensive plexus of veins, and the spinal nerve roots as they exit the dural sac passing through the intervertebral foramina, are all contained within the epidural space. The epidural contents are arranged in a series of metameric and circumferentially discontinuous units, as separated by zones where the dura contacts the canal wall, as shown in Figure 2. However, the posterior epidural space becomes more continuous in the thoracic region.

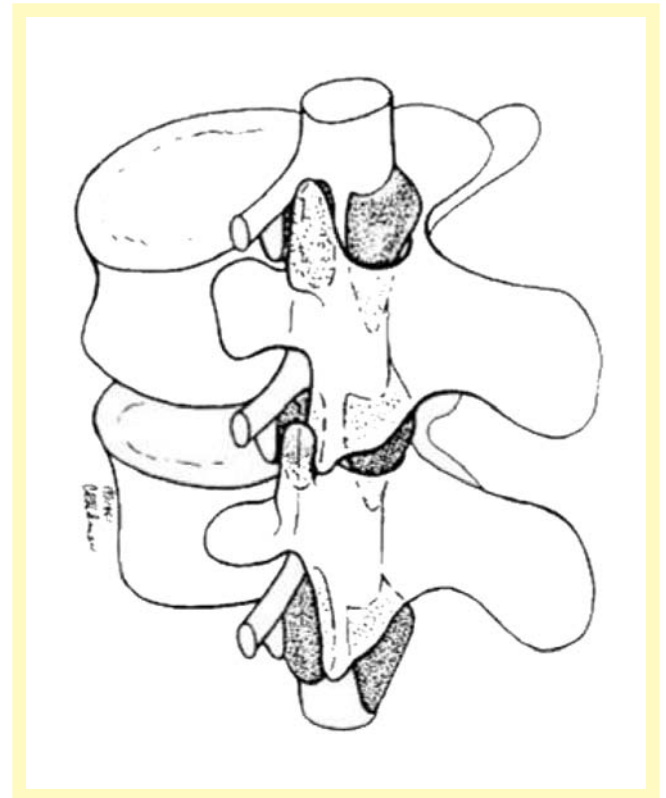
Figure 1: Medial sagittal preparation of the human spinal canal, with dura held slightly away from the spinal cord.



Posterior epidural space

The posterior epidural space is enclosed by two steeply arched ligamenta flava. The ligamentum flavum may not completely merge at the midline.¹⁷ The ligament extends laterally as far as the articular facets, and its thickness increases with distance down the column. Claims of a midline fibrous septum to the homogenous low viscosity fat of the posterior epidural space are not confirmed by cryomicrotome or histological examinations.¹⁷ In fact, the epidural fat is unique in the body in having no fibrous content.¹⁷ Traditional techniques have shown that the

Figure 2: A drawing of the compartments of the lumbar epidural space (stippled). The epidural contents are discontinuous circumferentially, and repeat metamericly. Where no contents are represented, the dura is in contact with the spinal canal wall. Adapted from Hogan, 1991.



anterior-posterior depth of the posterior epidural space varies with the vertebral level, ranging from 1–1.5 mm at C5, to 2.5–3 mm at T6, to its widest point of 5–6 mm at the L2 level.^{19,20} Indeed, when examined by cryomicrotome sectioning, there is no cervical posterior epidural content above C7.²¹

Lateral epidural space

The lateral epidural space communicates freely with the paravertebral space through the intervertebral foramina. The pia and arachnoid membranes are contiguous with the spinal nerve roots as they leave the spinal cord and exit through the intervertebral foramina, where they blend with the perineurium of the spinal nerves. The dura mater also extends over the nerve roots laterally, but becomes much thinner and blends with the connective tissue of the epineurium.

Dural barrier

The spinal dura mater extends from the foramen magnum to the second segment of the sacrum. The dura itself is made of a dense collection of collagen and elastic fibres. The traditional description of collagen fibres running in a longitudinal direction²² has been disputed by a number of studies of the dura using scanning electron microscopy that indicate that fibres of the dura run in neither a longitudinal direction nor parallel to each other.²³

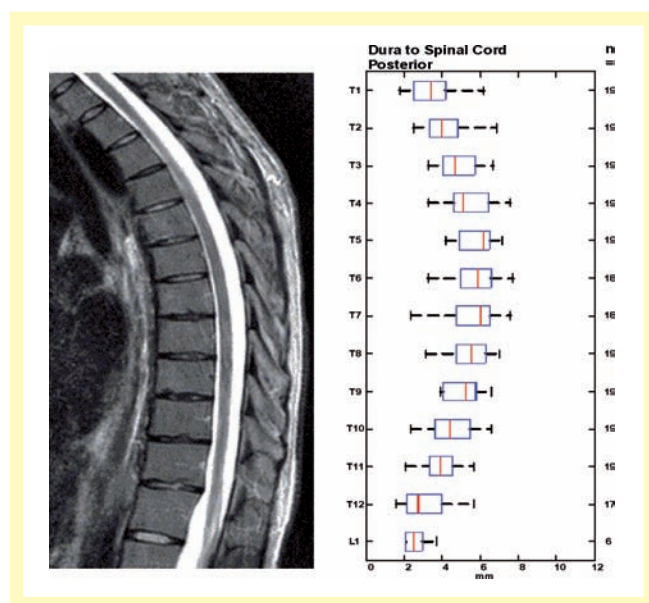
There is a large amount of variation in the cerebrospinal fluid (CSF) volume of patients. In addition, it has been shown that the volume of CSF in the lumbosacral region varies significantly in obese patients, presumably due to compression of the dura due to inward movement of soft tissue through the intervertebral foramina.²⁴ The same study shows that there is a reduction in CSF volume with abdominal compression. This is an important

consideration for pharmacological interactions of drug delivery in the parturient and obese patients. There is a possibility of greater than intended effects of drug delivery without anticipated dilution of the anaesthetic from an expected CSF volume. Indeed, the variability of CSF accounts for 80% of the variability of peak of block height and regression of sensory and motor block.²⁵

Relative geometry of spinal cord and surrounding thecal tissue

Results from MRI studies indicate that the spinal cord lies anteriorly within its thecal boundaries in the apex of the thoracic curve.²⁶ Essentially, the spinal cord follows the straightest line through the imposed geometry of the vertebrae. Figure 3 illustrates this relationship. Therefore, within the lumbar curve the cord is relatively posterior to its thecal boundaries. Therefore, intrathecal injections at thoracic levels may have a greater absolute margin of error before needle contact with neural tissue – although the consequences of inadvertent contact are possibly more disastrous. It is well known that the geometry of the processes dictates the angle of entry of the needle for mid-line neuraxial blockade, and this contributes to extra space between the dura and spinal cord posterior at thoracic levels.

Figure 3: Typical medial sagittal MRI scan of the thoracic spine (left) and box-plots (median, upper and lower quartile indicated) of the distance between the dura and spinal cord, posterior (right). Note the anterior positioning of the spinal cord in the thoracic curve, and relatively posterior position of the cauda equina lumbar. Adapted from Lee, Van Zundert and Breedveld, 2007.



How do injected solutions spread through the epidural space?

Using in vivo CT myelography, immediately after epidural injection large pools or accumulations of contrast are seen near the injection site that compress and distort the dural sac.²⁷ Hydrodynamic studies of fluids injected into the epidural space have yielded conflicting results: Some researchers have concluded that the epidural space acts as a Starling resistor;²⁸ however, others have found that fluid leaves the porcine epidural space via channels that are open and functional at low epidural pressure, and that there was no evidence for recruitment of additional pathways.²⁹ In the latter study, the authors suggest that after epidural injection, pressure does not immediately rise to a plateau value because the structures within the spinal canal are somewhat compressible. When epidural pressure exceeds epidural vein pressure, blood is displaced into the central venous circulation. In addition, a small volume of cerebrospinal fluid is displaced rostrally. This phenomenon has been demonstrated in clinical practice: Cephalad spread of sensory blockade after

intrathecal injection of local anaesthetic (LA) is increased when LA or saline is injected into the epidural space soon after the intrathecal injection.³⁰⁻³³

Cryomicrotome sectioning after epidural injection of ink, which by nature allows further distribution of injectate compared to myelography, has shown that solution injected into the epidural space spreads through numerous small channels between fat lobules, rather than a unified advancing front.³⁴ Therefore, the pattern of spread varies between the area close to the injection site and the margin of distribution, where fluid pressure is at its lowest. Furthermore, cryomicrotome sectioning has demonstrated that the lateral extension of the posterior longitudinal ligament (sometimes referred to as the fascia of the posterior longitudinal ligament) forms a barrier to injectate.³⁴ The fascia funnels injectate to the nerves in the intervertebral foramina, where it spreads along the spinal nerve sleeve and dorsal root ganglia. Indeed, it is possible that an important component of epidural block is due to the action of LA at these sites.

Fluids injected in the epidural space are evacuated through several mechanisms. As described above, a significant volume is lost through the intervertebral foramina. Furthermore, drainage by lymphatics, diffusion across the dura, and uptake in epidural veins contribute to the removal of epidurally injected agents.³⁵⁻³⁷

Central neuraxial techniques

Spinal anaesthesia (commonly the bolus delivery of anaesthetic intrathecally below the termination of the spinal cord) and epidural anaesthesia at any vertebral interspace, most often with the accompanied insertion of a catheter for intra-operative and postoperative pain management, are used frequently by most anaesthesiologists. Both are considered safe techniques with many indications to relieve pre-operative and postoperative pain, acute pain (trauma and obstetric patients) and chronic pain relief (e.g. in cancer patients). Despite the maturity of both techniques, there has been, in a mechanical sense, relatively minor innovation since their inception in the 19th century.³⁸

There are limitations to the suitability of neuraxial techniques for anaesthesia and pain management. Table I indicates the biochemical merits and possible restrictions of the respective anaesthesia techniques. The main difference between the techniques is the diffusion distance to the nerves, with epidural anaesthetics having to diffuse first through the meningeal barrier. A relatively modern technique that ideally combines the best features of both the above-mentioned methods, without including their weaknesses, is combined spinal-epidural (CSE) anaesthesia.³⁹⁻⁴¹ CSE anaesthesia generally involves the sequential delivery of spinal anaesthetic, followed by the placement of an epidural catheter – providing both the profound block of spinal, and adaptability of epidural techniques.

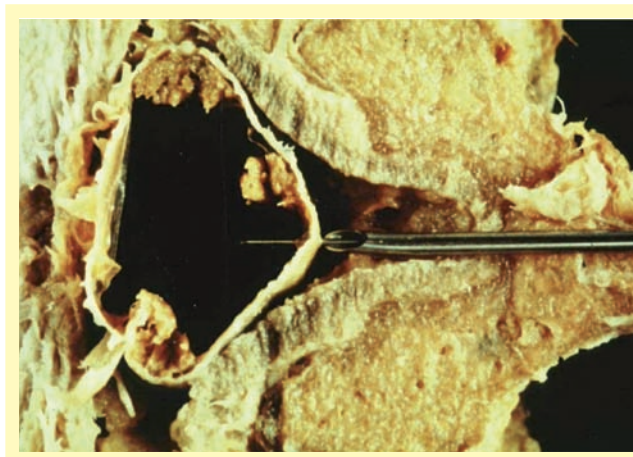
Applications of CSE technique in the lumbar region

The CSE technique (as shown in Figure 4) attained widespread popularity in obstetric anaesthesia worldwide, due to the rapid and reliable onset of analgesia, produced by the spinal component, resulting in high maternal satisfaction scores.^{42,43} The epidural catheter provides the traditional back-up, with either top-ups or a continuous infusion system, either to improve an insufficient spinal block or to restore an expired block.

Depending on the LA solution used, including opioids or other additions, a fast reliable spinal block develops, similar to a single shot spinal anaesthesia. However the CSE allows for dose reduction in order to obtain a limited regional anaesthesia block (limited extent of sensory blockade, often avoiding motor blockade) with minimal side effects for both mother and baby. Disadvantages of the CSE technique are that it is a technically more demanding, more expensive and more time-consuming technique compared to each of the techniques alone, and that only those with an advanced experience in spinal and epidural techniques should be allowed to use the technique.

Table I: Advantages and possible disadvantages of spinal and epidural anaesthesia techniques respectively

	<i>Advantages</i>	<i>Disadvantages</i>
<i>Spinal Anaesthesia</i>	<ul style="list-style-type: none"> • Rapid onset of the neural blockade (quick time to anaesthetise the patient) • Profound block • Low drug dosing 	<ul style="list-style-type: none"> • Single bolus (injection) nature means there is only a single opportunity to ensure correct anaesthesia • Unpredictable level of blockade
<i>Epidural Anaesthesia</i>	<ul style="list-style-type: none"> • Titratable (adjustable concentration) levels for pain management • Ability to prolong indefinitely • Good for postoperative pain management 	<ul style="list-style-type: none"> • Missed nerve segments (inconsistent block) • Incomplete motor blockade • Poor sacral (towards the tailbone) spread of the anaesthetic • Local anaesthetic toxicity to the tissue

Figure 4: Epidural Tuohy needle in situ, acting as a guide for the long spinal needle, which is positioned in the subarachnoid space.

CSE is not only feasible in obstetrics (vaginal and Caesarean deliveries), but is also a lucrative technique in ambulatory surgery, vascular, orthopaedic and general surgery, and urology. The sequential technique can be used in virtually all patients (excluding anticoagulated patients) who are operated on below the umbilicus, even if high-risk patients are involved. Postoperative pain relief using the epidural catheter further contributes to a fast rehabilitation with fewer complications.

Complications of CSE anaesthesia

Encountered problems in CSE techniques are similar to those of the components, including misalignment of the needles, incorrect delivery site of the anaesthetic (with subsequently toxic reactions or unexpected levels of [sensory] neural blockade), trauma to spinal blood vessels, Post-Dural Puncture Headache (PDPH), and paralysis.^{22,39,44-46} Despite a relatively low incidence of complications, the problems result in higher costs of care, increased morbidity for the patient, and restricted application of the techniques. The CSE technique complicates positioning of the needles in that it is not suitable to use loss of resistance to saline injection, the fluid of choice, for positioning of the epidural needle. This is because the saline may be wrongly identified as cerebrospinal fluid when inserting the spinal needle. In reviews of common regional anaesthesia techniques (excluding CSE), it has been noted that the epidural technique is the hardest to master: The anaesthesiologist often learns to successfully perform a lumbar epidural anaesthesia only after 40 to 70 procedures.⁴⁷ The CSE technique is even more difficult due to its added complexity.

Single epidurals are, contrary to single spinal injections, also performed above the lumbar region, often with the use of 16G or 18G Tuohy needles. It is well established that approximately

1% of epidural attempts accidentally perforate the dura mater. The incidence of serious neurological complications in epidural procedures is, however, far below that of the incidence of inadvertent dural tap.⁴⁴ This auspicious fact gives rise to the question of what safety margin might be associated with introduction of a spinal needle through the canula of a correctly positioned epidural needle for perforation of the dura and delivery of anaesthetic bolus spinally. When performing CSE techniques, the practising anaesthesiologist often has better recognition of the dural 'click', and can faithfully halt the spinal needle in the subarachnoid space, whilst avoiding contact with the delicate nerve fibres. Danger of nerve trauma from inadvertent contact with the needle and higher risks of paralysis preclude most anaesthesiologists from considering puncture of the dura above the termination of the cord.

Thoracic CSE anaesthesia

A pioneering application of CSE anaesthesia is the practising of the technique at thoracic levels. There are a number of advantages to delivering the (spinal) anaesthetic directly to the required heights in the body. Firstly, one of the most obvious advantages is that there is no blockade of the lower extremities, i.e. little caudal spread. This means that a significantly larger portion of the body experiences no venal dilation, and may offer a compensatory buffer to adverse changes in blood pressure intra-operatively. This is one of the major risks identified in surgery.⁵ Secondly, the dosing of the anaesthetic is exceedingly low, given the highly specific block to only certain nerve functions along a section of the cord. Thirdly, the degree of muscle relaxation achievable without central or peripheral respiratory or circulatory depression is superior to that with general anaesthesia. In addition, the danger of cardiac arrest is much diminished. This is an important consideration for the aging population (especially in Westernised countries) and the consequent increasingly greater danger of using general anaesthesia. Fourthly, the patients have motor control over their legs during the surgery, which in turn means many patients exhibit a high level of satisfaction with the technique and decreased anxiety.

How to perform a thoracic CSE technique

This section describes the technique used in Catharina Hospital, Eindhoven, the Netherlands, for the administration of thoracic CSE anaesthesia. In earlier studies, Van Zundert et al have chosen the tenth thoracic interspace, although more studies are necessary to identify the most optimal interspace.^{12,48} An example application is laparoscopic cholecystectomy, which, although usually performed under general anaesthesia, can be performed using the thoracic CSE anaesthesia as a regional technique with a number of potential advantages – as previously elucidated.

The patient is placed in either the left lateral recumbent position or the sitting position. Clear markings are made on the patient's back to define the exact thoracic interspace (T10-11). A nurse holds the patient stable, while the back of the patient is adequately prepared, taking care of full aseptic conditions, including draping. After infiltrating the area with a 2% lidocaine solution for local analgesia, the thoracic epidural space is identified using the 'loss

Table II: Indications and contraindications of thoracic CSE anaesthesia

Indications	Contraindications
Abdominal surgery: bowel, cholecystectomy, gastric operations, vascular operations	Major bleeding is expected
Caesarean sections	Abdominal surgery includes the pelvic region (e.g. prostate resection)
Difficult patients with contraindication for general anaesthesia	Operations below the inguinal groin (i.e. urological or orthopaedic surgery)
Surgeries requiring a conscious and/or ambulatory patient	Not suitable for patient to be conscious
Experienced anaesthesiologist with CSE techniques	Inexperienced anaesthesiologist
	No contraindication for general anaesthesia

Table III: Advantages and disadvantages of the thoracic CSE technique

Advantages	Disadvantages/Risk
Patient is awake	Shoulder pain (However, it is easy to prevent shoulder pain with the irrigation of 30 ml of 0.5% lidocaine solution above the liver region)
Avoidance of general anaesthesia and its sequelae (with possibility for anaesthetic management of traditionally very challenging patients)	Itching (Itching is due to the addition of opioids in the subarachnoid space)
Lower extremities can compensate for adverse changes in haemodynamics (e.g. blood pressure)	Higher risk of serious neurological sequelae following contact of spinal needle with neural tissue
Short stay	Haemodynamic effects: decrease in blood pressure and/or heart rate is possible by blocking the sympathetic nerves, including the cardiac nerves. Fluid therapy and vasopressors can overcome the problem
Operations possible on out-patient basis	
Fast recovery	

of resistance' technique to air method, with a midline technique. No saline is used as the seeker solution, as one needs to be absolutely sure that any fluid that comes back is indeed from the patient, and thus should be cerebrospinal fluid.⁴¹

Once the 16G Tuohy needle is in the epidural space, a long 27G pencil point spinal needle is used (e.g. CSE Cure™, Smiths Medical International Ltd, Kent, UK), as illustrated in Figure 5. The needle illustrated (which we use in our practice) has markings on the Tuohy needle that allow the user to know exactly how far the spinal needle protrudes beyond the tip of the Tuohy needle. During the introduction of the spinal needle through the epidural needle, the dura mater can often be felt, which gives a clear indication that the spinal needle should be inserted slightly further to enter the subarachnoid space. The last manoeuvre should be done carefully, with controlled, slow, forward advancement of the spinal needle. Contact with the spinal cord must, needless to say, be avoided. This is the MOST critical aspect of the procedure, and relies on the correct placement of the epidural needle: Assuming the epidural needle is correctly positioned, the anaesthesiologist should be able to perceive the fracture of the dura, and intrathecal placement of the spinal needle. Lack of CSF aspiration after the anaesthesiologist feels contact upon the spinal needlepoint, and fracture of that tissue should immediately terminate any attempt of the technique. Upon penetrating the dura, the spinal and the epidural needles are secured together by a locking device, by turning the spinal needle over the hub of the epidural needle. This ensures that the spinal needle does not move forward any further. Removing the stylet allows free aspiration of CSF – evidence of the dura mater perforation. When correct subarachnoid placement has been confirmed by a flow of clear CSF, an isobaric bolus

Figure 5: Tuohy needle with distance markings (in mm) on the epidural needle, and the longer spinal needle inserted through it. The handle of the spinal needle covers the hub of the Tuohy needle so that the protrusion of the spinal needle can be read, which is especially helpful once the needle has penetrated the dura.



consisting of 1 ml of plain bupivacaine 5 mg/ml with 0.5 ml of sufentanil 5 µg/ml is injected intrathecally. After removal of the spinal needle, the epidural catheter is threaded into place as usual. Once the Tuohy needle is removed, the epidural catheter is taped, leaving 4 cm of the epidural catheter in place. Immediately the patient is turned into the supine horizontal position for the

operation, while nasal oxygen $4 \text{ L}\cdot\text{min}^{-1}$ is started. Patients are normally kept in such a horizontal position, although adjustments of the operating table are possible. Avoidance of extreme degrees of head-down tilt will be more comfortable for the patient, and is not required for the procedure in our experience.

Should paraesthesia be encountered at any point during the procedure, retraction of the needles (both epidural and spinal) is necessary. At NO point should an injection be given, as this could be a sign of incorrect needle position, and may result in neural damage. NO epidural injections are given at this point either. Also NO test doses are given. If the spinal bolus has already been given and any further injections into the epidural catheter are needed, it should consist of small doses of a local anaesthetic solution, not exceeding test doses. The increased delicacy of a thoracic CSE technique requires utmost caution from the anaesthesiologist – and aversion for incorrect drug delivery exceeding standard neuraxial techniques.

Monitoring of the patient should be similar to other surgical interventions, including heart rate, blood pressure, and SpO_2 , with recordings every minute for the first 15 minutes, and every 5 minutes thereafter. The extent of the sensory blockade should be evaluated before the surgeon starts the incision, including testing the trunk and the upper and lower extremities. Motor blockade of the lower extremities should be assessed every 5 minutes until the start of surgery. At the end of surgery it is wise to note the extent of the sensory blockade and also assess any motor blockade of the lower extremities. Only when the block is considered adequate (minimum block extent includes the T4 to L2 dermatomes, evaluated by pinprick), the surgeon is allowed to start the procedure, using carbon dioxide insufflations and an intra-abdominal pressure limit of 12 mm Hg. Patients may follow the procedure on a monitor screen, if they wish to do so. Patients should be given the opportunity to convert to general anaesthesia (if appropriate), or to ask for sedatives and opioid analgesics if they express any dissatisfaction with the anaesthetic result. For anxiety, IV (intravenous) midazolam 2 mg aliquots can be given. Pain relief can be obtained with IV fentanyl 50 μg , and hypotension with IV ephedrine 5 mg boluses as required. Shoulder tip pain (often on the right-hand side) is a common problem after laparoscopic surgery (30–50%) under general anaesthesia,⁴⁹ most probably due to the acidic effects of CO_2 . Delivery of a lidocaine 0.5% solution in the peritoneal cavity above the liver may successfully obtund the origin of the pain.

As with standard CSE techniques, the epidural catheter can be used to give a top-up if the procedure lasts longer than expected and in case inadequate pain relief during the surgical intervention should occur. It is wise to give a top-up when the patient gives an indication of abdominal discomfort. Once the operation is finished, the epidural catheter can be removed, as pain relief with paracetamol and Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) is effective enough in the overall majority of patients.^{50,51} It is advocated to follow up the patient in the postoperative period to ascertain full recovery of all aspects of the neuraxial blockade.

Complications and side-effects

The new technique presented in this article is strictly reserved for experienced physicians who are familiar with all aspects of the CSE technique, whereby a good choice of the material is paramount. Until further evidence is available, the CSE technique at thoracic level with subarachnoid placement of the spinal needle above the level of termination of the spinal cord, requires great caution and should not be used routinely. The application of this technique should be restricted until much larger numbers of patients have been studied. Serious damage could occur if contact were made with nervous tissue (spinal cord) not involved in the transmission of sensations reaching conscious perception. Any development of paraesthesia should immediately warn the anaesthesiologist, who should cease giving any injections. As the cephalad and caudal spread of the local anaesthetic solution is limited and concentrated around the injection area, the subsequent sensory blockade also limits the sympathetic blockade; hence the impact on haemodynamic factors (blood

pressure) is lower. Bradycardia will only occur if all cardio-accelerator nerves are blocked, which usually will be the case if the upper extent of the sensory blockade is well above T4. A limited block as described from T4 to L2 will consequently lead to minimal cardiovascular changes. The differential blocking effect of bupivacaine may have been relevant, although fluid therapy and the use of vasopressors also play an important role.

Published studies using the thoracic CSE technique

Van Zundert et al published a case-report in which a patient with severely abnormal respiratory function (chronic obstructive pulmonary disease with severe emphysema attributed to homozygote α -1-antitrypsin deficiency), requiring continuous oxygen therapy, had frequent respiratory infections and severe functional impairment.¹² Even with minimal activity the patient developed hypoxaemia. Using the thoracic CSE technique, with a minute dose of local anaesthetic, cholecystectomy could be performed successfully, with no problems preoperatively. The patient was discharged from the hospital on Day 4 with no further deterioration of his pulmonary function. Figure 6 shows the patient ambulatory at the end of the operation. Anaesthesiologists occasionally are confronted with patients awaiting heart or lung transplantations because of terminal disease and requiring other types of surgical interventions, which are extraordinarily challenging for standard anaesthesia techniques. These challenging patients may be offered regional anaesthesia as a good alternative to general anaesthesia.

Figure 6: At the end of the operation, the patient is able to lift his lower legs and move himself unaided from the operating table into his own bed.



Van Zundert et al also performed a feasibility study in 20 patients, using the CSE technique in the lower thoracic region, and concluded that segmental spinal anaesthesia can be used successfully and effectively in laparoscopic surgery in healthy patients.⁴⁸ For the first time it was clearly demonstrated that segmental spinal anaesthesia is achievable, whilst avoiding caudal spread of the block to the lower lumbar regions of the spinal canal. Surgical patients included in the study, otherwise healthy, were all successfully operated on with minimal side effects, stable peri-operative haemodynamics and high satisfaction scores.⁴⁸

High-risk patients

Although formal studies have yet to be performed, we have practised the thoracic CSE technique (using the same approach as described above) in twelve patients with cardiovascular and/or pulmonary problems. Despite bad haemodynamic situations and/or severe end-stage lung problems, abdominal surgery (i.e. cholecystectomy, bowel and vascular surgery) could be performed successfully with the thoracic CSE method, with low impact on the patient. We believe that anaesthetic care of the patients would have been more difficult, with consequently larger impacts

on haemodynamic and pulmonary function, should these surgeries have occurred under general anaesthesia – the usual anaesthetic technique of choice. Although only one patient with severe lung disease was operated on successfully,¹² the several unpublished cases with cardiovascular and pulmonary problems were all successful, with no patients requiring conversion to general anaesthesia. Although the impact on the patients' haemodynamics was undoubtedly greater than in patients without such severe problems, the use of vasopressors was restricted to 25%. This patient group undoubtedly would also have received vasopressors if operated on under general anaesthesia, due to the lower cardiovascular and pulmonary reserves.

Questions

A valid query of the proposed thoracic CSE technique is why a CSE is not performed at lumbar levels, with subsequently greater administration of local anaesthetic to achieve the desired cephalad spread and height of blockade, usually T4. Simply, a consequence of the greater local anaesthetic volume would be development of caudal blockade with more impact on haemodynamics than when the segmental spinal block is limited to the thoracic region.

Another potential criticism of the thoracic CSE technique is that an alternative regional technique, single epidural catheter, could be employed to achieve the same anaesthetic quality and similarly mitigate the necessity of general anaesthesia. Some authors have used thoracic epidural,⁵² lumbar spinal,⁶ or even local anaesthesia³⁵ in a series of patients undergoing laparoscopic cholecystectomy. Usually these were patients with restrictive physiology, but they tolerated surgery well. Often surgeons complain of not obtaining sufficient muscle relaxation when straight epidural techniques are used. Spinal anaesthesia at the lumbar level can also be performed, at the expense of larger doses, more haemodynamic consequences, and some modifications of the surgical technique (i.e. use of N₂O in stead of CO₂, insertions of trocars only below the umbilicus, and gentle surgical manipulation during the operation). Not all patients studied by Hamad et al could successfully be operated on with their regional anaesthesia technique using the lumbar spinal approach. Applying local anaesthetics to the skin, subcutis, fascia and parietal peritoneum through trocar sites reduces postoperative analgesia requirements and pain intensity, although all patients still required general anaesthesia as well.⁵³

Conclusion

CSE techniques can be used in the thoracic region in patients who otherwise would receive general anaesthesia. General anaesthesia and single epidural techniques are also valid methods for many abdominal interventions. However, high-risk patients with limited cardio-respiratory reserves present challenges to the anaesthesiologist. The use of the thoracic CSE technique in the thoracic space extends the boundaries of regional anaesthesia. Only a constantly vigilant, experienced anaesthesiologist, well-versed in the CSE technique, should consider using this method – after carefully weighing the pros and cons, and in assurance of his or her ability to successfully carry out the procedure (AND stop should it not go according to plan!). Damaging the spinal cord hovers as the sword of Damocles over the CSE technique in the thoracic region. Only time and the benefits of the thoracic CSE technique will tell whether it will eventually enter widespread anaesthetic practice. SAJAA

Conflicts of Interest

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