EPIDURAL ANALGESIA – CURRENT VIEWS AND APPROACHES

Edited by **Sotonye Fyneface-Ogan**

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Preface

The World Health Organization defines pain as "an unpleasant sensory or emotional experience associated with actual or potential tissue damage, or described in terms of such damage". According to Baszanger, "[p]ain is a person's private experience, to which no one else has direct access and cannot be reduced by objectification, it cannot, ultimately, be stabilized as an unquestionable fact that can serve as the basis of medical practice and thus organize relations between professional and lay persons". Therefore pain, whatever the source, must be treated. Epidural analgesia has been extensively used to relieve pain of some regions of the human body.

Epidural analgesia is now frequently used to carry out postoperative and labor analgesia. First described in 1901 by Corning, the exploration of the epidural space is technically demanding and requires a good knowledge of the relevant anatomy and contents of the space.

The use of this space for various purposes in obstetrics has improved over the years. One publication by the American Society of Anesthesiologists Task Force on Obstetric Anesthesia illustrates consistent improvement of knowledge in this area. Epidural analgesia is produced with the use of low dose local anesthetics (such as bupivacaine, ropivacaine, lidocaine, levobupivacaine), opioids, or alpha agonists alone, or in combination. It is known to provide superior regional analgesia over conventional systemic routes (intravenous or enteral), with minimal systemic side effects (nausea, sedation, constipation). In low doses these local anesthetics produce more sensory block and with less motor block. However the aim of striking a difficult balance between the lowest motor block possible (to facilitate labour and vaginal delivery, and even allow ambulation) and an optimal analgesia could be a challenging one. Local anesthetic concentrations as low as 0.0625% bupivacaine have been used with fentanyl 20 micrograms for epidural analgesia for labor.

Generally speaking, agents injected into the epidural space are distributed by three main pathways: diffusion through the dura into the cerebrospinal fluid (CSF), then to the spinal cord or nerve roots; vascular uptake by the vessels in the epidural space into systemic circulation; and uptake by the fat in the epidural space, creating a drug depot from which the drug can eventually enter the CSF or the systemic circulation.

Epidural analgesia is a commonly employed technique of providing pain relief during labor. The number of parturients given intrapartum epidural analgesia is reported to be over 50% at many institutions in the United States and United Kingdom. While this figure is much lower in some developed countries, intrapartum epidural analgesia is almost non-existent in many parts of low resource countries as a result of the dearth of manpower and equipment. A survey of obstetric anesthesia in the United States indicated that the percentage of women given intrapartum epidural analgesia increased from 22% in 1981 to 51% in 1992 at hospitals performing at least 1,500 deliveries annually. The increased availability of epidural analgesia and the favorable experiences of women who have had painless labor with epidural block have reshaped the expectations of pregnant women entering labor.

Although epidural analgesia is the most widely used method of pain relief in childbirth it does not mean that the method is free of complications or contraindications, but these are considered to be of minor importance and a generally infrequent event. In general, the gains outweigh the losses and epidurals are now regarded as a safe method for both mothers and babies.

Pain from labor or otherwise does not involve only the patient, or the expectant mother, but their families and relations as well as the professionals who assist the patient and who give sense and meaning to the pain of others through compassion, acknowledgement and admiration; sentiments that the sufferer perceives and analyses as part of the meaning of such suffering, and which finally legitimizes it or not, gives it meaning or not, and therefore makes it seem "useful" or not. Pain must be relieved no matter the gender or the age!

Epidural analgesia has been well-known to confer excellent pain relief and complete dynamic analgesia leading to a substantial reduction in the surgical stress response. It provides favorable effects on coagulation and homeostasis, as well as on cardiorespiratory, gastrointestinal and immune functions, all these potential positive influences being theoretically translated into an improved quality of patient recovery.

Epidural analgesia can be administered by intermittent boluses (by a clinician or by patient controlled epidural analgesia (PCEA) using an appropriate pump); continuous infusion; or a combination thereof. PCEA is used to supplement a basal rate, to allow a patient to manage breakthrough pain in order to meet their individual analgesic requirements. Like Intravenous Patient Controlled Analgesia (IV PCA), PCEA can provide more timely pain relief, more control for the patient, and convenience for both the patient and nurse to reduce the time required to obtain and administer required supplemental boluses. Unlike IV PCA, the lockout interval of PCEA varies widely based on the lipid solubility of the opioid administered, from 10 minutes with fentanyl to 60 to 90 minutes when morphine is used. If local anesthetic is used, the lockout interval is taught to be at least 15 minutes to allow for peak effect of the supplemental local anesthetic dose.

Epidural analgesia has been found to be very useful for postoperative pain relief in paediatric patients. Some of the numerous benefits include earlier ambulation, rapid weaning from ventilators, reduced time spent in a catabolic state, and lowered circulating stress hormone levels. Specific protocols and guidelines tailored to suit the pediatric patients can increase the success of placement, optimize the efficacy of analgesia and increase overall safety. These specific epidural protocols are directed at how to confirm correct catheter placement, which type of age-specific infusion to use and how much is safe, and how to treat side effects. Epidural analgesia is useful as part of a multimodal approach to acute and chronic pain management in children. The single S+ isomers, ropivacaine and levobupivacaine, are the drugs of choice in pediatric practice. The reduced cardiac and central nervous system toxicity, and less motor blockade, suggest that these agents may be more beneficial, particularly in infants and neonates. The maximum suggested dosage for racemic bupivacaine (0.2mg/kg/h for infants and neonates, 0.4 mg/kg/ h for older children) has led to improved safety of continuous epidural infusions.

The administration of pharmacologic active agents to geriatric patients is complicated by the adverse conditions imposed by the aging process such as diminished functional activity, decreased metabolic rate, decreased function of liver and kidneys, increased sensitivity to anoxia and loss of blood, and increased drug sensitivity is likewise increasing in importance. Epidural analgesia has been found to reduce the intravenous opioid requirements in the geriatric population following surgeries of thoracic, upper abdominal, lower abdominal region.

Generally, epidural analgesia is time-consuming; it requires specific technical skills, pharmacological abilities and professional surveillance. Clearly, epidural analgesia is not devoid of risks and failures may occur.

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Anatomy and Clinical Importance of the Epidural Space

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1. Introduction

The epidural space is one of the most explored spaces of the human body. This exploration demands a good knowledge of the relevant anatomy and contents of the space. First described in 1901 (Corning JL, 1901), the epidural space is an anatomic compartment between the dural sheath and the spinal canal. In some areas it is a real space and in others only a potential space.

Various methods have been used to study the anatomy of the epidural space by investigators. Methods such as epiduroscopy in cadavers and patients, anatomical dissection, Magnetic Resonance Imaging (MRI), Computerized Tomographic epidurography (Yan et al., 2010), epidural injections of resins and the use of cryomicrotome sectioning in cadavers frozen soon after death (Hogan QH, 1991), have been used to demonstrate the inner layout of the space.

The use of the term 'space' has been controversial amongst anatomists. It is argued that the term would be more appropriate for the subarachnoid space than the epidural. It is claimed that the epidural space is not an open anatomical space whether in life or death. The only time a space is present is when the dura mater is artificially separated from the overlying vertebral canal by injection of contrast media or solutions of local anesthetics (Parkin & Harrison, 1985).

2. Embryology of the epidural space

Histological transverse sections of human lumbar spines of adults and fetuses aged 13, 15, 21, 32 and 39 weeks (menstrual age) were studied (Hamid et al., 2002). It was found that at the 13th week the epidural space had been filled with connective tissue and the dura mater was attached to the posterior longitudinal ligament. By the 13th week of embryonic development, three distinct stages had been formed and differentiate progressively within the connective tissue (Rodionov et al., 2010).

These are:

- the primary epidural space (embryos of 16-31 mm crown-rump length (CRL));
- reduction of the primary epidural space (embryos of 35-55 mm CRL);

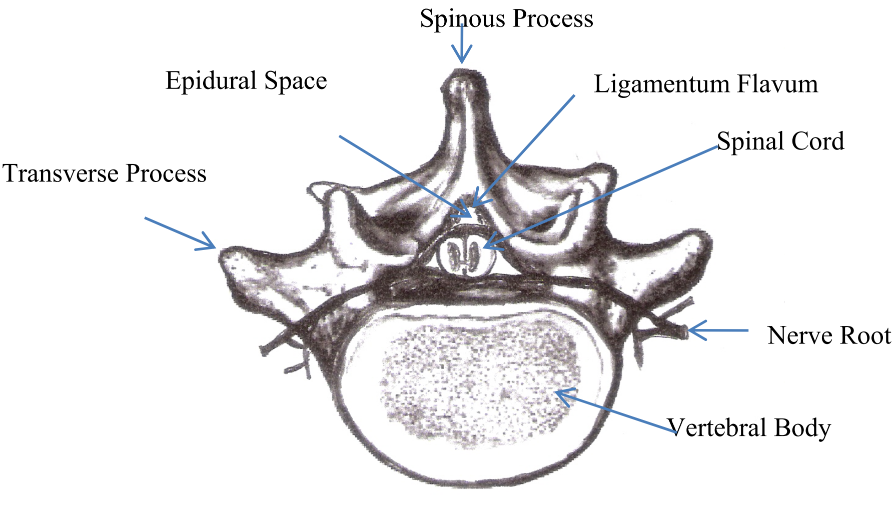
- the secondary epidural space (embryos of 60-70 mm CRL and fetuses of 80-90 mm CRL).

It has been found that the morphogenesis of the primary epidural space is determined by the formative influence of the spinal cord and its dura mater, while that of the secondary epidural space is determined by the walls of the vertebral canal (Rodionov et al., 2010).

Within this period of embryonic life, the posterior longitudinal ligament (PLL) attaches to the vertebral body beside the midline, and to the posterior edge of intervertebral disc. The anterior internal vertebral venous plexus is formed and located anterolaterally and anteromedially. At 15 weeks, the posterior longitudinal ligament develops better into deep and superficial layers. At 21 weeks, the attachment between the dura mater and PLL was ligament-like at the level of the vertebral body (Hamid et al., 2002). At 32 weeks, the dura mater was adherent to the superficial layer of PLL. At 39 weeks, groups of adipocytes begin to develop.

3. Anatomy

The vertebral column is made up of 24 individual vertebrae comprising 7 cervical, 12 thoracic and 5 lumbar while 5 sacral vertebrae are fused and the 3-5 coccygeal bones, though fused, remain rudimentary. These vertebrae house the epidural and the subarachnoid spaces.

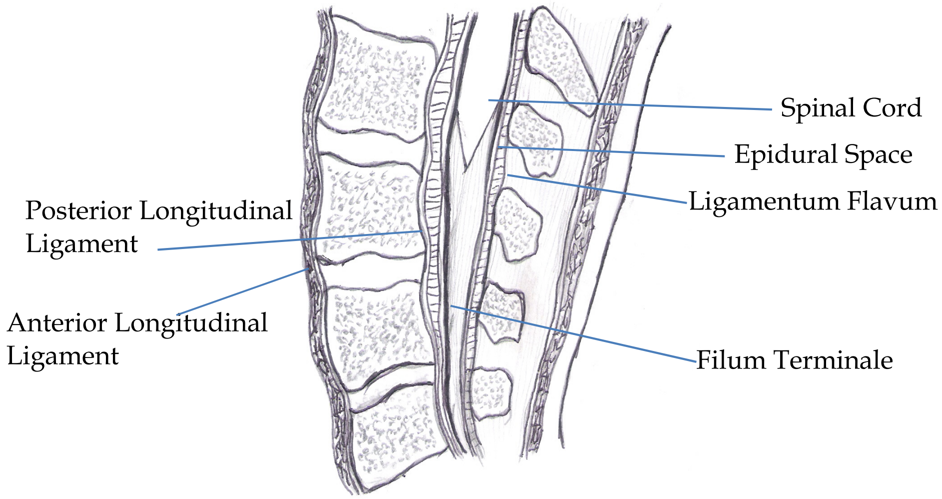


Transverse Section of the Lumbar Vertebra

3.1 Measurement of the epidural space

The epidural space is most roomy at the upper thoracic levels. The epidural space at the posterior space in the adult measures about 0.4 mm at C7-T1, 7.5 mm in the upper thoracic region, 4.1 mm at T11-12 region and 4-7 mm in the lumbar region, (Nickallis & Kokri, 1986). The space is far greater than that of the subarachnoid space at the same level. It takes about

1.5 – 2.0 ml of a local anesthetic to block a spinal segment in the epidural space while the volume (0.3 ml) is far less in the subarachnoid space for a similar block. It has been shown (Macintosh and Lee, 1973) that the paravertebral spaces, both serially and contralaterally, communicate with each other in the epidural space.



Sagittal section of the Lumbar Region

3.2 Shape and size of the epidural space

These are largely determined by the shape of the lumbar vertebral canal and the position and size of the dural sac within it. It has been suggested that though merely a potential space (Bromage, 1978) it could be up to 5 mm in depth (Husemeyer & White, 1980).

3.3 Types of epidural space

The epidural space can be categorized into cervical, thoracic, lumbar and sacral epidural spaces. These spaces can be defined according to their margins. At the cervical epidural space, there is a fusion of the spinal and periosteal layers of dura mater at the foramen magnum to lower margin of the 7th cervical vertebra. While the thoracic epidural space is formed by the lower margin of C7 to the upper margin of L1, the lumbar epidural space is formed by the lower margin of L1 vertebra to the upper margin of S1 vertebra. The sacral epidural space is formed by the upper margin of S1 to sacrococcygeal membrane.

3.4 Boundaries of the epidural space

The epidural space is bounded superiorly by the fusion of the spinal and periosteal layers of the dura mater at the foramen magnum. Inferiorly, it is bound by the sacrococcygeal membrane. The space is bounded anteriorly by the posterior longitudinal ligament, vertebral bodies and discs while the pedicles and intervertebral foraminae form the lateral boundary. The ligamentum flavum, capsule of facet joints and the laminae form the posterior boundary of the epidural space.

3.5 Pressure of the epidural space

The epidural space with the exception of the sacral region is said to be under negative pressure. The significance of the negative pressure has been a point of considerable argument. It has been hypothesized that the initial or 'true' negative pressure encountered when a needle first enters the epidural space could be due to initial bulging of the ligamentum flavum in front of the advancing needle followed by its rapid return to the resting position once the needle has perforated the ligament. The bulging has been confirmed to occur in fresh cadavers, and pressure studies carried out during performance of epidural blocks in patients lend weight to this hypothesis (Zarzur E, 1984).

Negative pressure can be magnified by increasing and reduced by decreasing the flexion of the spine. The negative pressure appears to be positive when the vertebral column is straightened. Depending on the position of the needle, two different components of negative pressure have been recognized. A basal value ranging from -1 to -7 cmH_2O could be observed when entering the epidural space. It remains stable providing the patient is well relaxed. An artefactual component up to -30 cmH_2O could appear if needle is further advanced against the dural sac (Usubiaja et al., 1967).

The epidural space identification is frequently dependent on the negative pressure within this space. It has been demonstrated that the epidural pressure is more negative in the sitting position than in the lateral decubitus position especially in the thoracic region. It therefore suggests that the space is better identified in the sitting position when the hanging drop technique is used to identify the epidural space (Gil et al., 2008).

3.6 The contents of the epidural space

This space contains semi-liquid fat, lymphatics, arteries, loose areolar connective tissue, the spinal nerve roots, and extensive plexus of veins. The epidural contents are contained in a series of circumferentially discontinuous compartments separated by zones where the dura contacts the wall of the vertebral canal (Hogan, 1998).

3.6.1 Fat

The distribution of the epidural fat has been studied. It is now known that the epidural space contains abundant epidural fat that distributes along the spinal canal in a predictable pattern (Reina et al., 2006). Fat cells are also abundant in the dura that forms the sleeves around spinal nerve roots but they are not embedded within the laminas that form the dura mater of the dural sac. The fat in the epidural space buffers the pulsatile movements of the dural sac and protects nerve structure, creates a reservoir of lipophilic substances, and facilitates the movement of the dural sac over the periosteum of the spinal column during flexion and extension. The epidural fat has a continuous pattern of distribution that assumes a metameric pattern especially in the adult human (Reina et al., 2006). Drugs stored in fat, inside dural sleeves, could have a greater impact on nerve roots than drugs stored in epidural fat, given that the concentration of fat is proportionally higher inside nerve root sleeves than in the epidural space, and that the distance between nerves and fat is shorter.

Similarly, changes in fat content and distribution caused by different pathologies may alter the absorption and distribution of drugs injected in the epidural space (Reina et al., 2009).