Caudal epidural anesthesia in pediatric cardiac surgery: A comparative study between the use of bupivacaine combined with fentanyl or clonidine versus the use of bupivacaine alone

Theses presented for partial fulfillment of MD in anesthesiology

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(قَالُوا سُبحَانَكَ لَا عِلمَ لَنَا إِلاَّ مَا عَلَّمتَنَا إِنَّكَ

أَنتَ العَلِيمُ الحَكِيمُ)

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CEB: Caudal epidural block

WDR: Wide dynamic range neurons

VIP: Vasoactive intestinal peptide

GABA: Gamma amino butyric acid

NRM: Nucleus raphe magnus

CPB: Cardio pulmonary bypass

ACTH: Adrenocorticotrophic hormone

CL: Clearance

VdSS: Steady state volume of distribution

ADRs: Adverse drug reactions

CNS: Central nervous system

CPR: Cardiopulmonary resuscitation

CSF: Cerebrospinal fluid

PDPH: Post dural puncture headache

vWF: von Willebrand factor

ADP: Adenosine di-phosphate

PAF: Platelet activating factor

PLA2: Phospholipase A-2

AT III: Antithrombin III

MAP: Mean arterial pressure

HR: Heart rate

Introduction

Pain is an unpleasant sensory and emotional experience. It is caused by noxious stimulation due to injury, diseases or surgery.

Caudal epidural analgesia is an excellent adjuvant to general anesthesia in pediatric patients. The use of regional is effective and safe in pediatric surgery if performed by properly trained anesthesiologists. It also allows early tracheal extubation in pediatric cardiac surgery which can minimize pulmonary complications, decrease pediatric intensive care unit (PICU) length of stay and possibly decrease hospital length of stay ***(Leyri et al.,2005)***.

When early tracheal extubation is planned, the anesthesia technique is adjusted for so-called fast-track management. Regional anesthesia in combination with general anesthesia may be valuable in congenital heart surgery, because it can decrease intraoperative opioid requirements and facilitate early extubation.

Many studies have found caudal anesthesia to be an effective and safe method for control of postoperative pain in children including those who have had open heart surgery; the main disadvantage being its short duration of action ***(Tripi et al., 2005)***. Even long acting anesthetic drugs such as bupivacaine provide only 4-8 hours of analgesia.

Prolongation of the duration of action caudal analgesia has been achieved by the addition of various adjuvants. ***(Eduardo et al., 2003)***

Fentanyl has been suggested being the opioid least likely to cause respiratory depression when administered caudally.

Also, clonidine, a partial alpha-2 adrenergic agonist, has been used as an additive for its beneficial sedative effects and inhibition of substance-P release. Clonidine acts through the activation of α2 adrenergic receptors in the medulla. Sympathetic nervous system outflow from the brain is decreased resulting in a decrease in blood pressure, heart rate and adrenergic activity ***(Lene et al., 2003)***.

Chapter 1
Anatomy of the caudal canal

CAUDAL EPIDURAL BLOCK

Caudal anesthesia has been used for many years and is the easiest and safest approach to the epidural space. When correctly performed there is little danger of either the spinal cord or dura being damaged.

Caudal or sacral epidural block is gaining wider publicity because of proven efficacy in pediatric patient pain management, acute & chronic pain management, spinal endoscopy & epidural adhesiolysis. Though caudal technique was reported earlier than lumbar technique, the first technique lost much of its clinical utility. This was because of inconsistent results secondary to inadequate understanding of anatomy.

APPLIED ANATOMY

The caudal (sacral) canal extends from the upper border of sacral bone (in relation to lumbar epidural space) to the sacral hiatus. Whole of this canal is enclosed in sacral bone.

Sacrum

The five sacral vertebrae unite to form sacrum. The sacrum articulates with fifth lumbar vertebra superiorly, coccyx inferiorly & iliac bones laterally. The anterior surface of sacrum has four paired openings for the exit of anterior rami of sacral nerves ***(figure 1).*** The posterior surface is convex & rough in nature because of fusion of vertebral elements. Median sacral crest runs over the posterior surface (thick crest represents the fused portions of sacral spinous process). The posterior surface has four pairs of foramina for escape of posterior rami of sacral nerves. These foramina are smaller when compared to anterior foramina. The laminae of fifth sacral vertebra (sometimes fourth also) fails to fuse; the resultant gap is called the sacral hiatus. On either side of sacral hiatus are the remnants of the inferior articular processes of the fifth sacral vertebra which are called the sacral cornua. The sacral hiatus is covered by sacrococcygeal membrane which is an extension of the ligamentum flavum and is pierced by coccygeal & fifth sacral nerves. Medial to sacral foramina intermediate sacral crest can be appreciated. They are formed by fusion of transverse process of sacral vertebrae. These crests end at sacral

cornua, which are also nothing but remnants of articular process of fifth sacral vertebra ***(Chen et al., 2004)***.

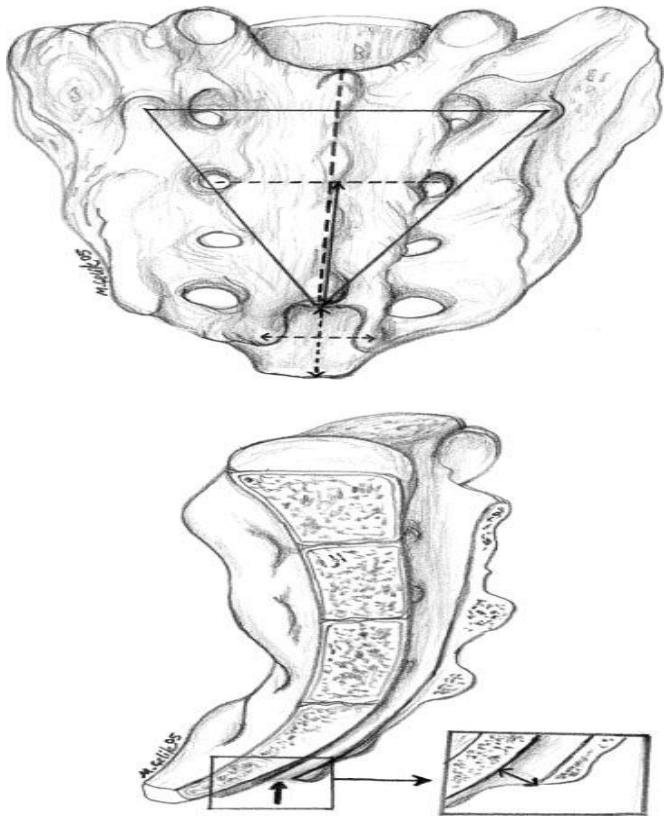

Figure 1: Anatomy of the sacrum, anterior and lateral view ***(Chen et al., 2004)***.

Coccyx

Coccyx, otherwise called tail bone gets attached superiorly to sacrum & inferiorly to anococcygeeal

ligament. Coccyx is actually made up of 3 to 5 vestigeal remnants of vertebrae. The inferior portion of coccyx is mobile & prone for fractures. Coccyx curves anteriorly & superiorly. Ganglion impar is situated at the junction of sacrum & coccyx.

Sacral (caudal) canal

This canal has a total volume of 30-35ml in adults after the contents have been evacuated (cadaver). The spinal cord ends at the lower border of L_1 vertebra, subsequently the sacral & coccygeal nerves pass to sacral canal as cauda equina. The dura ends at S_2 level & the pia continues as filum terminale to get attached to coccyx. The sacral nerve roots (upper four) anterior rami exit through anterior sacral openings & posterior rami through posterior sacral openings. As mentioned earlier, the fifth sacral nerve & coccygeal nerves traverse the canal & pierce through sacrococcygeal membrane to come out. The vertebral venous plexus continues into sacral canal, they are more concentrated towards anterior surface. The remainder of the sacral canal is filled with adipose tissue, which is subject to an age-related decrease in its density. This change may be responsible for the transition from the predictable spread of