Introduction

Pain is a highly unpleasant sensory and emotional experience. Various pharmacological agents and analgesic delivery systems have been employed to avoid under-treatment of pain ***(Rowney et al., 1998).***

Treatment of acute pain is one of the most important tasks of perioperative pediatric anesthesia. Pain-relieving agents are usually administered on the basis of the concept of balanced analgesia, which involves a combination of analgesics with either synergistic or additive effects ***(Winter et al., 2008).*** Postoperative analgesia through the caudal route is considered to be the most appropriate and satisfactory analgesia for small children undergoing lower abdominal surgery ***(Aprodu et al., 2008).***

Over the years, various regional anesthetic procedures have gained popularity for postoperative analgesia because in addition to providing effective postoperative pain relief, they also reduce the requirement of general anesthesia intra-operatively without significant side effects ***(Menzies et al., 2009).***

The goal of post-operative pain relief is to reduce or eliminate pain with minimum side-effects and in our setup as cheaply as possible. Effective pain relief means a smooth postoperative period, increased patient compliance and an early discharge from hospital ***(Morgan et al., 1996).***

Langlade et al suggested that the postoperative pain treatment must be included in the anesthetic planning even before induction of anesthesia, adopting the idea of 'managing pain before it occurs' ***(Langlade et al., 1997).***

Caudal anesthesia is one of the commonly used regional blocks in children. This technique is a useful adjunct during general anesthesia and also for postoperative analgesia after lower abdominal operations ***(Khalil et al., 1999).***

Administration of a single agent for caudal block with a high dose may provide a satisfactory analgesia but may cause side effects i.e. hypotension, respiratory depression etc. To overcome this problem, two agents with low doses may prove superior in achieving effects i.e. prolonged effect and minimal side effects. To overcome this problem, two agents with low doses may prove superior in achieving effects i.e. prolonged effect and minimal side effects. Ketamine, clonidine and various opioids have been combined with bupivacaine with varied degrees of success ***(Nagiub et al., 1991).***

Bupivacaine is the most commonly used local anesthetic in caudal anesthesia in pediatric practice, and it provides reliable, long-lasting anesthesia and analgesia when given via the caudal route. However, the mean duration of surgical analgesia provided by local anesthetics is limited and thus single shot caudal anesthesia is indicated only for surgery expected to last less than 90 min ***(Prakash et al., 2006).***

The administration of opioids into the epidural space prolongs the duration of caudal analgesia Tramadol, a synthetic analogue of codeine, is a racemic mixture of two enantiomers: The (+) enantiomer has a moderate affinity for the μ receptor and also inhibits serotonin uptake, while the (-) enantiomer is a norepinephrine inhibitor ***(Raffa et al., 1993).***

Tramadol is a centrally acting analgesic which has been licensed for use in children older than 1 year of age in many of European countries since 1977. Tramadol has been shown to provide effective, long-lasting analgesia after epidural administration in both adults and children.

These properties result with an analgesic potency equal to that of pethidine, but without any respiratory depressant effect ***(Vickers et al., 1992).***

Recent studies have shown that single dose of tramadol with or without bupivacaine provide effective analgesia intra-operatively that extends well into the post-operative period without any serious side effects10. Different doses of tramadol have been administered caudally to evaluate the analgesic efficacy in providing post-operative pain relief ***(Shrestha et al., 2010).***

Aim of the Work

The aim of the study to compare caudal analgesia with bupivacaine and bupivacaine plus tramadol, and asses if tramadol can be effective and safe adjuvant to bupivacaine for providing postoperative analgesia in children undergoing lower abdominal surgeries.

Review of Literature

I. STRESS RESPONSE

Stress responses to surgical trauma and postoperative pain elicit changes in hormonal secretion **(*Figure 1*)** ***(Solak et al., 2000)***.

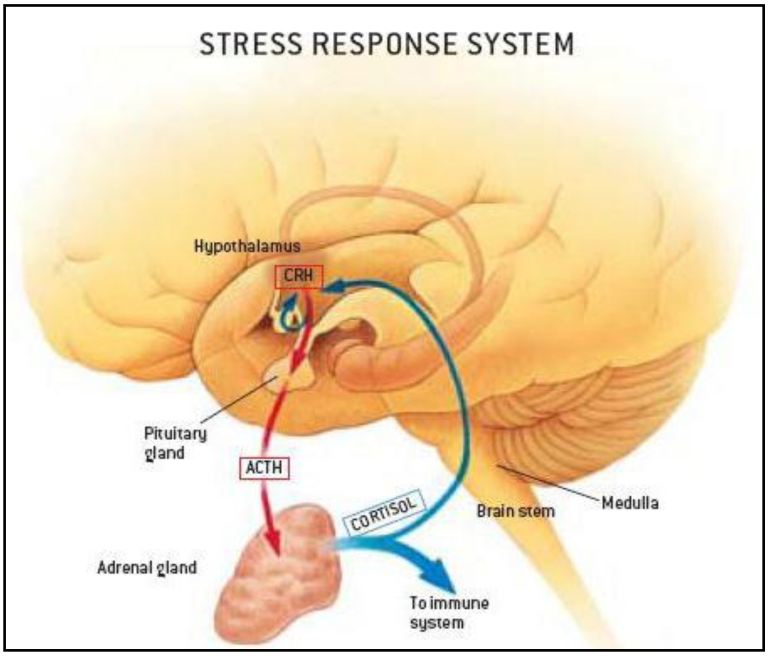

Figure (1): Stress response system ***(Bozkurt et al., 2000)***

Surgical trauma is associated with endocrine stress responses characterized by hyperglycemia, an increase in adrenocorticotropic hormone, cortisol, prolactin, antidiuretic hormone, growth hormone, catecholamines, angiotensin II, aldosterone, glucagons, IL-1 and lactate, and decrease in insulin and testosterone, as well as metabolic stress responses via the activation of the sympathetic and somatic nervous system ***(Bozkurt et al., 2000).***

The net effect of increased levels of the previously mentioned hormones is to promote the provision of substrates from the catabolism of stored fuels for a maximum chance of survival ***(Kehlet, 1998).***

The neuroendocrine stress response has both an afferent and an efferent pathway as well as a central integrative component ***(Kehlet, 1998)***.

Pain, both somatic and visceral, represents the major afferent pathway. The efferent pathways of the neuroendocrine response include sympathetic nervous system activation as well as the release of a host of neuroendocrine hormones ***(Hagen et al., 1980)***.

These responses begin during surgery with elevated stress hormones maintained for days after. There are a number of potential adverse physiologic sequelae of surgical trauma and unrelieved pain that relate in varying degrees to the neuroendocrine stress response. These include; (1) cardiovascular stress, (2) autonomic hyperactivity, (3) tissue breakdown (production of a catabolic state with suppression of anabolic hormones), (4) increased metabolic rate, (5) pulmonary dysfunction (most significant after upper abdominal and thoracic surgery), (6) increased blood clotting (hypercoagulability), (7) fluid retention, (8) dysfunction of the immune system, (9) delayed return of bowel function (ileus). The adverse physiologic sequelae of surgical trauma that relate more directly to the neuroendocrine stress response include hypertension, tachycardia, protein catabolism, immune system suppression, and impaired renal function***(Kouraklis et al., 2000)***.

More directly as a consequence of the neuroendocrine stress response, blood glucose concentration increases as a result of increased hepatic glycogenolysis and gluconeogenesis prompted by increased cortisol and catecholamines. In addition, peripheral use of glucose is decreased. It is now established that poor glucose control is associated with increased wound infection and impaired wound healing. Another adverse effect is protein catabolism, which is influenced by increased cortisol concentrations ***(Kouraklis et al., 2000)***.

The breakdown products from skeletal muscles and to a lesser degree, from visceral muscle proteins are used by the liver either to synthesize acute-phase proteins or to be converted to other fuel substrates. Significant protein catabolism results in marked weight loss and muscle wasting in patients after major surgical and traumatic injury ***(Kouraklis et al., 2000)***.

Increased lipolytic activity stimulated by cortisol, catecholamines and growth hormone, results in mobilization of triglyceride to form glycerol and fatty acids, which in turn provides substrates for gluconeogenesis or ketones. Increased arginine vasopressin and aldosterone secretion may result in salt and water retention, supporting the preservation of adequate body fluid volumes ***(Kouraklis et al., 2000)***.

Accordingly, interventions that modify or reduce the severity and duration of the surgical stress response are more successful in completely blocking these responses when they are less severe ***(Kouraklis et al., 2000)***.

II. VERTEBRAL COLUMN

The spine is composed of the vertebral bones and fibro cartilaginous intervertebral disks. There are 7 cervical, 12 thoracic and 5 lumbar vertebrae. The sacrum is a fusion of 5 sacral vertebrae, and there are small rudimentary coccygeal vertebrae. At each vertebral level paired spinal nerves exit the central nervous system ***(Figure 2) (Kleinman and Mikhail, 2006)***.

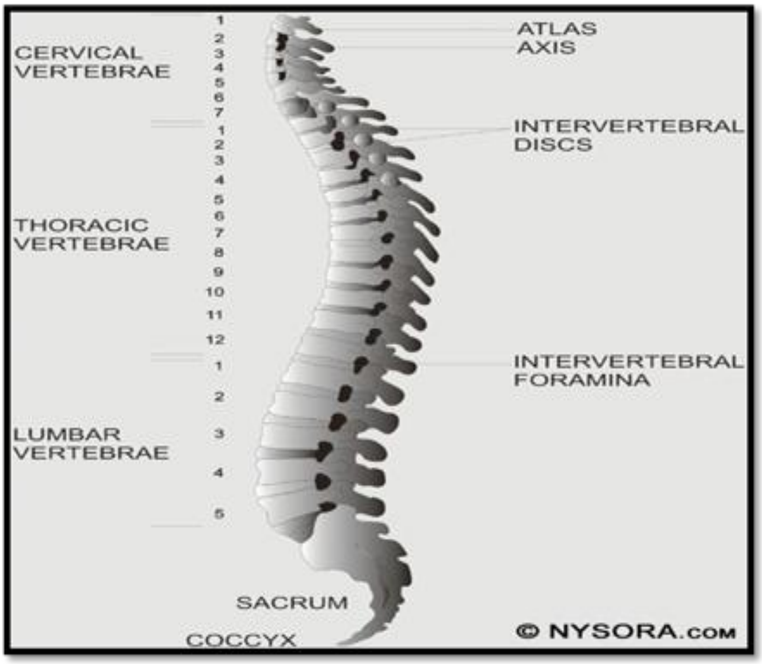

Figure (2): Vertebral Column ***(Brown, 2005).***

The spinal canal contains the spinal cord with its coverings (meninges), fatty tissue, and a venous plexus. The meninges are composed of three layers: the pia mater, the arachnoid mater, and the dura mater. The pia mater is closely adherent to the spinal cord, whereas the arachnoid mater is usually closely adherent to the thicker and denser dura mater ***(Brown, 2005).***

The spinal cord extends from the foramen magnum to the level of L3 in pediatrics. The anterior and the posterior nerve root at each spinal level join one another and exit the intervertebral foramina forming spinal nerves from C1 to S5. Because the spinal cord normally ends at L3 in pediatrics, lower nerve root course some distance before exiting the intervertebral foramina. These lower spinal nerves form the cauda equina (horse tail). Therefore, performing a lumbar (subarachnoid) puncture below L3 in a child avoids potential needle trauma to the cord, damage to the cauda equina is unlikely as these nerve roots float in the dural sac and tend to be pushed away (rather than pierced) by an advancing needle ***(Brown, 2005)***.

As a child grows older, nerve diameter increases along with more connective tissue in the endoneurium. This accounts for longer onset time but prolonged duration of a block in adults versus children ***(Bosenberg, 2004).***

Anatomical landmarks:

The sacrum is roughly the shape of an equilateral triangle, with its base identified by feeling the two-posterosuperior iliac processes and a caudal summit corresponding to the sacral hiatus. It is concave anteriorly. Its dorsal aspect consists of a median crest, corresponding to the fusion of sacral spinous processes. Moving laterally, intermediate and lateral crests correspond respectively to the fusion of articular and transverse processes. The sacral hiatus is located at the caudal end of the median crest and is created by failure of the S5 laminae to fuse ***(Figure 3)***. The hiatus is surrounded by the sacral cornua, which represent remnants of the inferior S5 articular processes and which face the coccygeal cornua. Palpation of the sacral cornua is fundamental to locating the sacral hiatus and to successful caudal block. The sacral hiatus is the shape of an inverted U, and is covered by the sacro-coccygeal ligament, which is in continuity with the ligamentum flavum. It is large and easy to locate until 7-8 years of age. Later, progressive ossification of the sacrum (until 30 years old) and closing of the sacro-coccygeal angle make its identification more difficult ***(Adewale et al., 2000).***

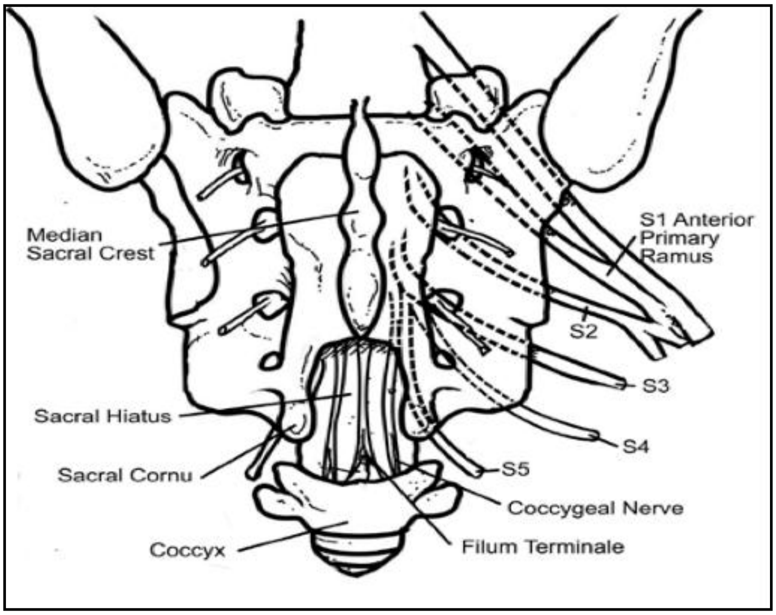

Figure (3): The posterior aspect of the sacrum and sacral Hiatus ***(Adewale et al., 2000).***

Sacral canal:

The sacral canal is in continuity with the lumbar epidural space. It contains the nerve roots of the cauda equina, which leave it through anterior sacral foraminae. During caudal block, leakage of local anesthetic agent through these foraminae explains the high quality of analgesia, attributable to diffusion of local anesthetic along the nerve roots. Spread of analgesia cannot be enhanced above T8-T9 by increasing injected local anesthetic volume. The dural sac (i.e. the subarachnoid space) ends at the level of S3 in infants and at S2 in adults and children. It is possible to puncture the dural sac accidentally during caudal anesthesia, leading to extensive spinal anesthesia. Therefore the needle or cannula must be cautiously advanced into the sacral canal, after crossing the sacro-coccygeal ligament. The distance between the sacral hiatus and the dural sac is approximately 10mm in neonates ***(Adewale et al., 2000).***

Segmental arteries supply the spine (including the vertebral bodies, paraspinal muscles, dura and nerve roots) and the spinal cord with blood. The bony spine is supplied by anterior and posterior central arteries that arise directly from the segmental and radicular arteries ***(Krings et al., 2007).***

The anterior spinal artery travels along the anterior sulcus and typically originates from the two vertebral arteries, whilst the typically paired posterolateral spinal arteries originate from the preatlantal part of the vertebral artery or from the postero-inferior cerebellar artery. These three arteries are not capable of feeding the entire spinal cord; instead, they are reinforced from the anterior radiculomedullary and posterior radiculopial arteries that derive from various segmental levels ***(Grunwald et al., 2001).***

The anterior radiculomedullary artery is known as the artery radiculomedullaris magna (i.e. the Adamkiewicz artery). The anterior radiculomedullary arteries branch in a very typical way to reach the spinal cord. The ascending branch continues along the direction of the radicular artery in the midline of the anterior surface. The descending branch, being the larger one at thoracolumbar levels, forms a hairpin curve as soon as it reaches the midline at the entrance of the anterior fissure ***(Krings et al., 2007).***

The venous drainage of the cord is via radially symmetric intrinsic spinal cord veins and small superficial pial veins that open into the superficial longitudinal median anastomosing spinal cord veins. These veins are following more or less the arteries, the anterior and posterior median spinal veins; drainage of blood from the spine occurs through the valveless internal and external venous vertebral plexus that is connected to the azygos and hemiazygos venous systems ***(Grunwald et al., 2001).***

III. PEDIATRIC CAUDAL BLOCK

Caudal block is an epidural anesthesia of the cauda equina roots in the sacral canal, accessed through the sacral hiatus. Caudal block is a common pediatric regional technique that is quick to learn and easy to perform, with high success and low complication rates. In children, caudal block is most effectively used as adjunct to general anesthesia and has an opioid-sparing effect, permitting faster and smoother emergence from anesthesia ***(Dalens and Hasnaoui, 1989).***

Caudal block is widely used in pediatric anesthesia practice for orthopedic, lower abdominal, and genitourinary surgical procedures, with the advantages of ease of application, reducing the requirement of inhalational anesthetics, and providing effective postoperative analgesia. These benefits are especially important in ambulatory and day surgery patients because it reduces analgesic requirements and facilitates early discharge ***(El Hamamsy et al., 2008).***

It has been demonstrated that pre-surgical caudal block attenuates the stress response of anesthesia and surgery and decreases postoperative narcotic use **(*Dalens, 2000*).**

In children less than 8 years of age**,** clinically significant changes in blood pressure are generally not seen with the sympathectomy associated with neuraxial anesthesia. This obviates the need for volume loading prior to performing epidural or subarachnoid blocks. The reason for this blood pressure stability is not defined but may possibly be related to the reduced resting sympathetic tone in children when compared to adults ***(Dalens, 2000).***

The physiological differences in the pediatric population affect the pharmacology of both ester and amide local anesthetics. Ester local anesthetics are metabolized by plasma cholinesterases. The plasma enzyme levels in children less than 3 months of age are decreased when compared to adult values but this is not clinically significant. Amide local anesthetics are primarily protein bound in the plasma via albumin and α1-glycoprotein**,** both of which are decreased in neonates and infants. This leads to higher levels of free drug in the plasma which is physiologically active and responsible for the possibility of cardiac and central nervous system toxicity. Infants less than 6 months of age have about half of the protein binding of older children and adults ***(Klimscha et al., 1998).***

Maximum doses of amide local anesthetics should therefore be reduced by 50% in this age group. It is also