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Study on Epidural Analgesia during Labour to Control Labour Pain

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Abstract

The severity of labour pain was recognized by the Romans, who termed delivery the *poenamagna – the* "great pain" or "great punishment." Pregnancy, though is one of the most pleasant part of a woman's life is marred by the anxious awaiting of a painful labour. Although labour is painless in a few women, the vast majority considers it painful, and a clear majority rates it as severe pain. Melzack, one of the authors of the gate control theory of pain, developed a questionnaire to assess the intensity and emotional impact of pain. Using this tool, he observed that labour pain was rated as more painful than cancer pain and that, among nulliparous women with no prepared childbirth training; it was nearly as painful as amputation of a digit without anaesthesia.Traditionally a number of techniques have been employed to provide labour analgesia. But Epidural analgesia is considered to be the gold standard in labour analgesia.

Keywords: Poenamagna; Labour Pain; Epidural Analgesia.

Introduction

Among the current methods of obstetric analgesia, regional analgesia (the most widespread technique being epidural analgesia) offers the best effectiveness/safety ratio. Epidural anaesthesia is an effective means of providing analgesia during labour. The increased availability of epidural analgesia and the favourable experiences of women who have had painless labour with epidural block have reshaped the expectations of pregnant women entering labour. Compared with other forms of pain relief, epidural analgesia is associated with the highest level of maternal satisfaction.

Historical Review

Ancient Methods

Folklore, superstition, opposition from the church as well as members of the medical profession have all played a part in delaying the development of various techniques of pain relief. There is evidence that women have always sought relief from pain of childbirth by adopting various means and methods. These methods were mostly physical, psychological or pharmacological.

In Pago Pago, the strong men in the tribe were employed to assist the birth by pressing their heels into lower ribs of labouring parturients during the contractions.

Aburel and Cleland's discovery that uterine pathways entered the cord at 10^{th} and 11^{th} thoracic segments may have provided a pseudoscientific basis for this practice. Ancient Chinese employed opioids and soporific sponges for the relief of labour pains. Helen of Troy prepared herbal remedies that banished sorrow from the memory.

Hippocrates, the Father of Medicine, remarked "Divinumest opus sedaredolorem" (divine is the work to subdue pain). The new era of analgesia and

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anaesthesia was initiated in 1772 with Joseph Priestley's discovery of nitrous oxide.

Inhalational Methods

James Young Simpson was the first to use Ether to aid delivery of a dead foetus after internal podalic version on 19th January, 1847. He also used Chloroform for childbirth on 8th November, 1847. Nathan Colley Keep used Ether successfully for labour analgesia in April 1947. In February 1848 Gardner of New York used chloroform in obstetrics. On 7th April 1853, the successful administration of chloroform analgesia to Queen Victoria by John Snow for the birth of her eighth child, Prince Leopold is the most important milestone in the history of obstetric anaesthesia. In 1880 Stanislav Klikovich was the first to use a mixture of 80% nitrous oxide and 20% oxygen to provide analgesia for labour. In 1911 AE Guedel devised the first machine for self-administration of nitrous oxide and air in labour. Trichloroethylene was used in obstetrics for the first time in 1943 through Freedman's inhaler. This method was unreliable as some mothers received an apparent overdose. In 1933 Minnitt of Liverpool, designed a machine for the self-administration of N_2O and air in labour. In 1936 Wasley Bourne first used Divinyl Ether in obstetrics. In 1958 – Lucy Baldwin modified Walton's dental anaesthetic machine to allow the women self-administer varying concentrations of nitrous oxide. In 1961, Tunstall used a mixture of 50% nitrous oxide and 50% oxygen in one cylinder. In 1848 – Heeffelder first used Ethyl chloride. In 1953 – Virginia Apgar published description of a method to establish a simple, clear classification of newborn infants which can be used as a basis for comparison of the results of obstetric practices and types of maternal pain relief. Heaney first used Ethylene in obstetric practice and published a review article. In 1960 Artusio introduced Methoxyflurane which was widely used for obstetric analgesia. Concern about the depressant effects of all volatile agents on the foetus and gradual development of better techniques of pain relief in labour led to a decline in their use.

Parenteral Techniques

Parallel to the evolution of inhalational methods of pain relief in childbirth was the development of parenteral techniques. Parenteral techniques were pioneered by Alexander wood. 1860: Kormann administered Morphine to control the pain of labour by hypodermic needle. 1869: Oscar Liebreich used chloral hydrate. 1870: Guilbert used a combination of chloroform and morphine in obstetric practice. 1902: Von-Steinbuchel used a combination of morphine and scopolamine in labour to produce 'twilight sleep'. This method eventually fell into disrepute because of the high incidence of asphyxia neonatorum. 1923: Cleisz used barbiturates for labour. 1940: Benthen first used Meperidine in labour. 1954: Hershenson used chlorpromazine for labour analgesia because of its hypnotic effects. 1966: Filler and Filler used pentazocine to produce analgesia of rapid onset and short duration.

Rectal Preparations

1874: Pirogoff in Russia and Dupuy in France instilled Ether rectally. 1913: Gwathmey introduced Ether into the alimentary tract to produce analgesia. 1933: Gwathmey analgesia consisting of a combination of morphine and magnesium sulphate injected hypodermically and colonic Ether in a mixture of olive oil, alcohol and quinine was used.

Local Anaesthetic Techniques

1853: Alexander Wood refined a syringe for injections and began administration of drugs into the area of nerve trunks. He is referred to as the' Father- in-law' of nerve blocks. 1891: Qunicke described paramedian approach for performing lumbar dural puncture. 1899: August Bier used cocaine for spinal anaesthesia and was the first to describe post-dural puncture headache. 1901 The first caesarean delivery in UK using cocaine spinal anaesthesia was performed at Manchester Maternity Hospital. 1903: Braun used epinephrine in place of elastic bandages to decrease the rate of local anaesthetic absorption. 1937: Cosgrove and colleagues summarized the experiences of the use of spinal anaesthesia in labour. 1945: Tuohy modified Lemmon's technique using a ureteral catheter introduced into the subarachnoid space via a needle with a Huberpoint. 1908: Pudendal nerve block was first described by Muller via transperineal and trans- vaginal routes. 1926: Gellert described the paracervical nerve block for effective pain relief.

Epidural Technique

1901: Cathelin introduced caudal analgesia by injecting cocaine through caudal canal via sacral hiatus. 1909: Von Stoeckel used procaine in the caudal analgesia by injecting cocaine through sacral hiatus. 1930: Aburel traced the afferent pain fibres carrying the pain impulse from the uterus and

demonstrated that by blocking this plexus pain of early labour was relieved. 1931: Dogliotti, "Father of Obstetric Analgesia" rediscovered lumbar epidural loss of resistance technique. 1943: Greenhill used hyperbaric solutions with smaller doses for continuous spinal anaesthesia. 1949: Tosten Gordhindroduced lignocaine. 1957: Ekenstam synthesised Bupivacaine. The popularity of epidural anaesthesia was enhanced by headlines in the press proclaiming 'painless childbirth at last' after the Fourth World Congress of Anaesthesiogists in London in1968. Next was the concept of use of local anaesthetic and opioids either alone or in combination. Recent advance in the labour analgesia is the introduction of walking epidurals by using low concentrations of local anaesthetic making the parturient ambulant.

Review of Anatomy

Epidural space is the potential space between the spinal duramater and the periosteum and ligaments lining the vertebral canal. The duramater is made of two layers the endosteal and the meningeal layer. The two layers are closely fused within the cranium. Below the foramen magnum, these two layers are separate. The outer layer forms the periosteum lining the spinal canal. The inner layer forms the spinal duramater. Between these two layers is the epidural or the periduralspace. The epidural space is widest in the midline posteriorly with an average of 5mm between ligamentum flavum and the posterior surface of the spinal dura. The depth is slightly more, proximal to the inferior border of the lamina due to the obliquity of the vertebral lamina. Thus the epidural space is composed of a series of discontinuous compartments that become continuous when the potential space separating the compartments is opened up by injection of air or liquid. According to a study dorsomedian fibrous tissue connects the duramater and the ligamentum flavum in the lumbar region fairly frequently. Due to these fibrous strands, the injected fluid distends the space laterally rather than in the midline.This has been confirmed anatomically through epiduroscopy and epidurography. These fibrous strands are responsible for occasionally unilateral anaesthesia following apparently adequate epidural technique.

Table 1: Characteristics of Ligamentumflavum at Different Vertebral Levels

Site	Skin to Ligament (cm)	Thickness of Ligament(mm)
Cervical	-	1.5-3
Thoracic	-	3-5
Lumbar	3-8	5-6
Caudal	Variable	2-6

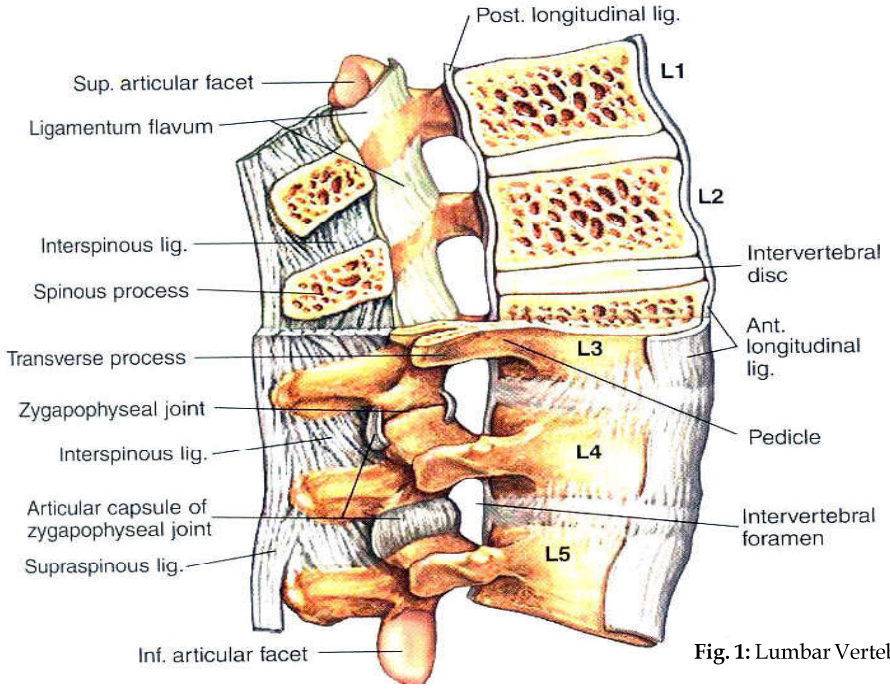

Fig. 1: Lumbar Vertebral Liagments

The epidural space is entered most safely and easily in the mid lumbar region.

The lumbar spine and the interspinous ligaments are widest in the mid-lumbar region making an easy land mark for insertion of the epidural needle.

Lateral View of Lumbar Vertebral Ligaments

Contents of Epidural Space

1. Fat: It is the ubiquitous material in the space and is highly vascular. The fat competes with the nervous tissue of the spinal roots, cord and blood vessels within the spinal cord for the drug. Drugs with high lipid solubility and lipoprotein binding characteristics tend to enter the fat phase and remain there for a period of time, depending on their pharmacodynamics and briskness of local blood flow competing for uptake.
2. Spinal arteries: The arteries that traverse the space arise from the vertebral, ascending cervical, deep cervical, intercostals, lumbar and ileo-lumbar arteries. They anastamose with those above and below and across the midline and lie mainly in the lateral parts of the epidural space.
3. Epidural veins: the venous plexus of the vertebral canal which drain the adjacent structures and the spinal cord lie in the anterolateral parts of the epidural space.

They form a network, which runs vertically within the epidural space. It can be subdivided into a pair of anterior venous plexus which lie on either side of the posterior longitudinal ligament into which basivertebral veins empty and a posterior venous plexus.

These are valveless (Batson's plexus) and afford a connection between the pelvic veins below with the intracranial veins above. These veins become distended during coughing and straining and also when the inferior venacava is obstructed by large abdominal tumours or in late pregnancy. When these epidural veins engorge, the epidural space is markedly reduced.

Aspiration tests may not always indicate intravenous position of a needle or catheter and subsequent injections of air or local anaesthetic will be carried directly to the heart. The appropriate dose of the drug should preclude this problem.

4. *Lymphatics*: The lymphatics run anteriorly from each intervertebral foramen. They drain the dural cul-de-sacs of the dural root sleeves and empty in the longitudinal channels in front of the vertebral column.

Connections between Epidural Space and Paraspinal Tissue Space.

The epidural space is not a closed space. Many of the tissue planes around the spinal canal connect to form an extended system of tracks.

There are 58 foramina in all. The areolar tissue around these foramina varies in density according to age. As age advances the soft and tenuous tissue undergoes increasing condensation to form a definitely recognizable structure. The fibrous tissue thickens and blocks the intervertebral foramina with aging.

This confines the solutions injected into the epidural space within the spinal canal and they escape less rapidly along the neurovascular bundles into the paravertebral spaces. Thus dosage should be reduced. The spread is greater in pregnant females.

Physiological Aspects of Epidural Space

Haldt and Moloney were the first to describe negative pressure in the epidural space in 1928. This negative pressure is maximum at points of firm attachments. It is maximum in the thoracic region, less in the lumbar region and least or absent in the sacral region.

Lower lumbar _ 0.5 cm H_2O

Upper lumbar _ 1.0 cm H_2O

Thoracic _ 1.0 to _ 3.0 cm H_2O

(Average_ 2.0 cm of H_2O)

Three theories have been put forth to explain the negative pressure.

1. The Cone Theory: Jonzen, 1926, Eaton in 1938 and Lawrence in 1948 put forward this theory. According to this theory, the needle introduced into the epidural space depresses the dura, creating a larger space. This theory was reviewed in the studies conducted by Aitkenhead in 1979 in experiments on dogs.
2. Transmission Theory: According to Macintosh and Bryce-Smith the negative pressure in the epidural space is caused by the transmission of the intrapleural negative pressure through intervertebral foramina to the epidural space. It varies with the depth of respiration. i.e., clinically this negative pressure will be diminished or absent if the patient is not relaxed or straining. Marked flexion at the spinal column increases the negative pressure. A rise in negative pressure may favour the spread of local anaesthetic solution in the epidural space.

3. *Flexion Theory:* This theory states that the negative pressure is directly proportional to the flexion of the spine.

Physiology of Pain in Labour

Pain is transmitted from the periphery by small 'A' delta and C fibres, the cell bodies of which lie in the dorsal root ganglia. From the dorsal horn central projections enter the grey matter. Except for a few A delta fibres that terminate in the marginal layer (Lamina I) the remainder synapse in the substantia gelatinosa (Lamina II), communicating by a series of interneurons with cells whose bodies reside in lamina V. These wide dynamic range neurons respond to both high intensity stimuli provoked by pain and also to low intensity light touch. Increased activity in these neurons results in impulse transmission in the anterolateral ascending columns.

Substance-P together with other peptides acts as neurotransmitter in the pain pathway. It is found in the cell bodies of dorsal root ganglia and released in the substantiagelatinosa in response to painful stimuli. The activity of a series of interneurons in the Lamina II inhibits substance-P release. These interneurons are activated by collaterals from the large sensory fibres and also by descending inhibitory fibres in the dorsolateral funiculus.

Stimulation of inhibitory neurons or opioid receptors in the substantiagelatinosa acts principally by reducing cyclic AMP levels in the opioid sensitive cells, resulting in presynaptic inhibition of release of substance-P and also by postsynaptic hyperpolarization of the dorsal horn neurons. Thus the increase in activity in Lamina V neurons and in the anterolateral ascending columns is prevented. Opioids are more effective in blocking activity produced by C than A delta fibres.

Labour – Anatomical and Physiological Aspects:

Labour is divided into 3 stages

The first stage: Begins with the onset of regular painful uterine contractions and ends at full dilatation of the cervix. Average duration in the primigravida is 8-10 hours and in multigravida 6-8 hours.The first stage of labour is divided into latent phase when the cervix slowly dilates upto 3 cm and an active phase when the cervix dilates from 3 cm to 10 cm.

The active phase is further divided into early active phase when the dilatation is upto 7 cm and the late active phase to full dilatation. During the active phase, the cervix dilates at the rate of about 1 cm per hour. The second stage: Extends from full dilatation of the cervix to the birth of the foetus and varies from a few minutes to about 2 hours. It is divided into the perineal stage and the expulsive stage.

The third stage: Is the period after the birth of the foetus to the expulsion of the placenta and membranes. The average duration is about 5 minutes

Prelabour: Prelabour is defined as the development phase of preparation for parturition. It occurs several weeks before the onset of true labour. The cervix begins to soften and dilate. Progesterone, oxytocin, prostaglandins (PGE2 and PGF2a), cortisol, prostacyclin, interleukin 8 and monocyte chemotactic peptide interact with each other producing the prelobour softening of the cervix.

The mother, the foetus and the placenta all contribute to the maintenance of pregnancy, the initiation of labour and finally the birth of the foetus. The key component in the initiation of labour is the foetal brain which influences the foetoplacental unit via the hypothalamopituitary –adrenoplacental axis.

The increase in the oestradiol levels at term causes a shift in the oestrogen to progesterone ratio in favour of estrogen, which leads to increase in the oxytocin sensitive receptors in the myometrium and decidua and activates amnion to produce prostaglandin. PGF2a is responsible for myometrial contractility. PGE2 is essential for cervical ripening. The main sources of these are the decidua for PGF2aand amnion for PGE2.

Uterine changes: The uterus is composed of smooth muscle (myometrium). During the transition from pregnancy to labour, the myometrial oxytocin sensitive receptors increase. There is increased frequency and amplitude of contraction of the myometrium and also increase in the concentration of myometrial gap junctions between these smooth muscle cells thereby facilitating synchronization.

Cervical changes: The cervix is mainly made of connective tissue collagen. Gradual softening of the cervix occurs 4 weeks prior to onset of labour (prelabour). This involves degradation of stromal collagen by changes in its proteoglycan complexes and increase in the water content of the ground substance leading to reduced tensile strength which eventually results in effacement and dilatation.

Foetal membranes: The decidua and the amnion are the main sources of arachidonic acid, the main precursor of prostaglandin. The decidua also produces prostaglandin synthetase enzyme.

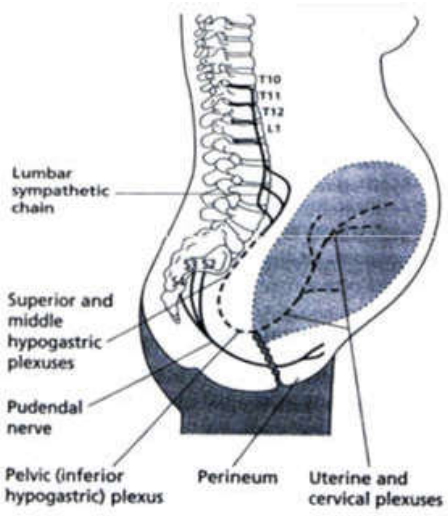

Fig. 2: Sensory Pathways

The Sensory Pathways Involved in Parturition

Beneficial Effects of Epidural Analgesia:

1. When analgesia is provided by opioids, the hyperventilation is decreased somewhat but the depressant effect of the opioid may still cause hypoventilation and hypoxia.1 Complete pain relief obtained with epidural analgesia prevents the transient period of hyperventilation during a contraction and thus prevents hypoventilation during uterine relaxation, so that the $PaCO_2$ remains in the range of 28-32 mm Hg and PaO_2 increases to 100 mm Hg.
2. Epidural analgesia, by blocking the nociceptive inputs and sympathetic efferents, reduces the release of catecholamines and cortisol. This reduces the work of the myocardium.
3. Epidural analgesia eliminates that portion of the increase in cardiac output and blood pressure which is caused by pain. It is thus beneficial to parturients, provided of course that maternal hypotension is avoided.
4. The relief of pain and anxiety with a continuous lumbar epidural analgesia decreases the total work of labour, maternal metabolism and oxygen consumption. Hence, it significantly reduces the maternal and foetal acidosis. In this aspect, epidural analgesia is far superior to the analgesia provided by systemic opioids.
5. Epidural analgesia blocks the reflex inhibition of gastric motility. Unlike opioids, it does not delay the gastric emptying. Thus it has a salutary effect on the gastrointestinal function as a whole.
6. Properly administered epidural analgesia will relieve most of the pain and thus obviate many of the psychological and emotional reactions to severe pain mentioned previously.
7. Effective analgesia, by reducing the sympathetic overactivity, can reduce or eliminate uterine hyperactivity or hypoactivity and can change incoordinate uterine contractions into a normal labour pattern. It also improves any placental hypoperfusion and any existing deterioration of uterine blood flow.
8. It has been shown that epidural analgesia, by its vasomotor blocking effect, increases intervillous blood flow in parturients. This is of value to all foetuses,but is particularly important to foetuses at risk such as those born to mothers with pregnancy-induced hypertension, heart disease and diabetes.

Maternal hypotension must be strictly avoided by appropriate prophylactic measures (e.g. intravenous infusion of fluids, leftward displacement of the uterus) to achieve these benefits.

Methods of Pain Relief in Labour

A variety of labour analgesia options are available, including psychoprophylaxis, transcutaneous electrical nerve stimulation (TENS), systemic medication, inhalational techniques and neuraxial blocks. In addition, other regional techniques such as caudal and paracervical blocks are used infrequently.

Psychoprophylaxis

"Natural childbirth" was a phrase coined by Grantley Dick-Read in 1933 who believed that childbirth was a painless procedure and did not need medical intervention. Fernand Lamaze popularised natural childbirth as an option for parturients. Other methods include hypnosis (which is effective in a small proportion of parturients but is not universally useful) and acupuncture (which does not seem to be of any use in labour).

Transcutaneous Electrical Nerve Stimulation

This is thought to reduce pain by nociceptive inhibition at a presynaptic leveling the dorsal horn by limiting central transmission. TENS is also thought to enhance the release of endorphins and dynorphins centrally. However, reports have failed to demonstrate its effectiveness in labour analgesia.

Systemic Medication

Opioids are the most commonly used class of drugs but they have various side effects like respiratory depression, nausea and vomiting and excessive sedation.

They cross the placenta freely and may cause respiratory depression in the newborn. The commonly used opioids include pethidine, fentanyl, butorphanol and remifentanil. Other systemic medications used in the treatment of labour pain include sedative-tranquilisers and ketamine.

Inhalational Analgesia

Inhalational analgesia involves the administration of sub anaesthetic concentrations of inhaled anaesthetics to relieve pain during labour. It provides a limited amount of pain relief. Entonox (50:50 N_2O/O_2 mixture) has been used for many years as both a sole analgesic and as an adjuvant to systemic and regional techniques of labour. Desflurane (0.2%), enfurane and isoflurane (0.2-0.25%) have also been used successfully.

Regional Analgesia Techniques

A variety of regional techniques are used in labour analgesia to provide optimal analgesia with minimal depressant effects.

Epidural Analgesia

Lumbar epidural analgesia offers a safe and effective method of pain relief in labour. Low doses of local anaesthetics and opioid combinations are administered to provide a T10-L1 sensory block. The benefits of epidural analgesia include effective pain relief without appreciable motor block and a reduction in maternal catecholamines.

Spinal Analgesia

A single shot subarachnoid injection of local anaesthetic or opioid provides effective and rapid onset of labour analgesia.

Combined Spinal-epidural Analgesia

The combined spinal-epidural (CSE) technique is widely used in obstetric practice and it offers effective, rapid-onset analgesia with minimum risk of toxicity or motor block. In addition, it provides the ability to prolong the duration of analgesia as required.

Conclusion

Epidural analgesia is used principally for pain relief during labour. It is estimated that some 20% of all parturients now receive epidural analgesia for pain relief in labour. Safe and effective relief of pain during labour and delivery accomplished by the skillful use of epidural analgesia prevents the stress response in the mother. Obstetricians and anaesthetists have always feared that incidence of instrumental deliveries in women receiving epidural analgesia could be higher than in those who do not receive it. Ideally pain relief with epidural techniques should be produced with the minimum disturbance to the progress of labour or to sympathetic functions, sensory functions (proprioception) and motor functions of the CNS. Thus it is intriguing to the obstetric anaesthetist to strike a balance between patient satisfaction by providing good analgesia, reduce motor block thus making the parturient participate in labour and decrease the instrumental deliveries due to prolonged second stage.

References

1. Breen TW, Shapiro T, Glass B, Foster-Payne D, Oriol N. Epidural anesthesia for labor in an ambulatory patient. AnesthAnalg. 1993;77(5):919-24.
2. Hodgkinson R, Husain FJ. Obesity and the cephalad spread of analgesia following epidural administration of bupivacaine for cesarean section. AnesthAnalg. 1980;59(2):89-92.
3. Stienstra R, Jonker TA, Bourdrez P, Kuijpers JC, van Kleef JW, Lundberg V. Ropivacaine 0.25% versus bupivacaine 0.25% for continuous epidural analgesia in labor: A double-blind comparison. AnesthAnalg. 1995;80(2):285-89.
4. Eddleston JM, Holland JJ, Griffin RP, Corbett A, Horsman EL, Reynolds F. A double-blind comparison of 0.25% ropivacaine and 0.25% bupivacaine for extradural analgesia in labour. Br J Anaesth. 1996; 76(1):66-71.
5. Muir HA, Writer D, Douglas J, Weeks S, Gambling D, Macarthur A. Double-blind comparison of epidural ropivacaine 0.25% and bupivacaine 0.25%, for the relief of childbirth pain. Can J Anaesth. 1997;44(6):599-604.
6. Owen MD, D'Angelo R, Gerancher JC, Thompson JM, Foss ML, Babb JD, Eisenach JC. 0.125% ropivacaine is similar to 0.125% bupivacaine for labor analgesia using patient-controlled epidural infusion. AnesthAnalg. 1998;86(3):527-31.
7. Kopacz DJ, Emanuelsson BM, Thompson GE, Carpenter RL, Stephenson CA. Pharmacokinetics of ropivacaine and bupivacaine for bilateral intercostal blockade in healthy male volunteers. Anesthesiology. 1994;81(5):1139-48.
8. Aberg G, Adler R. Thermographic registrations of some vascular effects of a local anesthetic compound. Swed Dent J. 1970;63(10):671-78.

9. Aberg G, Andersson R. Studies on mechanical actions of mepivacaine (Carbocaine) and its optically active isomers on isolated smooth muscle: Role of Ca++and cyclic AMP. ActaPharmacolToxicol. 1972;31(5-7): 321-36.
10. Aps C, Reynolds F. An intradermal study of the local anaesthetic and vascular effects of the isomers of bupivacaine. Br J ClinPharmacol. 1978;6(1):63-68.
11. Aberg G, Wahlstrom B. Vascular effects of mepivacaine. ActaPhysiolScand. 1969;330(Suppl):71.
12. B. Saichandana, G. Rachana sri, A. Surendar and B. Suniltej "controlling of wall lamp using arduino", International Journal of Pure and Applied Mathematics, 2017;116(24):349-354, ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version).
13. Segal S, Eappen S, Datta S. Superiority of multi-orifice over single-orifice epidural catheters for labor analgesia and cesarean delivery. J ClinAnesth. 1997; 9(2):109-12.
14. Surendar, A. Evolution of gait biometric system and algorithms- A review. Biomedical and Pharmacology Journal, 2017;10(1):467-472.
15. Vimalkumar, M.N., Helenprabha, K., Surendar, A. Classification of mammographic image abnormalities based on emo and LS-SVM techniques. Research Journal of Biotechnology, 2017;12(1):35-40.