Exploratory Laporotomy in a Neonate Under Spinal Anaesthesia

1*K. Malleswari, 2*Dr.D.Rama Brahma Reddy 3*Ch.Daveedu

*1 Dr. D. Rama Brahma Reddy, Department of phytochemistry, Nalanda institute of pharmaceutical sciences,Siddarth Nagar, Kantepudi(V), Sattenapalli(M),Guntur (DIST)- 522438,AP,India. malleswarikunchala105@gmail.com

*2 K.Malleswari, Department of pharmaceutics, Nalanda institute of pharmaceutical sciences,Siddharth Nagar, Kantepudi (V), Sattenapalli (M),Guntur(DIST)-522438,AP,India. malleswarikunchala105@gmail.com

*3 Ch. Daveedu, Student of B.pharmacy, Nalanda institute of pharmaceutical sciences, Siddharth Nagar, Kantepudi (v), Sattenapalli(M), Guntur(DIST)-522438,AP, India. malleswarikunchala105@gmail.com

ABSTRACT

Exploratory Laparotomy is a surgical incision utilised in both emergency and elective scenarios to gain access to abdominal surgery. General anaesthesia is usually necessitated due to the substantial insult of the approach and to facilitate organ relaxation and paralysis. However, this brings with it the need for an assessment of the suitability of the anaesthetic technique, with a large number of patients having comorbidities significant enough to exclude them from surgery. Locoregional anaesthesia, provided via spinal, epidural, or a combined approach offers a means of providing anaesthesia that places a reduced level of strain on patients' cardiorespiratory function. We review the existing literature on the topic of so-called "awake laparotomy" performed with locoregional anaesthesia and present a case series including both elective and emergency procedure. The first regional anesthetic technique performed was spinal anesthesia, and the first operation under spinal anesthesia was in 1898 in Germany by August Bier. Before this, the only local anesthetic techniques were topical anesthesia of the eye and infiltration anesthesia. The central nervous system (CNS) comprises the brain and spinal cord. Neuraxial anesthesia refers to the placement of local anesthetic in or around the CNS. Spinal anesthesia is a neuraxial technique in which local anesthetic is placed directly in the intrathecal (subarachnoid) space. This activity reviews the technique, contraindications, and indications of spinal anesthesia and highlights the interprofessional team's role in managing these patients.

Keywords: Exploratory laparotomy, epidural anaesthesia, spinal anaesthesia, locoregional anesthesia, awake laparotomy, laparotomy decision,Neuraxial anaesthesia.

INTRODUCTION

Spinal anaesthesia was described by Bier in children 1898. Bainbridge then described spinal anaesthesia in children aged 4 months to 6 years in 1901.Neonates with congenital or acquired anomalies require surgical intervention. Choice of anaesthesia is not confined to general anaesthesia which causes a greater risk of respiratory complication and postoperative apnoea. Spinal anaesthesia is popular for surgery in neonates and infants especially in the last 2 decades. It has not been limited to herniotomy, abdominal surgery and lower limb surgery but also for repair of meningomyelocele, ligation of patent ductus arteriosus.3Several Physiological effect of this technique provides an improved outcome.[1] It provides rapid onset with excellent muscle relaxation, desired hemodynamic stability, compatible with light sedation level to maintain protective airway reflexes and rapid recovery. Other benefit seen include altered coagulation, increased blood flow, and reduction in surgical stress response.[2]

Figure-1:Diagram of Spinal Anaesthesia

The central nervous system (CNS) comprises the brain and spinal cord. Neuraxial anaesthesia refers to the placement of local anaesthetic in or around the CNS. Spinal anaesthesia is a neuraxial technique where local anaesthetic is placed directly in the intrathecal (subarachnoid) space.[3] The subarachnoid space houses sterile cerebrospinal fluid (CSF), the clear fluid that bathes the brain and spinal cord. An adult human has roughly 130 to 140 mL of CSF, which continually cycles throughout the day. Approximately 500 mL of CSF is produced daily. Other neuraxial techniques include epidural and caudal anaesthesia, each having its particular indications. Spinal anaesthesia is only performed in the lumbar spine and is used for surgical procedures involving the lower abdomen, pelvis, and lower extremities.[4]

OBJECTIVES

- Identify the technique of spinal anaesthesia.
- Determine the indications of spinal anaesthesia.
- Identify the complications of spinal anaesthesia.
- Communicate the importance of improving care coordination among the interprofessional team to enhance the delivery of care for patients undergoing spinal anaesthesia.[5]

HISTORY OF SPINAL ANAESTHESIA IN NEONATES

In 1899, Bier authored a seminal paper on spinal anesthesia entitled "Experiment regarding the cocainization of the spinal cord. The use of spinal anesthesia remained a popular modality for lower extremity and abdominal surgeries until the 1940s. Improvements in the safety of general anesthetics and case reports of paraplegia related to spinal anesthesia made general anesthesia an appealing viable alternative [6].While a 1960 paper showing the safety of spinal anesthesia rekindled interest in adult spinal anesthesia, it was not until the 1980s that it regained popularity in the pediatric population. In 1984, Abajian described that spinal anesthesia was an effective alternative to general anesthesia in premature infants to avoid postoperative apnea (POA) and bradycardia.In December 2016, the Food and Drug Administration (FDA) issued a statement warning that "repeated or lengthy use of general anesthetic and sedation drugs during surgeries or procedures in children younger than 3 years or in pregnant women during their third trimester may affect the development of children's brains" (FDA 2017).

BACKGROUND OF SPINAL ANAESTHESIA

Spinal anaesthesia is a neuraxial anesthetic technique that consists of a single injection of local anesthetic into the subarachnoid space. The subarachnoid space, also known as the intrathecal space, contains cerebrospinal fluid (CSF). Depositing local anesthetic in the subarachnoid space provides a dense sympathetic, sensory, and motor blockade to the abdomen, pelvis, and lower extremities. Spinal anaesthesia is differentiated from caudal or epidural neuraxial anesthesia by the location of local anaesthetic, level of the block, and potency among another factor. Because the spinal anesthesia is used as a single shot, the duration is typically less than 90 minutes. Although not common in the U.S., many practices around the world routinely use adjuvants to prolong the duration of spinal anesthesia.[7]

RATIONALE FOR USING SPINAL ANAESTHESIA IN HIGH RISK NEONANTES

The target audience of published review articles on spinal anesthesia in infants are often directed towards other anesthesiologists. [8]In this article, we aim to highlight formation. relevant to other practitioners who may interact with infants receiving spinal anesthesia outside of the perioperative period (hospitalists, primary care providers, surgeons, neonatologist, etc.)

ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS OF SPINAL ANAESTHESIA IN NEONATES AND ADULTS

1.Dural Sac: Terminates at S3 and spinal cord at L3 vertebral levels, at birth. Adult level (S2 and L1 respectively) is not reached until 2nd year of life]. Intercristal line (Tuffier's line) still remains a reliable landmark similar to adults since in younger children, it passes through L4-5 /L5 –S1. Newborns have a narrow subarachnoid space (6-8 mm) and low CSF pressure, necessitating greater precision and avoidance of lateral deviation.

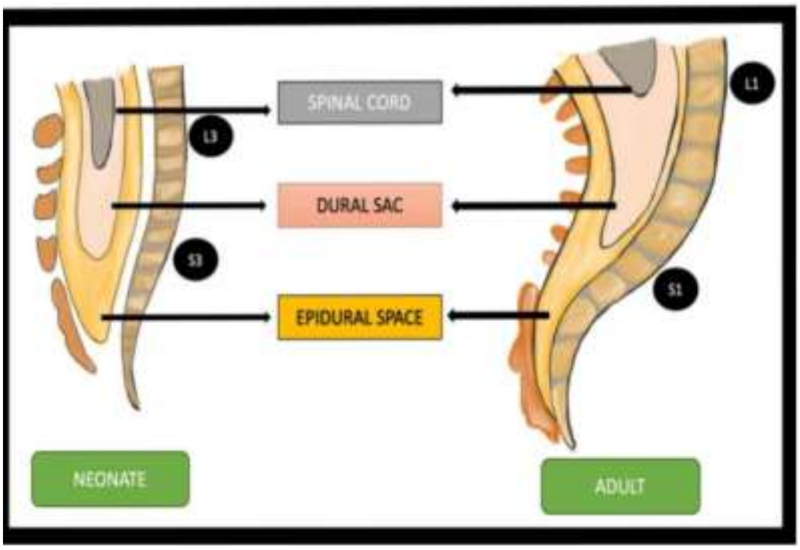
2.CSF: Children require higher dose of local anesthetic (LA) drug due to higher total CSF (neonates 10 ml/kg, infants and toddlers 4 ml/kg, adults 2 ml/kg) and spinal CSF volumes (50% in children vs. 33% in adults).[9]

3.Meninges: Highly vascular piamater and high cardiac output lead to rapid re-absorption of LA and shorter duration of block in children, explaining 30% prolongation of block by addition of epinephrine, unlike in adults.

4.Myelination: In children, endoneurium is loose, presenting little barrier to drug diffusion, with faster onset and offset of block.

5.Spine and Ligaments: Ligaments are less densely packed, and feel of loss of resistance is less marked. Increased spine flexibility limits normal thoracic kyphosis and facilitates cephalad spread and higher level of sensory block.

Figure-2:Anatomy and physiology of Neonates and Adult



6.CVS: Hemodynamic suppression following SA is absent in children due to a smaller peripheral blood pool, immature sympathetic autonomic system, and compensatory reduction in vagal efferent activity.Hence, preloading before SA is not a routine in children.[10]

7.Respiratory system: High levels (T2-4) of block reduce outward motion of lower ribcage, decrease intercostal muscle activity and may lead to paradoxical respiratory movement in children. However, diaphragm compensates for loss of ribcage contribution in most cases.

DRUGS USED IN SPINAL ANAESTHESIA

1.local anaesthetics

Bupivacaine

Tetracaine

Chloroprocain

2.Opioids

Morphine

Fentanyl

3.Alpha-2 antagonist

Clonidine

Dexmedetomidine

MECHANISM OF ACTION OF LOCAL ANAESTHETIC DRUGS IN SPINAL ANAESTHESIA

Local anaesthetic acts on nerve roots and conduction block occurs

Local anaesthetic binds to Alpha subunit of voltage gates Na+ channels and prevent channel activation,Na+ influx and depolarization

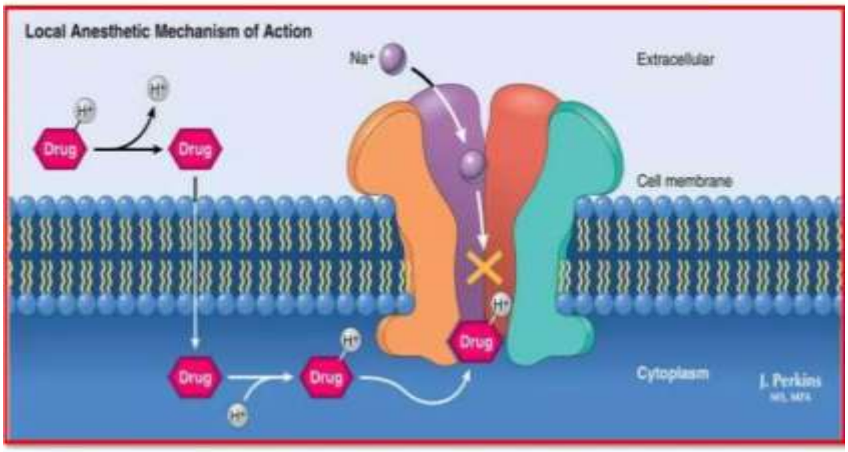


Figure -3:Mechanism of action of local anaesthetics

TECHNIQUES OF SPINAL ANAESTHESIA IN NEONATES

- Patient positioning
- Needle selection and landmarks
- Dosing and adjuvants

1.Patient positioning

Monitors, oxygen administration, and sedation are initiated. A pillow is placed in the patient's lap, and arms wrapped around the pillow to support both the arms and the head. The anesthesiologist and an assistant stand on either side of the bed and help sit the patient up straight on the OR table, with legs outstretched. The foot of the bed can be lowered 30 degrees to aid with patient comfort. An assistant stands on the side of the bed in front of the patient to hold the patient and help coach them through the procedure. Care is taken to avoid corneal abrasions in sedated patients.[11]

2.Needle selection and landmarks

The technique of needle placement for spinal anesthesia is like that of a neonatal lumbar puncture. The baby is placed in either a sitting position, where the patient is held upright, or in a lateral position with the legs tucked and the back arched towards the provider. Ensuring that the patient is held stationary in optimal position is key to successful placement. The intervertebral space is extremely small and minor deviations from flexion, extension, or lateral

rotation can easily lead to technical failure. Local anesthetic cream may be placed on the skin 30 minutes prior to the procedure to minimize pain. Caution must be used with regard to the type of local anesthesia present in the cream, the amount of cream used, the surface area of skin it is applied to, and the duration of time it is in contact with skin in order to avoid adverse events.[12]

3.Dosing and adjuvants

Recommendations from the 2018 ESRA/ASRA guidelines on local anesthesia dosing in children stipulated a bupivacaine dosing regimen for pediatric spinals. The bupivacaine dosing recommended decreases with increasing age. Tetracaine can also be used. Recently, we published our experience using isobaric mepivacaine and chloroprocaine for spinals in patients under age 18.[13]

Bupivicaine Dosing:

- < 5kg: 1mg/kg
- 5-10 kg: 0.5mg/kg
- 10-15kg: 0.4mg/kg
- > 15kg: 0.3mg/kg

INDICATIONS

Neuraxial anesthesia is used as a sole anesthetic or in combination with general anesthesia for most procedures below the neck.[14] As mentioned in the introduction, spinal anesthesia is in common use for surgical procedures inv absolute contraindications are lack of consent from the patient and elevated intracranial pressure (ICP), primarily due to intracranial mass and infection at the site of the procedure (risk of meningitis).

CONTRAINDICATIONS

There are a number of specific contraindications to SA In children that are listed below:

- Coagulation abnormalities
- Systemic sepsis or local infection at the puncture Point
- Uncorrected hypovolaemia
- Parental refusal or an uncooperative child
- Neurological abnormalities such as spina bifida,Increased intracranial pressure
- Procedures lasting more than 90 minutes.[15]

ADVANTAGES OF SPINAL ANAESTHESIA

1.Avoids air way manipulation

2.Reduced risk of postoperative apnoea

3.Minimal respiratory depression

4.Better cardiovascular stability

5.Faster recovery

6.Reduced need for opioids

7.Lower rates of postoperative complications

8.Useful in high -risk neonantes

9.Simple and quick technique

10.Stable hemodynamics

SIDE-EFFECTS AND COMPLICATIONS

Appropriate patient selection and care should be established to help obviate common complications associated with neuraxial anesthesia. While many of the complications are of very low incidence, it's worth being aware of them. Severe complications are believed to be extremely rare, but the frequency is probably underestimated. Some common complications include the following [16]

- Backache (more common with epidural anesthesia)
- Postdural puncture headache (as high as 25% in some studies): non-cutting needle should be utilized for patients with a high risk for postdural puncture headaches, and the smallest gauge needle available is recommended for all patients.
- Nausea, vomiting
- Hypotension
- Low-frequency hearing loss
- Total spinal anesthesia (most feared complication)
- Neurological injury
- Spinal hematoma
- Arachnoiditis
- Transient neurological syndrome (especially with lidocaine

LIMITATIONS:

Despite several specific indications and advantages, this technique has some limitations:

1. Single shot technique provides mere 70-80 minutes of surgical anesthesia and shorter post-operative analgesia. This can be overcome with judicious use of additives and CSE technique.
2. Need for sedation and GA in some children for performance of block and despite successful block during the surgery. [17]
3. Technical difficulties: Lack of co-operation and their unique anatomical features make SA in children challenging. Bloody tap and difficulty in aspiration are associated with failure of SA Failure rates of 5-15% have been reported. However, many recent large studies have documented a good success rate. Technical difficulties and failure may thus be a matter of individual skill and experience.
4. Pediatric spinal needles are expensive and may not be freely available.
5. Standard adult needles can be used in school-going and older children, and with due care even in younger children (6 mth-1 year).

CASE REPORTS:

We present a case series from a UK District General Hospital of three laparotomies performed in patients considered to be high risk for general anaesthesia; all were carried out under combined spinal and epidural anaesthesia. Each resulted in a successful outcome for the patient involved, with no patients requiring conversion to general anaesthesia. All cases included in this review were discussed at the local governance meeting, and consent for publication with the inclusion of anonymised radiological images was obtained.[18]

Case 1

A 75-year-old male, with a background of hypertension, previous myocardial infarction, chronic obstructive pulmonary disease, and pulmonary fibrosis, was admitted with severe abdominal pain and bilious vomiting. He had recently completely radical chemoradiotherapy for a junctional oesophagogastric cancer, with an indwelling gastrostomy tube for feeding. The abdomen was distended and tender on palpation; however, no signs of peritonitis were present. Blood tests on admission were unremarkable, with only a mild rise in the inflammatory markers, normal lactate, mylase, and renal function.

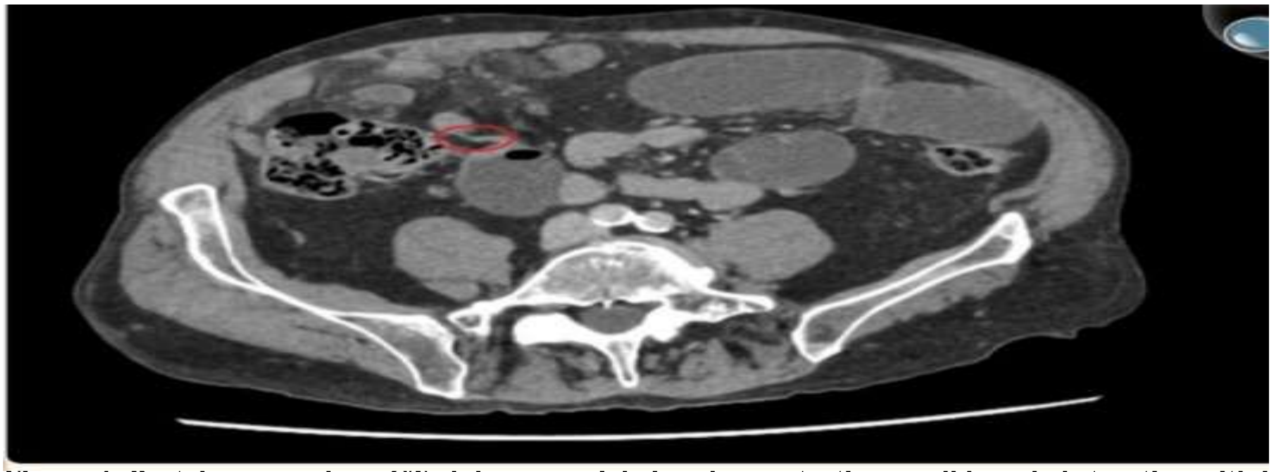


Figure-4: Portal venous phase CT abdomen -axial view demonstrating small bowel obstruction with jejunal and ileal dilation and the transition point

Case-2

78-year-old female, with known atrial fibrillation, congestive cardiac failure, hypothyroidism, and previous breast cancer, presented with a history of persistent abdominal pain and bilious vomiting. Her past surgical history included previous laparotomy and abdominal aortic aneurysm repair several years earlier. Along with anti-hypertensives and diuretics, the patient was also on the direct oral anticoagulant apixaban regularly, which was held prior to surgery. Clinical examination revealed a mildly distended and tender abdomen, but no signs of peritonitis. She had, however, presented two days after the onset of her symptoms and appeared to have aspiration pneumonia with hypoxia, tachypnoea, and lung shadowing on chest x-ray.[19]

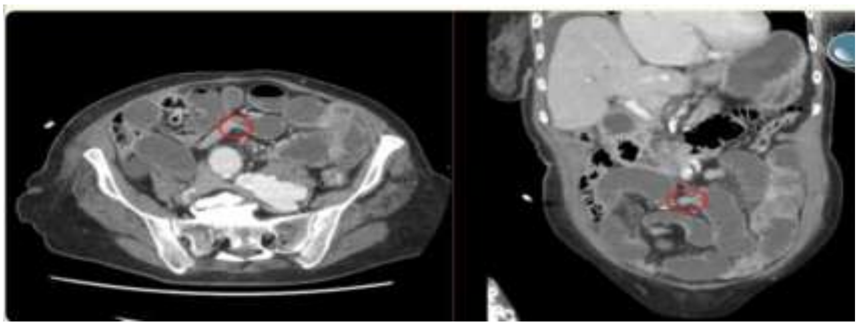


Figure-5:Axial and coronal portal venous phase CT images demonstrating a high grade small bowel obstruction ,with a transition point noted in the right iliac fossa

Case-3:

An 80-year-old female patient was investigated for anaemia and found to have caecal adenocarcinoma. A staging CT scan confirmed no distant metastasis with locoregional lymphadenopathy. Radiological TNM staging was T2 N1 M0.[20]

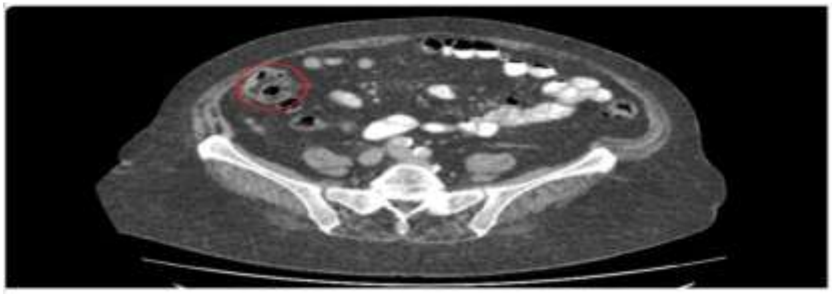


Figure-6:Portal venous phase CT abdomen -axial view showing circumferential caecel wall thickening

CONCLUSION:

Spinal anesthesia does not appear to have a significant effect on neurodevelopment outcomes or POA. However, for patients requiring staged/multiple procedures or with significant comorbidities, utilization of a spinal anesthetic may be a better option. Ultimately, an individualized, careful discussion between parents, anesthesiologists, and surgeons regarding this will elucidate the optimal approach.

Today, more than a century ahead since its inception, although firmly established as safe, SA still remains underutilized in children. Based upon extensive literature review and our own experience, we are convinced that SA is safe, cost-effective, and technically feasible technique. It has a remarkable safety record in pediatric population in the hands of an experienced anesthetist, proper patient selection, drugs, and dosages. As anesthetists become more experienced, it may well become a preferred choice either alone or as a part of balanced technique in children undergoing elective surgeries, rather than just as an alternative in the high-risk pediatric patients.

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