Update in Anaesthesia

Paediatric spinal anaesthesia

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Summary

Spinal anaesthesia provides a good alternative to general anaesthesia in newborns with increased anaesthesia-related risk, and for infants undergoing lower abdominal or lower extremity surgery during the first 6 months of life. It is most successful as a single shot technique, limited to surgery lasting less than ninety minutes. Spinal anaesthesia in children requires the technical skills of experienced anaesthesia providers.

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EDITORIAL COMMENT

This article correctly suggests that the resurgence of interest in spinal anaesthetic techniques in neonates and young infants was driven by the reduced risk of postoperative apnoea. More recently, concerns have arisen about the long term effects on neurodevelopment after exposure to general anaesthesia due to evidence from a broad base of literature in animals. Although the current human evidence is not conclusive, a large paediatric trial is underway and will begin to report in 2014 as this issue goes to press. The GAS (General Anaesthesia vs Spinal 2015) study will look at the differential rates of postoperative apnoea and examine neurodevelopment up to age 5 years, the final reports are due in 2018. Spinal anaesthesia is currently the mainstay of practice for young infants in many low resource environments. It could be that this pattern of practice may be adopted throughout many more healthcare systems in years to come.

INTRODUCTION

Spinal anaesthesia consists of inserting a spinal needle into the subarachnoid space and, when a free flow of cerebrospinal fluid (CSF) is obtained, injection of a solution of local anaesthetic directly into the CSF.

Spinal anaesthesia (SA) was first described in children in 1909[1] but did not become part of routine practice until the 1980's when regional anaesthesia increased in popularity. The particular advantage suggested for SA in children was the avoidance of general anaesthesia (GA) in those at risk of postoperative apnoea. Several studies demonstrated that SA had a particular role in high-risk former preterm neonates undergoing inguinal herniorraphy.[2]

APPLICATIONS OF SPINAL ANAESTHESIA

SA remains popular for ex-premature infants, specifically those undergoing inguinal herniorraphy. These patients often have a history of apnoea of prematurity, bronchopulmonary dysplasia and chronic lung disease. The incidence of postoperative apnoeas correlates with gestational age at birth, the post-conceptional age at surgery, weight, anaemia and a history of apnoeas. General anaesthesia increases the risk of apnoea and bradycardia, and ex-premature infants remain at risk until after 60 weeks post-conception.[3,4]

Outside the neonatal period, SA has been used for general surgery (rectal biopsy, incision of rectal abscess), urological surgery (orchidopexy, circumcision), lower limb orthopaedic surgery,[5] and may be of particular use in developing countries as an alternative to general anaesthesia.

SA has also been suggested for patients in whom GA may pose a significant risk such as those with facial dysmorphia and difficult intubation, muscular dystrophy, family history of malignant hyperthermia or a full stomach with aspiration risk.[5]

SA has also been described in combination with GA in children undergoing complex surgery. For instance, preoperative morphine SA combined with GA for scoliosis surgery is associated with reduced blood loss and better pain control.[6,7] SA has been used with GA during cardiopulmonary bypass in neonates to blunt the stress response, protect hemodynamic status and reduce perioperative morbidity and mortality,[4,9] although its use in this situation is not common. SA has also been described for use in chronic pain management.[4,8]

CONTRAINDICATIONS TO SA

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.

ANATOMICAL CONSIDERATIONS

A line connecting the top of the iliac crests crosses the spinal axis at the L5-S1 level in neonates and infants up to one year of age and at the L4-L5 level in older children.[5] The spinal cord ends approximately at L3 level at birth and at L1-L2 level in children over one year old.

The distance between the skin and the subarachnoid space is influenced by age – from 10 to 15mm in newborns.[10] The distance between skin and subarachnoid space can be related to height or weight using the formulae:

Distance from skin to subarachnoid space (cm) = 0. 03 x height (cm)

Distance from skin to subarachnoid space (mm) = [2 x weight (kg)] + 7(mm)[11]

The subarachnoid space in newborns is very narrow (6 to 8mm) and successful lumbar puncture in this population requires great precision and avoidance of lateral deviation.

Cerebrospinal fluid is a clear body fluid that occupies the subarachnoid space and the ventricular system of the brain and spinal cord. Cerebrospinal fluid volume at different periods of life is shown in Table 1.

Table 1. *CSF volume in children*

	Cerebrospinal fluid volume (ml.kg^{-1})
Neonates	10
Infants less than 15kg	4
Young children	3
Adolescent /Adult	1.5 - 2

The volume of distribution of drugs injected into the subarachnoid space is higher in infants and neonates than in adults and consequently the injected dose is relatively greater in infants and neonates.

PHYSIOLOGICAL EFFECTS OF SPINAL ANESTHESIA

Hemodynamic consequences of SA

Cardiovascular changes related to the SA are less common in children than in adults. In children under 5 years of age, minimal changes in heart rate and blood pressure have been reported.[5,12,13] In older patients (>8 years old), the sympathetic block can induce bradycardia or hypotension. A few studies of SA in newborns have noted hypotension ten minutes after injection of the local anaesthetic. Cardiovascular changes due to spinal block are generally short lasting and respond to a bolus of intravenous fluid (10ml.kg^{-1}).[14] Cardiovascular stability in infants undergoing SA is probably related to smaller venous capacitance in the lower limbs leading to less blood pooling, and to relative immaturity of the sympathetic nervous system resulting in less dependence on vasomotor tone to maintain blood pressure.

Respiratory effects of SA

Respiratory effects of SA are generally seen in association with high motor block above T6.[5] Children with severe chronic lung disease should receive supplemental oxygen or Continuous Positive Airway Pressure (CPAP) during SA.

TECHNIQUE OF SA IN CHILDREN

Preoperative preparation

The technique should be explained fully to the parents (and child if appropriate), with a description of risks and benefits. Informed consent should be obtained.

A full blood count including platelet count and coagulation screen (prothrombin time, PT; activated partial thromboplastin time, APTT) may be performed preoperatively where clinically indicated. Blood tests are not usually required for a routine herniotomy, the most common indication for infant spinal anaesthesia.

The child should be fasted as for GA (4 to 6 hours for milk and 2 hours for clear liquid). If possible, topical anaesthesia is used by application of EMLA (Eutectic Mixture of Local Anaesthetics) or Ametop on the lumbar area, 60 to 90 minutes prior to SA. Premedication with oral or rectal atropine (20mcg.kg^{-1}) will vary with institutional preferences, but you should consider using it in all ex-premature neonates.

Operative management

In the operating room, routine monitoring and standard intravenous infusion are started. Some anaesthesiologists have suggested placing the intravenous cannula in an anaesthetized lower extremity after performing the subarachnoid block. We advise placing it prior to SA puncture. Although cardiopulmonary complications are unlikely following SA, they are possible and the presence of a cannula will allow more rapid intervention, particularly in environments where trained anaesthetic assistants are not universally available

There should be an assistant for the anaesthetist to help with preparation of the equipment, positioning and holding the child during insertion of the SA. All drugs and equipment should be prepared and checked prior to starting. Full barrier aseptic technique

Table 2. *Dose of local anaesthetic for SA in children*

Weight	< 5kg	5 to 15kg	> 15kg
Isobaric or hyperbaric bupivacaine 0.5%	1mg.kg^{-1} (0.2ml.kg^{-1})	0.4mg.kg^{-1} (0.08ml.kg^{-1})	0.3mg.kg^{-1} (0.06ml.kg^{-1})
Isobaric or hyperbaric tetracaine 0.5 %		0.4mg.kg^{-1} (0.08ml.kg^{-1})	0.3mg.kg^{-1} (0.06ml.kg^{-1})

Figure 1. *Lateral position to perform SA in 4kg newborn*

should be used, with a sterile work surface for equipment. The operator should use sterile gloves, gown and mask and the patient's skin should be cleaned with an alcoholic solution such as 0.5% or 2% chlorhexidine (+/- iodine). The skin should be allowed to dry and a sterile sheet should be placed over the child with a hole to reveal the field. The dose of local anaesthetic solution is calculated according to the weight of the child and is shown in Table 2;[5] the drugs should be drawn into a 1-2ml syringe as appropriate and placed on the sterile work surface in preparation for use.

Both the sitting or lateral decubitus position have been described for lumbar puncture.[4,5] We have great experience of the lateral position for awake neonates or infants but careful attention must be directed at maintaining patency of the airway which may be compromised with overzealous positioning (Figure 1). The lateral position may be easier than the sitting position for older patients for whom intravenous sedation with a benzodiazepine such as midazolam may be indicated.

Lumbar puncture is performed at L3-L4 or L4-L5 level. Various sizes and lengths of needles are available depending on the child's age. We use a 25G or 26G needle with stylet for neonates and infants (Figure 2). Using a needle without a stylet is not recommended since epithelial tissue can be deposited in the intrathecal space and may cause dermoid tumours of the neural axis.

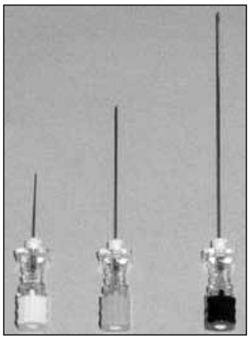

Figure 2. *Different types of SA needles*

A free flow of cerebrospinal fluid should be obtained when the spinal needle is advanced into the intrathecal space. The local anaesthetic syringe is attached and the anaesthetic solution is injected over 30 seconds (Figure 3). The legs should not be lifted after the spinal injection has been administered, otherwise an excessively high block will develop.

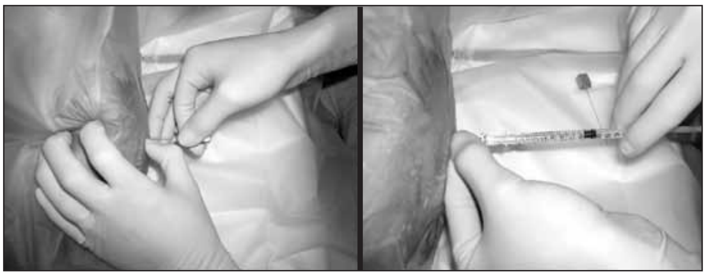

Figure 3. *Lumbar puncture and LA injection with 1ml syringe*

SA may produce a degree of sedation in newborns and infants so additional intravenous sedation is not required.[15] Intravenous sedation should be avoided if at all possible in infants at risk of apnoea. We find that a dummy dipped in sucrose or honey will help to settle these infants.

Postoperative care

In our hospital, children are discharged from the post anaesthesia care unit when the block disappears, i.e. free lower limb movement returns. Children are allowed to feed on demand, provided there are no surgical restrictions. All infants younger than 60 weeks post conception are monitored on the ward for 24 hours after SA.

COMPLICATIONS OF SA

There are a number of potential complications of SA that are listed below:

- Potential traumatic puncture with spinal damage. Careful technique with the appropriate equipment and a trained assistant is essential
- Respiratory (+/-cardiovascular) insufficiency due to high SA or secondary to intravenous sedation. Resuscitation measures must be taken (ABC) - tracheal intubation and volume resuscitation may be required.
- Convulsions due to overdose of local anaesthetic. All doses should be calculated carefully and checked with another practitioner.
- Post dural puncture headache. This has been reported in children >8 years old, but the incidence in younger children is unknown, in part since headaches in infants and young children are difficult to assess.[5,16]
- Infectious complications such as meningitis. The incidence of meningitis is very low – careful aseptic technique must be used at all times and multidose ampuoles of local anaesthetic must never be used. We suggest repeating lumbar puncture in patients who develop fever after SA.[4,5]
- Neurological injury due to injection of incorrect solutions. Great care must be taken at all times in preparation and checking of drugs.

CONCLUSION

In our experience, the incidence of serious complications associated with SA is very low, even in small premature infants. We think that this technique provides a good alternative to general anaesthesia in newborns with increased anaesthesia-related risk and for infants undergoing lower abdominal or lower extremity surgery during the first 6 months of life. SA may be used to avoid GA in patients outside the neonatal period, if needed combined with intravenous sedation. SA is most successful as a single shot technique, limited to surgery lasting less than 90 minutes. SA in children requires the technical skills of experienced anaesthesia providers. Neonates and infants are at high risk of complications during surgery, irrespective of the type of anaesthesia, and the presence of clinician trained in paediatric anaesthesiology is mandated.

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