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SAFETY AND EFFICACY OF PEDIATRIC SPINAL ANAESTHESIA, SHARING EXPERIENCE

1. **GHULAM NABI MEMON**
2. **FARIDA WAGAN**
3. **MEHBOOB AHMAD WAGAN.**
4. **GHULAM MUSTAFA LAGHARI**

1. ***Professor & Chairman,***
   Department of Anesthesiology
2. ***Associate Professor***
   Department of Obstetrics & Gynecology,,
   People's University of Medical and Health Sciences for women, Shaheed Benazirabad, District Nawabshah, Sind Pakistan.
3. ***Professor & Chairman,***
   Department of Pharmacology.
   Liaquat University of Medical & Health Sciences, Jamshoro, Sind, Pakistan
4. ***Registrar,*** PG FCPS11,
   Department of Anesthesiology,
   Peoples University of Medical & Health Science for Women, Shaheed Benazirabad, District Nawabshah, Sindh, Pakistan

Correspondence to:
DR. GHULAM NABI MEMON.
Professor & Chairman,
Department of Anesthesiology,
People's University of Medical and Health Sciences for women
Shaheed Benazirabad, District Nawabshah, Sind Pakistan.
On job deputation, as Consultant Anesthetist, Department of Anesthesiology & ICU, King Abdul Aziz University Hospital of King Khalid University Hospitals, King Saud University, Riyadh, KSA.
Email: memongn@yahoo.com, Contact 00966507919805

ABSTRACT

Design: Prospective, non-randomized, interventional, clinical trial.
Setting: This study was conducted at People's Medical College Hospital, People's University of Medical & Health Sciences for women, Nawabshah, Sindh, Pakistan, from October 2008 to April 2009.
Patients and Methods: Patient demographic data include age, sex, weight. The procedural data include type and duration of surgery, onset and duration of motor block, height and duration of sensory block, complications and failure of spinal anesthesia. Spinal performed in lateral decubitus position with 0.75% bupivacaine 0.3 mg/kg. The adequacy of block was judged by motor paralysis in lower limbs and lack of response to firm skin pinch at incision site.
Results: 46 cases out of 50 cases were successful, three cases failed due to difficulty in locating subarachnoid space and inadequate flow of CSF, one case failed for no obvious reason.
Demographics: 42 patients were male and 8 female, Age range 10 to 82 months; mean 36.75 +/? 19.4.
Block characteristics: Onset of motor block 113.2 +/? 6.9 seconds, motor block duration range 75 to 120 minutes, mean 107 +/? 10.8 minutes, Height of analgesia T5.3 +/? 0.89.
Hemodynamics. BP & HR remained stable throughout the procedures.
Conclusion: Pediatric spinal anesthesia is a safe, reliable and effective technique.

Key Words: Pediatric spinal, Safety of pediatric spinal, pediatric spinal in Pakistan.

INTRODUCTION

First time in history at 9:09 am, August 22nd, 1898, in Kiel Germany, Karl August Bier operated on an eleven-year old boy (fourth case of his series) for tuberculous inflammation of the ischium under spinal anesthesia1. In May 1900, Bainbridge published a report on spinal anesthesia in an infant of three months for the repair of a strangulated hernia2. In year 1909, the biggest series of pediatric spinal anesthesia was published by Tyrell-Gray; who reported 300 pediatric surgical procedures below diaphragm under spinal anesthesia3. C.I. Junkin, 1932, used spinal anesthesia with sedation in children between the ages of 2 weeks to 17 years old, he concluded that spinal anesthesia is as safe and satisfactory as in adults; however preliminary sedation is important and necessary.4 Berkowitz et al, 1950 reported spinal anesthesia in 350 children less than 13 years of age with sedation, for surgeries below diaphragm, without single complication.5 Gouveia 1970 performed spinal anesthesia in 50 children between 3 months and 12 years of age, the author observed no complications6. Cunto1975 has performed spinal anesthesia in 84 children between 19 days to 13 years of age, spinal anesthesia was considered safe by him7. Estela Melman, 1975 used spinal and caudal approach to anesthetize 200 children aging 17 days to 15 years with lidocaine and sedation with ketamine 1 to 2 mg/kg i/v, no major anesthetic complications or deaths were attributable to technique8.
Despite the successful reports from different enthusiastic researchers around the world,

the pediatric spinal could not gained the due popularity at the global level because of its side effects and complications and because of faster advancement of general anesthesia. As the safety of general anesthesia improved, spinal anesthesia fell into disfavor; however pediatric spinal anesthesia did not disappear but remained underutilized relative to general anesthesia[9].

It was not until 1984, when Abajian et al re-introduced infant spinal anesthesia successfully to the modern era10. Since 1984, the popularity of pediatric spinal anesthesia has increased considerably, especially, in cases where general anesthesia carries a high risk as in premature babies.[11, 12] Since then, pediatric spinal anesthesia has been accepted and practiced widely but still, caudal epidural is one of the most commonly used regional anesthesia technique in pediatric patients.[13]

The high degree of safety, efficacy, reliability, cardio-respiratory stability and minimal complication rate is witnessed by many anesthetists with pediatric spinal anesthesia[14, 15]. The use of pediatric spinal is rising day by day.

Despite these advantages, the short duration in pediatric spinal may be a major disadvantage in prolonged surgeries, another concern in pediatric spinal is the need for supplemental sedation, because children do not like needles and despite successful block; children do not cooperate and are unable to lie still on operating table. In contrast to this, in neonates, the spinal anesthesia can be used without sedation. In neonates spinal anesthesia has sedative effect in its own right[16]

Benefits of pediatric spinal anesthesia.

01. Small dose of drug is required, which avoids the chances of local anesthetic toxicity.
02. There is positive end point of CSF flow that confirms the correct spinal needle placement.
03. There is predictable and rapid onset of dense motor block and profound analgesia.
04. There are minimal cardio-respiratory changes in children less than 6 years of age[14].
05. The stress response to surgery is better attenuated with spinal anaesthesia[17, 18].
06. Spinal anesthesia causes gut constriction, thus facilitates intestinal obstruction surgery[19].
07. Endotracheal intubation can be avoided in reactive airway disease[20].
08. Pediatric spinal is a good choice in patient with increased risk of PONV[21].
09. Spinal anaesthesia is a cost-effective alternative to general anaesthesia.
10. More recently, interest in spinal anaesthesia has been increasing following the finding that general anesthetics induce neurodegeneration in the brains of infant animals[22].
11. Pediatric spinal has minimal complication rate. The data of "The 3rd National Audit Project of the Royal College of Anaesthetists 2009" suggests that central neural blockade has a low incidence of major complications.[23]

MATERIALS AND METHODS.

With the approval of the ethical committee, all the willing in-patients, after satisfying inclusion and exclusion criteria were included in this study. Patient demographic data included age, sex, weight and pertinent medical history. The procedure related data include type of surgery, onset of motor block, duration of motor block, duration of sensory block, duration of surgery, height of sensory block, incidence and type of complications, need for supplementary drugs and conversion to general anesthesia and failure of spinal anesthesia.

Inclusion criteria.

- Parents/patients willing for spinal anesthesia.
- Age: between 60 weeks postconceptual age to 7 years[24].
- Weight: between 6 kg to 24 kg.
- Physical status, American Society of Anesthesiologist I and II.
- Patients scheduled for elective surgery below umbilicus.
- Expected duration of surgery around 70 to 100 minutes depending on age.

Exclusion criteria.

- Parental refusal.
- Coagulation abnormalities.
- Local infection at the spinal puncture site.
- Uncorrected hypovolaemia.
- Allergy or hypersensitivity to local anesthetic drugs.

Preoperative preparation and medication.

- Routine history, physical, general examination and local examination of spine.
- Risks and benefits explained to the parents and written informed consent obtained.
- Labs: a full blood count, including platelet count & coagulation screen performed.
- PT and APTT requested, where clinically indicated.
- Fasting ensured for 6 hours for milk/food and 4 hours for water.
- I/V line done and I/V fluid started since NPO.
- Fluid: 5% Dextrose with 0.18% saline infused at a rate of 4:2:1 formula since NPO.
- No preloading of fluid for spinal.
- Premedication include, Inj midazolam 100 microgram/kg i/v, Inj Glycopyrolate 2 microgram/kg i/v, Inj ketamine hydrochloride 1mg/kg i/v, before entering OR.
- Monitors applied and patient monitored. (in preoperative area)
- Oxygen by facemask.

Operating room management.

- Room temperature maintained at 25–30°C.
- Preparation for GA, emergency airway maintenance and intubation done.
- Emergency drugs prepared & labeled properly before start of procedure.
- Gentle shifting of the sedated patient to OR table and monitors reapplied.
- Surgeon washed, scrubbed and ready for surgery before spinal injection.
- Monitoring include ECG, NIBP, heart rate, SpO2, respiratory rate, temp and precordial stethoscope.
- Diathermy pad placed in position before positioning for spinal[25].
- Patients positioned in lateral position without flexing neck, taking care of airway.
- Bupivacaine Hcl, hyperbaric 0.75%, 0.3 mg/kg prepared in syringe and labeled.

Table 1 Demographic data.

	Description	Units/value
01.	**Number of patients**	50
	Male gender	42
	Female gender	08
02.	**Age in months (range)**	10 to 82
	Mean and standard deviation	36.75 +/- 19.4
	Median age in months	34
	Mode age in months	24
03.	**Weight in Kg (range)**	10 to 23
	Mean and Standard deviation	15.2 +/- 3.45
	Median weight in kg	14
	Mode weight in kg	13

Table 2 Procedural data. Majority of cases were inguinal hernia repair,

	Type of Surgery	Male	Female.	Number of cases
01.	Inguinal hernia repair.	24	00	24
02.	Imperforate anus	05	03	08
03.	Umbilical hernia.	05	01	06
04.	Exploratory laparotomy	02	01	03
05.	Appendicectomy	06	03	09
	Total	42	08	50

Table 111, duration of surgery in minutes

Mean duration of surgery	**43.36 minutes**
Standard deviation	10.11 minutes
Median duration	42 minutes

Table IV, Blockade characteristics

- Adequacy of block was judged by flaccid paralysis of lower limb.
- Duration of block was longer in elder children and vice versa.
- Duration of spinal analgesia was difficult to assess because all patients were sedated, pain free and we infiltered bupivacaine in surgical wound on the completion of surgery.

Motor blockade, onset in seconds, mean, SD	113.2 +/-- 6.9
Motor block, range in minutes	75 to 120
Motor block, duration in minutes, mean and SD	107 +/-- 10.8
Analgesia duration	Difficult to assess.
Height of analgesia, mean/SD	T5.3 +/-- 0.89
Height of analgesia, range	T7 to T4
Height of analgesia mode	T5

- Full barrier aseptic technique used for lumbar puncture, the anesthetist used sterile gloves, gown, mask & the patient's skin prepared, a sterile sheet placed over the child with a central hole to reveal the field.
- A skin wheal rose with lidocaine 1%, with 20 G needle at lumbar puncture site to avoid pain and jerky movement at the time of subsequent insertion of needle.
- 25 gauge, (0.8x25mm) needle of M/S Terumo Corporation used for LP. In elder children, 22 gauge (0.70x32mm) needle of M/S Terumo Corporation used.
- Lumbar puncture performed at intercristal line i.e. L4-L5 or L5- S1 level.
- Bevel of needle was directed laterally.
- As soon as free flow of CSF obtained, LA solution syringe attached, prepared dose of bupivacaine 0.3mg/kg injected slowly and needle removed.
- Patient positioned supine immediately with operating table leveled at zero position.
- Adequacy of block judged by flaccid motor paralysis in the lower limbs.
- Sensory block was judged by lack of response to painful stimuli at the incision site.
- Height of analgesia mapped at 15th minute of spinal injection.
- On completion of surgery, bupivacaine infiltered in wound for postoperative analgesia
- The use of extra fluids, vasopressors and other medications if used, were recorded.
- Incidence of apnea, desaturation & changes in BP, HR, recorded.

Hypotension: Defined as decrease in MAP more than 20% from baseline.
Bradycardia: Defined as a heart rate less than 15% of baseline.
Hypoxemia: Defined as SpO2 below 90%.
High spinal: Defined as motor block of the upper limbs, no response to hand pinch.
Postoperative care: Patients were transferred to recovery room and their vital signs monitored, till the block regress, The children were then transferred to ward; where maintenance fluid continued till orally allowed, children were allowed to feed as soon as possible, provided there were no surgical restrictions. All adverse effects were recorded. Patients were followed postoperatively in the ward to evaluate postoperative complication like PDPH, transient neurological symptoms, meningitis, meningism and backache.

EXPECTED COMPLICATION

The data of "the report of 3rd National Audit Project, Royal College of Anaesthetist Jan 2009" are reassuring and concludes that central neuronal blockade has a low incidence of major complications26. Elisabeth Giaufré et al in 1996, have published a multi central study from France Belgium and Italy on epidemiology and morbidity of regional anesthesia in children, in this study spinal anesthesia had zero mortality a very low morbidity rate, from 502 patients, there was only one complication caused by intravascular injection without clinical effects[27]. Intraoperative complications attributable to paediatric spinal anesthesia are very uncommon.

1. **Hemodynamic changes.** Children less than 5-year old tolerate high thoracic spinal with minimal changes in heart rate and arterial pressures, but in contrast among school-age children high levels of sensory block are associated with some alterations

Table V, Hemodynamic changes.

- Blood Pressure and heart rate remained stable throughout the procedure.
- Baselines readings were recorded before entering the theatre,
- 2nd reading recorded after premedication.
- There was a mean rise of 9% in MAP & mean rise of 8% in HR rate after premedication.
- There was gradual decrease in MAP, which touched the baseline value on 12th minute.
- The heart rate remained slightly elevated and touched the baseline at 30th minute.
- Initially after the block reading were recorded every minute for ten minutes.
- Then readings were recorded at every 5 minutes.
- For statistical analysis, readings were calculated at every 10 minutes.
- Overall impression: marked hemodynamic stability.

Reading time	Mean arterial pressure mm Hg Mean +/- SD	Heart rate, beats/minute Mean +/- SD
Base line reading before OR	62.89 +/- 4.32	92.65 +/- 4.33
After premedication	68.54 +/- 3.17	100.08 +/- 4.43
10 minutes after spinal	64.42 +/- 3.78	94.50 +/- 3.06
20 minutes after spinal	61.73 +/- 4.00	93.60 +/- 2.90
30 minutes after spinal	61.58 +/- 3.89	92.32 +/- 2.84
40 minutes after spinal	62.06 +/- 3.55	91.54 +/- 2.70
50 minutes after spinal	61.13 +/- 3.94	91.1 +/- 2.84

Table VI Complications during pediatric spinal anesthesia

S #	COMPLICATION TYPE	% INCIDENCE
01	Hypotension	0%
02	Bradycardia	0%
03	Desaturation	0%
04	Apnea	0%
05	Meningitis	0%
06	Postdural puncture headache	0%
07	Conversion to GA because of time	0%
08	Nausea, vomiting & retching	0%
09	Extra fluid & vasoconstrictor used	0%
10	Difficulty in locating subarachnoid space	06%
11	Failure rate	08%

in cardio respiratory variables14.

2. **Apnea, hypoxemia or bradycardia** may be related to prematurity, forced positioning during LP, pain during LP or hypoventilation due to a 'high spinal'.
3. **PDPH** has been reported in children elder than 8 years of age, but the incidence in younger children is unknown.
4. **Backach**e is expected to be caused by several reasons such as muscular hematoma, ligamentous injury, reflex muscular spasm or patients positioning during the operation.
5. **Shivering** can occurs in elder children during the recovery of spinal anaesthesia.
6. **Nausea,** vomiting & retching incidence is remarkably low pediatric spinal[21].
7. **Infection.** The incidence is very low, careful aseptic technique must be used.
8. **Transient** or permanent neurological symptoms may occur rarely.
9. Intravascular injection can occur inadvertently.
10. Sudden cardiac arrest can occur.

RESULTS

Spinal was successful in 46 (92%) children out of 50. Four cases failed due to inadequate block, in three cases there were difficulties in locating subarachnoid space and flow of CSF was not adequate, in fourth case there seemed to be no reason, every thing went smoothly but there was no effect at all. There were no adverse intraoperative events; overall there were no complication and difficulties. All patients remained hemodynamicaly stable throughout without preloading, no case of apnea or desaturation observed, no case of nausea, vomiting or retching observed, no case was converted to GA because of long surgery, no vasoconstrictor or any other drug used during any case, no extra fluid needed, there were no complaints of PDPH or transient neurological symptoms, No patient required rescue analgesia during procedure.

Demographics data, procedural data, blockade characteristics, hemodynamic changes and type & % incidence of complications are shown in table I, II, III, IV and V respectively.

DISCUSSION

Anatomical consideration.

1. Until third month of gestation, spinal cord occupies the whole length of vertebral column; subsequently vertebral column grows faster than spinal cord, such that at the time of birth, spinal cord ends at lumbar 3rd vertebra. Even after

birth, vertebral column grows faster than spinal cord such that adult spinal cord ends at lower border of lumbar 1st or to reach lumbar 2nd vertebra. To avoid trauma to spinal cord in children, we use L4 L5 or L5 S1 intervertebral space, which corresponds to intercristal line. In neonates intercristal line corresponds to L5 S1 interspace. In infants up to one year of age intercristal line is at the level of L4-L5. In older children and adults, intercristal line is at the level of L3-L4. So, irrespective of age, intercristal line can be used as a landmark for lumbar puncture.

2. During intrauterine life and in neonate spinal column is 'C' shaped; the cervical lordosis develops at the age of 3 months, when the infant start holding head in upright position. Lumbar lordosis develops later, when the infant start walking at the age of 6 to 9 months 28. So the chances of cephalic spread of local anesthetic solution are high, if volume, dose, baricity and position after spinal injection are not considered.
3. The average total CSF volume in an adult is around 150 ml i.e. around 2ml/kg, in contrast to it CSF volume in a neonate is 40 to 50 mL29 i.e. around 10 ml/kg30. In children, less than 15 kg the CSF volume is 4ml/kg almost twice the volume in adults, so larger doses of local anesthetic are required in neonates and children as compared to adults.

Physiological consideration.

1. Changes in heart rate and blood pressure: In children less than 5 years of age, minimal changes in heart rate and blood pressure have been reported14. It is probably related to smaller venous capacitance in the lower limbs leading to less blood pooling, secondly to immaturity of the sympathetic nervous system resulting in less dependence on vasomotor tone to maintain BP.
2. Respiratory depressant effects of spinal anesthesia are generally seen in association with high spinal, infants are diaphragm dependent for respiration.
3. Gastrointestinal tract, Spinal anesthesia produces sympathetic denervation proportional to height of the block and causes unopposed parasympathetic action leading to constricted gut with increased peristaltic activity; this is regarded by some as advantageous for gut surgery.[31]

Pharmacological consideration.

Comparatively larger doses of local anesthetics per kilogram body weight are required in children than in adults and that may be related to double the volume of CSF i.e. 4 ml/kg in children to 2 ml/kg in adults or to the relatively increased surface area of the spinal cord and nerve roots. The shorter duration of spinal anesthesia in children may be related to the higher volume of distribution and increased cardiac output. This results in faster drug distribution, uptake and elimination of the drug.

Abajian in 1984 reported the technique of unsupplemented spinal anaesthesia for inguinal hernia repair in premature babies with excellent results. Since then spinal anesthesia is widely accepted and practiced. No doubt spinal anesthesia is a good alternative to general anesthesia in infants and children, however it is still relatively underutilized at the global level and caudal epidural is still preferred. As per report of 3rd National Audit Project, Royal College of Anaesthetist Jan 2009, 21500 central neuraxial blocks are performed annually in children in the UK26. Over 70% of these procedures were caudal epidurals. The estimates show 18,050 caudals, 3,125 epidurals and only 325 spinals are performed in a year in the UK. For a beginner there is always a fear of complications with spinal anesthesia, especially cardio respiratory complication. However an excellent study of Tim F. Oberlander et al concludes that infants tolerate spinal anesthesia with minimal autonomic changes15. Another study of Shuji Dohi confirms that children up to age of 5 years do not develop changes in HR and blood pressure with spinal anesthesia14. Our study confirms their report and we did not observe any case of hypotension or bradycardia in our series although our height of sensory analgesia was T5 (mode) without preloading and our case series exhibited marked hemodynamic stability.

The cephalic spread of the local anesthetic solution may be influenced by baricity, dose, volume, rapidity of injection, and barbotage, other potential factors are the head-down position of the patient, High spinal block was presumed, when the child show no response to painful pinch of hand and loss of muscle tone in upper limbs and represents the most serious complication of pediatric spinal anesthesia and must be treated immediately. No case of total spinal, temporary or permanent neurological impairment observed in our study.

We used standard aseptic technique for lumbar puncture and we did not observe any incidence of meningitis or meningism or infection at the site of lumbar puncture.

CONCLUSION:

From this study we conclude that:

- Pediatric spinal anesthesia is a safe, reliable and effective technique.
- Duration of pediatric anesthesia may be limited to 75 to 120 minutes in this age group
- Duration is directly proportion to age, as the increase duration increases.
- There is marked hemodynamic stability even with high spinal.
- There is no need to preload the children for spinal under 7 years of age.
- Providing sedation and analgesia is mandatory.

Problems & Suggestion

1. At the time of study, 0.75%, hyperbaric bupivacaine is the only available local anesthetic agent for spinal use in Pakistan.
2. Pediatric spinal needles are not available in Pakistan.
3. We started spinal anesthesia with a minimum dose of bupivacaine i.e. 0.3 mg/kg, to restrict the block to lumbar and lower thoracic dermatomes but the sensory block was unexpectedly higher to the level T5 (mode).
4. It was difficult to follow patients after discharge for delayed complications of spinal.
5. We were unable to assess the duration of sensory analgesia, because, patients were under the influence of ketamine Hcl and local infiltration of wound with bupivacaine.

Contribution of Authors#

Author No 1 :Conduct study and plnary drafting
Author No 2: Final revision and rewriting
Author No 3: Designing and Final revision
Author No 4: References collection and checking

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