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Scalp Nerve Block in Children Undergoing a Supratentorial Craniotomy; A Randomized Controlled Study

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Abstract: The aim of this randomized double blinded controlled study was to evaluate the effect of SNB during craniotomies for supratentorial tumors in pediatric patients, with respect to intra- and postoperative hemodynamics, intraoperative anesthetic and analgesic consumption and postoperative analgesic requirements. Thirty children, aged 6 to 12 years, scheduled for elective craniotomies for supratentorial tumors were randomly assigned to one of two groups: control group (n = 15) and Scalp Nerve Block (SNB) group (n = 15). After a standardized induction and 5 min prior to head pinning, a SNB was performed. In the control group the block was performed with normal saline, while in the SNB group the block was performed with bupivacaine 0.25%. Intraoperative Mean Arterial blood Pressure (MAP) and Heart Rate (HR) were recorded before induction (baseline), 5 min after induction, at head pinning and at skin incision, together with sevoflurane and fentanyl consumption. Postoperative MAP and HR were measured and recorded. Postoperative pain assessment was done using Visual Analogue Scale (VAS) score. Rescue aualgesia (IV paracetamol, 15 mg kg^{-1}) was given for a VAS>3. Time to first rescue analgesic, number of patients who required aualgesia as well as number of paracetamol doses in the first 24 h postoperative were recorded. The SNB group showed more stable intraoperative and postoperative hemodynamics and a significant reduction in the total intraoperative fentanyl dose required. VAS scores were significantly lower in the SNB group compared to the control group till 12 h postoperative. Significantly fewer patients in the SNB group required rescue analgesic in the first 24 h postoperative (8 vs. 15, $p<0.05$). Time to first rescue analgesic was significantly longer in the SNB group compared to the control group (6.6 ± 1.9 h vs. 1.7 ± 0.8 h, $p<0.05$). Number of paracetamol doses required in the first 24 h postoperative was significantly higher in the control group compared to the SNB group. We conclude that SNB using bupivacaine 0.25% results in decreased intraoperative analgesic requirements and more stable intra- and postoperative hemodynamics. It also reduces postoperative pain leading to decreased postoperative analgesic consumption.

Key words: Postoperative pain management, neurosurgical anesthesia, scalp nerve block

INTRODUCTION

Intracranial surgery on children with supratentorial tumors poses a challenge to the anesthesiologist. Although, intracranial manipulation in itself is not painful yet certain aspects of the operation, including insertion of pins, skin incision and periosteal or dural contact induce noxious stimulation (De Benedittis *et al.*, 1996). Neuroanesthesiologists believe that pain management is inadequate in approximately 50% of cases (Stoneham and Walters, 1995).

Although, there have been advances in postoperative analgesia over the past years, these have not been widely adopted after neurosurgical operations (Dunbar *et al.*, 1999). Fear of complications as

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sedation, hypoventilation, miosis, seizures and intracranial bleeding inhibited prescribing effective multimodal pain management (Quiney *et al*., 1996).

Blockade of scalp innervation, which anesthetizes both the superficial and deep layers of the scalp was examined as a means of decreasing hemodynamic reactions after Mayfield head holder application (Pinosky *et al*., 1996). Scalp tissue is innervated by trigemiual nerve (V_1: Supratrochlear and supraorbital; V_2: Zygomatic temporal; V_3: Auriculo temporal) and the cervical superficial plexus: a posterolateral branch, the greater auricular and the three posterior branches: the greater, lesser and the third occipital nerves (Pardey *et al*., 2008). Local anesthesia by Scalp Nerve Block (SNB) was shown to decrease pain in craniotomy patients when compared to placebo patients with no signs of cardiovascular or CNS toxicity (Ngnyen *et al*., 2001).

Little information is available on the use of SNB in children. Pardey *et al*. (2008) reported the use of SNB in three children undergoing craniotomies. They found that SNB blunted the hemodynamic responses to the May field™ pin-holder placement, skin incision and craniotomy and also offered great hemodynamic stability during surgery. In addition, SNB greatly reduced the need for doses of opiates during the first 24 postoperative hours in all three patients. To the best of our knowledge there have been no randomized controlled studies to date assessing the use of SNB in children.

We designed this prospective, double blind, placebo controlled, randomized study to assess the quality of analgesia provided by SNB in children undergoing craniotomies for supratentorial tumors. We hypothesized that the use of SNB would result in more hemodynamic stability, lower postoperative pain scores, as well as reduction in total aualgesic requirements intra and postoperatively.

MATERIALS AND METHODS

After obtaining approval of the Local Ethics Committee and written informed consent from the guardians of the patients, 30 children ASA physical status I or II aged 6-12 years scheduled for elective craniotomy for excision of supratentorial cerebral tumors in the Cairo University Specialized Pediatric Hospital were included in this study, from the period January 2007 to May 2008.

During the preoperative visit, the Visual Analogue Scale score (VAS) was explained to the children and their parents. Exclusions criteria were, proven or suspected allergy to local anesthetics, a craniotomy incision extending beyond the field covered by SNB and inability to understand the VAS. Using a prospective, double blind and placebo-controlled study design, children were randomly assigned into 2 equal groups: control group (n = 15) and SNB group (n = 15) on the basis of a sealed envelope method.

Patients did not receive any premedication. EMLA cream was applied to the dorsum to both hands 1 h before surgery for all patients. Upon arrival to the operating room non -invasive Blood Pressure (BP), Heart Rate (HR) and arterial oxygen saturation (SpO_2) were continuously monitored using routine monitor (Viralet 3200 space labs). After insertion of 22-24 G intravenous cannula, induction of anesthesia was performed with propofol (1-3 mg kg^{-1}), fentanyl (2 µg kg^{-1}). Atracurium (0.5 mg kg^{-1}) was given to achieve muscle relaxation.

After tracheal intubation anesthesia was maintained using 1-2% sevoflurane (end-tidal concentration) in oxygen and air (FiO_2 0.5), fentanyl infusion at a rate of 2 µg/kg/h and Atracurium supplements were given to maintain muscle relaxation. Controlled ventilation was adjusted to achieve moderate hyperventilation (end-tidal CO_2 30-35 mmHg). A Foley's catheter was placed in the urinary bladder and core body temperature was measured by a nasopharyngeal probe. A radial artery catheter was inserted for continuous blood pressure monitoring and arterial blood sampling.

After induction of anesthesia, patients were randomly divided into two equal groups: control group in which SNB was performed with 16 mL 0.9% normal saline and SNB group in which SNB was performed using 16 mL 0.25% bupivacaine. The study solutions were prepared outside the operating room. The neurosurgeon and the anesthesiologist performing the block were blind to the drug being administered.

Scalp Nerve Block

The SNB was performed using the method described by Suresh and Voronov (2006). To block the supraorbital nerve, the supraorbital notch was palpated by running a finger from the midline laterally along the eyebrow. A 27 G needle was inserted in to the supraorbital notch perpendicularly and 1 mL of solution was injected into the space after careful aspiration. To block the supratrochlear nerve, the needle was withdrawn to skin level and directed medially several millimeters toward the apex of the nose and 1 mL of solution was injected. The auriculotemporal nerve was blocked with 2 mL of solution, 1.5 cm anterior to the ear at the level of the tragus with the needle perpendicular to the skin. Infiltration of 1 mL was made deep into the fascia and another 1 mL superficially as the needle was withdrawn. The posterior auricular branches of the great auricular nerve were blocked with 2 mL of solution between skin and bone, 1.5 cm posterior to the ear at the level of the tragus. The great, lesser and third occipital nerves were blocked with 2 mL of solution by infiltration along the superior nuchal line, approximately half way between the occipital protuberance and the mastoid process.

A Mayfield™ head holder was used for all craniotomies in this study. Intraoperative Mean Arterial blood Pressure (MAP) and HR were recorded before induction (baseline), 5 min after induction, at head pinning and at skin incision. If the HR or MAP increased by more than 20% over baseline value the fentanyl infusion rate was increased by increments of 1 µg/kg/h with an increased sevoflurane concentration as necessary. Intraoperative fentanyl requirements and hourly end-tidal sevoflurane concentration were recorded in each group.

At the end of the surgical procedure all patients received paracetamol 30 mg kg^{-1} rectally. Residual neuromuscular blockade was antagonized with neostigmine 0.05 mg kg^{-1} and atropine 0.02 mg kg^{-1}. After extubation children were transferred to the Pediatric Intensive Care Unit (PICU) to be observed for 24 h postoperatively.

Intensity of pain in the postoperative period was assessed by linear 10 cm visual analogue scale (VAS) (0 = no pain, 10 = severe pain) at 1, 2, 4, 8, 12 and 24 h postoperatively. VAS > 3 was treated by intravenous paracetamol 15 mg kg^{-1}. The time to the first rescue analgesic dose, number of patients receiving analgesic and number of analgesic doses required in the first 24 h postoperatively were recorded in each group. MAP and HR were measured on PICU admission and then at the same time points as the VAS. The occurrence of side effects related to the SNB technique was observed and recorded.

Statistical Analysis

Data are expressed as Mean±SD. Comparison between the groups was performed using unpaired t-test. Intragroup comparison was performed using repeated measures Analysis of Variance (ANOVA) with post hoc Dunnett's test. Categorial variables were compared using Chi-squared test. $p<0.05$ was considered statistically significant.

RESULTS

There was no significant difference between the two groups as regards age, weight, sex and duration of surgery (Table 1).

Both groups showed comparable hemodynamics at baseline and after induction. At head pinning and at skin incision there was a significant increase in MAP and HR in the control group in comparison to baseline values ($p<0.05$), while in the SNB group recordings were comparable to baseline. There was also a significant intergroup difference in MAP and HR at head pinning and skin incision with the control group showing significantly higher values ($p<0.05$) (Fig. 1, 2).

Table 1: Demographic data

Parameters	Control (n = 15)	SNB (n = 15)
Age (years)	8.1±2.5	8.9±2.1
Weight (kg)	24.3±6.5	26.1±5.9
Sex (male/female)	6/9	8/7
Duration of surgery (h)	5.1±1.3	4.9±1.5

Values are expressed as Mean±SD. SNB : Scalp Nerve Block

Table 2: Intraoperative analgesic and anesthetic requirements

Variables	Control (n = 15)	SNB (n=15)
Total fentanyl requirement (μg)	275.0±24*	180.0±36
Mean end-tidal sevoflurane concentration (%)	1.8±0.3	1.6±0.4

Values are expressed as Mean±SD. SNB: Scalp Nerve Block. * p<0.05 vs. SNB group

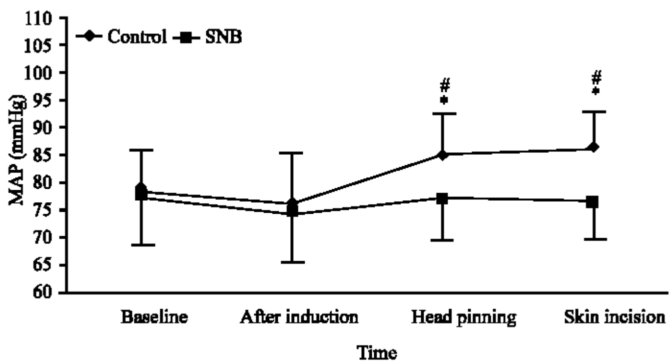

Fig. 1: Intraoperative changes in Mean Arterial Pressure (MAP) (Mean±SD). *p<0.05 vs. baseline. #p<0.05 vs. SNB

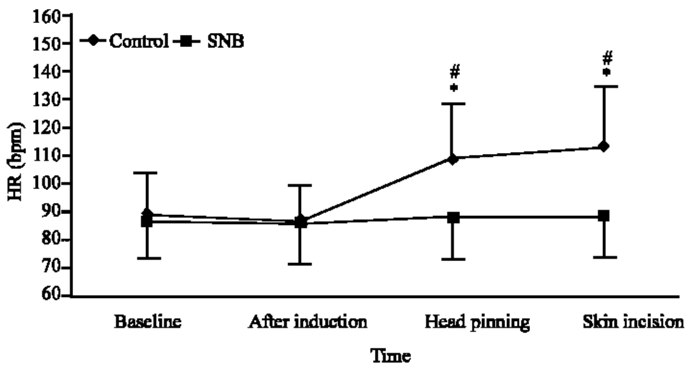

Fig. 2: Intraoperative changes in Heart Rate (HR) beat min^{-1} (bpm) (Mean±SD). *p<0.05 vs. baseline. #p<0.05 vs. SNB

Intraoperative total fentanyl dose requirement was significantly higher in the control group compared to the SNB group (p<0.05), while the mean end-tidal sevoflurane concentration was comparable in both groups (Table 2).

Postoperative MAP and HR values were significantly higher in the control group compared to SNB group during the PICU stay till 12 h (p<0.05). At 24 h there was no significant difference between the two groups (Fig. 3, 4).

The VAS scores were significantly higher in the control group compared to SNB group at 1, 2, 4, 8 and 12 h postoperatively (p<0.05) (Fig. 5). The time to first analgesic dose was significantly

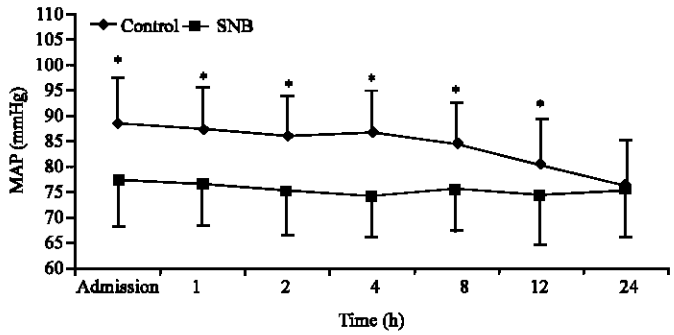

Fig. 3: Postoperative changes in Mean Arterial Pressure (MAP) (Mean±SD). *p<0.05 vs. SNB

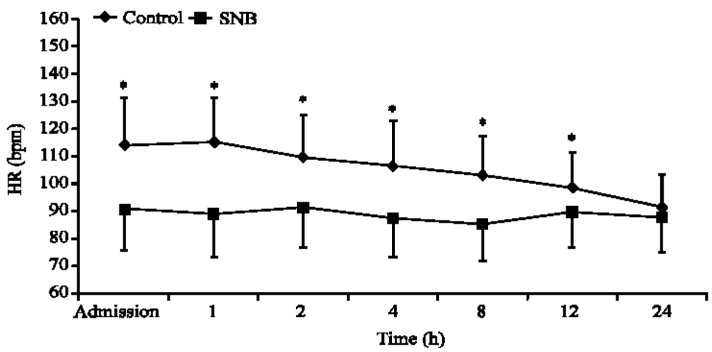

Fig. 4: Postoperative changes in Heart Rate (HR) beat min^{-1} (bpm) (Mean±SD). *p<0.05 vs. SNB

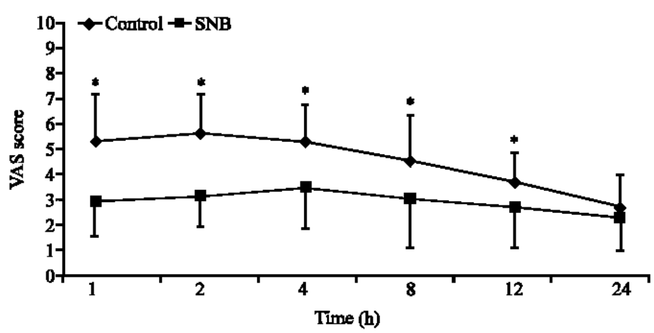

Fig. 5: Visual Analogue Scale (VAS) in the postoperative period (Mean±SD). *p<0.05 vs. SNB

longer in the SNB group compared to the control group (p<.05). All the 15 patients in the control group required rescue analgesia during the 24 h postoperative period compared to 8 patients in the SNB group (p<0.05). The number of analgesic doses required in each patient in the first 24 h postoperatively was significantly higher in the control group than in the SNB group (p<0.05) (Table 3).

No patient in the SNB group had any local or systemic undesirable effects associated with the use of the local anesthetic.

Table 3: Postoperative analgesia

Conditions	Control (n = 15)	SNB (n=15)
Time to first analgesia (h)	1.7±0.8	6.6±1.9*
No. of patients requiring analgesia in the first 24 h	15	8*
No. of analgesic doses required in the first 24 h		
1	0	4*
2	0	4*
3	3	0*
4	12	0*

Values are expressed as Mean±SD or number of patients. SNB : Scalp Nerve Block. * $p<0.05$ vs. control group

DISCUSSION

The present study shows, that SNB with 0.25% bupivacaine is an effective and safe technique when combined with general anesthesia in children undergoing craniotomy for supratentorial tumors. We found that the addition of SNB to the anesthetic plan successfully prevented the hemodynamic response to head pinning, reduced the anesthetic and analgesic requirement and efficiently decreased postoperative pain.

Wide variations of blood pressure are undesirable in patients undergoing craniotomy (Murthy and Rao, 2001). Abrupt increase in heart rate and blood pressure, most of which commonly occur during the time of scalp incision, head pinning, periosteal detachment, dural opening and brain retraction may lead to an increased risk for venous hemorrhage, sudden increase in intracranial pressure with a risk for herniation and worsening brain edema (Olsen *et al*., 2002). Therefore, minimizing hemodynamic perturbations remains an important element in the neuroanesthetic management of intracranial surgery.

This study demonstrates that addition of SNB to the anesthetic plan for pediatric patients undergoing craniotomy blunts the hemodynamic response to head pinning and skin incision. In agreement with these results, Pardey *et al*. (2008) had similar findings when using SNB for craniotomies in three pediatric patients. Also, Hartley *et al*. (1991) found that bupivacaine scalp infiltration blocks the hemodynamic responses to craniotomies in pediatric patients.

The same results were also demonstrated in adults. Lee *et al*. (2006) found that scalp block with 0.25% bupivacaine as an adjuvant to GA provided intraoperative hemodynamic stability as measured by HR and MAP. Pinosky *et al*. (1996) also performed a scalp block that successfully controlled hemodynamics during the placement of head pins. Hillman *et al*. (1987) reported hemodynamic attenuation with 0.5% bupivacaine scalp infiltration. In their study the surgeon infiltrated the local anesthetic along the incision line and along the proposed scalp flap line. The study did not include placement of head holding pins as a time point.

The current study showed also significant postoperative hemodynamic stability in patients who received SNB compared to the control group. In agreement with this finding, Ayoub *et al*. (2006) reported that SNB provided postoperative hemodynamic stability comparable to that of morphine when used as transitional analgesia.

Regarding intraoperative analgesia, the control group in present study required significantly more fentanyl supplementation than the SNB group. This was also reported by Lee *et al*. (2006), who found that only 2 out of 10 patients that received SNB needed intraoperative analgesic and anesthetic supplementation compared to all patients in the control group.

Although craniotomy pain is generally less severe than pain of extra cranial surgery (Leslie *et al*., 2003), more than 50% of craniotomy patients experience postoperative pain of moderate or severe intensity (Graham *et al*., 1999). The ideal analgesic for use in patients undergoing craniotomy is not yet available. Inspite of the fact that paracetamol alone is inadequate for post craniotomy pain

(Verchere *et al*., 2002), fear of complications such as sedation, hyperventilation and intracranial bleeding has inhibited prescribing effective multimodal pain treatment (Quiney *et al*., 1996).

Local anesthetic scalp blocks decrease postoperative pain when compared to placebo (Biswas and Bithal, 2003), this decrease makes sense because the scalp is densely innervated with C fibers and because the main cause of pain in this category of patients comes from the skin incision and muscle reflection, rather than from brain manipulation or resection (Nguyen *et al*., 2001).

Using VAS score, the present study demonstrated that children who received SNB had significantly lower VAS scores until 12 h postoperatively compared to the control group. This was evidenced by significantly fewer patients who received rescue analgesic, significantly longer time interval between the end of surgery and the first paracetamol dose, as well as lower number of postoperative paracetamol doses in SNB group compared to the control group. In consistent with present study, Nguyen *et al*. (2001) found that patients receiving SNB had lower VAS scores until 20 h postoperatively and longer time interval between the end of surgery and first analgesic dose when compared to the control group. The longer duration of postoperative pain relief in their study in comparison to present results can be explained by the fact that they performed the block by the end of the procedure while the block in the current study was performed before skin incision. Pardey *et al*. (2008) discussed the feasibility of the use of levobupivacaine for SNB in children as a lesser toxic local anesthetic and found that the children remained pain free for 20 h postoperative. We referred this long duration to the use of analgesic supplement postoperatively on fixed timing in their study. Ayoub *et al*. (2006) compared the transitional analgesia provided by SNB with that provided by IV morphine after remifentanyl based anesthesia during craniotomies. They found that SNB appears to be as effective as morphine in reducing postoperative pain scores with no side effects. This is consistent with present results that SNB is a safe and effective technique.

CONCLUSION

This study showed that bupivacaine SNB in children undergoing craniotomies for supratentorial tumors as adjuvant to general anesthesia can provide significant hemodynamic stability as measured by HR and MAP changes and significantly lower total intraoperative dose of fentanyl. Postoperatively there was also satisfactory analgesia as shown by significant lower VAS score, longer time to first analgesic dose and lesser number of children requiring rescue analgesia in first 24 h as compared to control group with no adverse effects. Lastly, it may prove fruitful to consider changing present practice in pediatric neurosurgery to include this technique as part of the routine anesthesia care.

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