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Hemodynamic and bispectral index changes following skull pin attachment with and without local anesthetic infiltration of the scalp

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Abstract
We studied the hemodynamic and bispectral index (BIS) changes in 44 patients undergoing cervical diskectomy with attachment of a Gardner-Wells tong (with two sharp conical pins) to the skull to facilitate intraoperative bone graft insertion. Patients were induced with fentanyl, thiopentone, and rocuronium and maintained with 66% nitrous oxide and 0.5% isoflurane, Before insertion of the pins, patients were randomly allocated to have either saline or lidocaine infiltration of the scalp at the proposed pin sites. Two minutes later, the pins were driven into the scalp. The BIS, mean arterial pressure (MAP), and heart rate (HR) were recorded before (baseline) and at 30, 60, 90, and 120s after pin insertion. Data were compared with the baseline values and between the groups. A significant increase in MAP and HR occurred throughout the study period in the saline group. Skull pinning increased BIS throughout the study period in the saline group only, with maximal increases observed at 90 and 120s (66.1 ± 6.3 at 90s and 65.7 ± 6.4 at 120s versus a baseline value of 62 ± 8, $P < 0.001$). The increase in BIS was significant in the saline group compared with the lidocaine group at each time point. In conclusion, increases in MAP, HR, and BIS produced by skull pinning were prevented by prior local anesthetic infiltration.

Key words Gardner–Wells tong · Skull pin · Bispectral index · Hemodynamics

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The bispectral index (BIS) has achieved popularity because it reflects hypnotic and anesthetic depth. BIS is a measure derived from processed electroencephalogram (EEG) data [1]. The BIS has been shown to be superior to other processed EEG parameters in assessing the depth of anesthesia and sedation [2,3]. A BIS value of 40–65 is suitable for anesthesia [4]. BIS can be used as a predictor of patient response to skin incision under anesthesia and it has decreased the incidence of intraoperative awareness [5,6].

Hypertension and tachycardia are the prominent hemodynamic responses observed on noxious stimulation of the scalp [7,8]. Such scalp stimulation may be the result of scalp incision or skull pin fixation. The two sharp skull pins of the Gardner–Wells tong are attached for cervical diskectomy followed by bone graft placement to impart stability to the cervical spine. This evokes a strong nociceptive input, thereby causing acute hypertension and tachycardia. These hemodynamic changes can be obtunded by infiltration of the scalp with local anesthetic [7–9] or by skull block prior to pin placement [10]. We hypothesized that BIS would increase when skull pins were attached without any adjuvant, if anesthetic depth was inadequate even in the presence of an inhalation agent, whereas it would remain unchanged when the pins were attached following local anesthetic infiltration of the scalp, which blocks nociceptive responses. Therefore, we sought to study the effect of skull pin application on the BIS in the presence or absence of local anesthetic infiltration.

The Institutional Review Board approved this prospective, randomized study and the patients gave informed consent. A total of 44 adult patients [22 each in the saline group (group I) and the lidocaine group group II)] scheduled for elective cervical disk surgery requiring the attachment of a Gardner–Wells tong to the skull were the subjects of the study. Exclusion criteria were any intracranial pathology, any systemic disease, and any chronic medication.

All patients were premedicated with diazepam 5mg orally on the morning of surgery. In the operating room, a BIS sensor (Aspect Medical System, Natick, MA, USA) was attached to the forehead and the monitor was set to generate a value every 15s. Routine monitoring consisted of an electrocardiogram (ECG), noninvasive blood pressure (NIBP) measurement, and pulse oximetry. Blood pressure monitoring was done by using

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the stat mode of the NIBP, which generates a value every 30 s. Fentanyl 2 $\mu g \cdot kg^{-1}$ was administered, and 5 min later anesthesia was induced with thiopentone and intubation was facilitated with rocuronium. Anesthesia was maintained with 0.5% isoflurane and 66% nitrous oxide. After normalization of the hemodynamic effects of tracheal intubation (approximately 5 min after intubation), the scalp was infiltrated at the proposed pin sites with either 2 cm^3 saline (group I) or 2 cm^3 plain lidocaine 2% (Group II). Two minutes later, pins were tightened into the scalp. BIS, NIBP, and the heart rate (HR) were recorded immediately prior to pin insertion (baseline) and subsequently at 30, 60, 90, and 120 s following pin placement.

Repeated measure analysis of variance (ANOVA) was applied to compare changes in various parameters with the baseline values in the same group. For post hoc comparison, the Bonferroni test was applied. The comparison of changes of various parameters between the two groups was performed using the Student *t* test. $P < 0.05$ was considered significant.

Both groups were comparable demographically (Table 1). Baseline MAP, HR, and BIS levels were comparable between the two groups. Pin attachment significantly increased MAP in the saline group compared with the baseline value as well as compared with the lidocaine group at each time point. No increase occurred in the lidocaine group; rather, MAP had decreased significantly at 120 s. The maximal rise in MAP in the saline group lasted up to 60 s. (103.5 ± 7.8 mmHg at 30 s and 103.0 ± 8.4 mmHg at 60 s compared with a baseline value of 90.3 ± 13.3 mmHg, $P < 0.01$, see Table 2). Similarly, pin attachment significantly increased HR in the saline group only. However, in the lidocaine group, HR decreased significantly at 90 and 120 s. HR changes between the two groups were statistically comparable during the study period (Table 3). In the saline group, pin placement significantly increased BIS from the baseline value of 62.4 ± 7.6, and this increase persisted throughout the study period. The greatest rise in BIS was noted at 90 and 120 s (66.1 ± 6.3 at 90 s and 65.7 ± 6.4 at 120 s, $P < 0.001$). Comparison of the BIS between the two groups revealed a significant increase in the BIS in the saline group at each time point (Table 4). Electromyogram (EMG) values in groups I and II were 30 ± 2 and 29 ± 1.5, respectively, after induction ($P > 0.05$) and remained at these levels throughout the study period.

As has been seen in previous studies, we too observed significant acute hypertension subsequent to skull pin placement in the saline group only. On the other hand, in the lidocaine group, because of blockade of nociceptive stimuli, HR and MAP showed a downward trend with the passage of time as the anesthetic depth increased. The significant blood pressure (BP) increase caused by skull pin attachment, therefore, represents a response to intense nociceptive stimulation and this in turn increases inputs to the cerebral cortex, reflected as increases in the BIS value.

Following pin fixation, there was an increase in BIS in the saline group only. The absence of increases in

Table 1. Demographic data

Parameter	Group I	Group II
Age (years)	45.0 ± 12.7	46.5 ± 11.4
Sex	17:5	18:4
Weight (Kg)	63.0 ± 10.5	60.3 ± 7.8

Data are mean ± SD
There were no significant differences between groups

Table 2. Mean arterial pressure changes after pin placement

Time (s)	Group I (mmHg)	Group II (mmHg)
Baseline	90.3 ± 13.1	92.0 ± 9.1
30	103.5 ± 7.8****###	93.3 ± 10.0
60	103.0 ± 8.4****####	92.4 ± 9.9
90	101.4 ± 9.6****####	90.4 ± 9.5
120	98.6 ± 10.0***##	88.9 ± 10.3**

Data are mean ± SD
** $P < 0.01$ compared with baseline
*** $P < 0.001$ compared with baseline
**** $P < 0.0001$ compared with baseline
$P < 0.01$ compared with group II
$P < 0.001$ compared with group II
$P < 0.0001$ compared with the group II

Table 3. Heart rate changes after pin placement

Time (s)	Group I (bpm)	Group II (bpm)
Baseline	89.9 ± 15.7	94.0 ± 13.2
30	95.7 ± 15.2*	91.9 ± 12.3
60	95.0 ± 14.7**	91.0 ± 11.9*
90	93.4 ± 14.9**	89.5 ± 11.5**
120	91.9 ± 15.9	88.5 ± 12.2**

Data are mean ± SD
* $P < 0.05$ compared with baseline
** $P < 0.01$ compared with baseline

Table 4. Changes is bispectral index after pin placement

Time (s)	Group I	Group II
Baseline	62.4 ± 7.6	58.0 ± 10.3
30	64.2 ± 7.2*##	57.9 ± 8.6
60	65.5 ± 6.1**##	58.5 ± 9.1
90	66.1 ± 6.3***###	57.6 ± 9.3
120	65.7 ± 6.4**##	58.2 ± 8.9

Data are mean ± SD
* $P < 0.05$ compared with baseline
** $P < 0.01$ compared with baseline
*** $P < 0.001$ compared with baseline
$P < 0.01$ compared with group II
$P < 0.001$ compared with group II

the lidocaine group shows the lack of cerebral cortex stimulation because of blockade of nociceptive inputs from the scalp. BIS is a predictor of patient response to skin incision [11]; however, its predictive value in unconscious patients might be significantly influenced by potentially arousing intraoperative stimuli because such stimuli increase plasma catecholamines [12]. The importance of an adrenergic system responsible for the modulation of consciousness is well known [13]. Exogenously administered adrenaline increases BIS values in deeply sedated patients but not in the presence of deep anesthesia [14,15]. In the saline group, despite sympathetic system activation, there was only a small (albeit significant) rise in BIS value. This demonstrates that the upsurge in plasma catecholamines did not increase the BIS value to the same extent that it increased BP and HR. The forestalling of a greater increase in BIS in the saline group might have been caused by the fentanyl, which was administered 5 min prior to anesthesia induction. Changes in BIS levels after a painful stimulation in volunteers are decreased by increasing opioid dosage[16]; Hans et al. [17] also emphasized the influence of analgesic depth on BIS response to pinion head holder placement.

There are some limitations to our study, the primary one being the implications of such a small rise in BIS value, because there is a low probability of explicit recall for BIS values of 75 or below. Also, the BIS changes were averaged over 15 s and thus it is difficult to compare the timings of the BIS response with respect to BP. Furthermore, the BIS value is a number derived from the preceding 15–30 s of EEG data; it is really a measure of the state just before the reading. The brain state, as measured by the BIS value, may change rapidly in response to strong stimulation. Finally, and most importantly, due to the lack of facilities we could not measure the plasma catecholamine levels to substantiate our hypothesis.

In conclusion, there is an increases in the levels of the hemodynamic parameters and BIS when the skull pins of a Gardner-Wells tong are inserted without local anesthetic infiltration of the scalp; these changes are completely prevented by prior local anesthetic infiltration of the scalp.

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