Original Article

Ultrasound Guided Nerve Stimulation and Nerve Stimulation Alone for Supraclavicular Brachial Plexus Block – A Randomized Comparative Study

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Abstract:

Background: *The safety of regional anaesthesia become more pronounced by the use of ultrasound and nerve stimulator. Supraclavicular nerve blocks known as 'spinal of the arm' are the most attractive upper extremity blocks to perform in our practice. In this study less experienced hands try to found the best approach for upper extremity block.*

Objective*: To comparethe success rate when Ultrasound addedwith Peripheral nerve stimulator in supraclavicular brachial plexus block.*

Methods: *After IRB approval and written consents from patients, total 66 patients divided into two groups,Group USNS had supraclavicular block guided by both ultrasound and Nerve stimulator. On the other hand Group BNS had this block by only Nerve stimulator. All the equipments kept ready and maintaining sterility a mixture of 0.5% Bupivacaine and 2% plain Lignocaine were prepared. The amount injected according to the body weight without crossing the toxic dose (2mg/Kg 0.5% Bupivacaine, 5mg/Kg 2% Lignocaine). Total volumes were 25-30ml for every patient.The sensory block was assessed by observers who unaware of the technique for every 2 minutes till the onset of block and every 10 minutes thereafter for 30 minutes. Any failure in establishing the block was converted to GA. The sensory dermatomes were assessed by alcohol swab. The motor blocks were evaluated by the same observer in each jointfor every 2 minutes till onset than 10, 20 & at the end of 30 minutes.Successful block was considered if no supplementation or conversion to general anaesthesia required.*

Results: *In all demographic variables and ASA Class, there was no differences in between the USNS group and BNS group.In group USNS block execution time was significantly higher($P<0.05$). The time required for both sensory and motor block was statistically significantly less in Group USNS compared to Group BNS (P value < 0.05). Regarding quality of motor block, at wrist joint statistical significance present between two groups (p value < 0.05). The duration of analgesia is significantly lower in Group BNS than Group USNS (P value is 0.012).In Group USNS, only one (3.03%) patient needed supplementation. But in Group BNS 7 (21.21%) patients needed supplementation. According to the definition, these cases were regarded as failed case. The success rate is significantly higher in Group USNS (P value is 0.024).*

Conclusion: *Combined use of ultrasound and peripheral nerve stimulator increases success rate than peripheral nerve stimulator alone in supraclavicular brachial plexus block. This combined method also reduces block execution time, early onset of both sensory and motor block, improve quality of sensory and motor block and less incidence of complications.*

Keywords: *Supraclavicular Block, Ultrasound guide, Peripheral nerve stimulator.*

(JBSA 2018; 31(2): 54-61)

Introduction:

Regional anaesthesia is a well accepted modality to achieve both economic and clinical benefits during the peri-operative period. The key to successful regional anaesthesia is to deposit the local anaesthetics as near as possible to the nerve structures. To achieve this, electrical stimulation by nerve stimulators or paresthesia (Blind technique) are being used, both of which relied on surface landmark identification. However, landmark techniques have limitations that includes variations in anatomy [1] and nerve physiology [2]as well as equipment accuracy have had an effect on success rates and complications.

Supraclavicular nerve blocks known as 'spinal of the arm' are the most attractive upper extremity blocks to perform in our practice. According to Kulenkampff and Persy,(1928) [3] in the early 20th century, the supraclavicular approach to the brachial plexus provides more effective and consistent regional anaesthesia to the upper extremity than other approaches to brachial plexus blockade. This block is ideal in providing a rapid onset, dense and efficient anaesthesia and analgesia for procedures from mid humerous proximally to those performed on the hand distally however the potential risk for pneumothorax and injury to surrounding structures had decrease its popularity. To locate peripheral nerves during the initiation of nerve blocks using peripheral nerve stimulator, with a low-intensity electrical current has become common practice in regional anaesthesia. The ability of a peripheral nerve stimulator to produce a motor response depends on the distance of the stimulus from the nerve (*i.e.*, the needle-to-nerve distance), as well as the intensity and duration of the current that has been set on the device [4] . Every device have a defined sensitivity and specificity. The peripheral nerve stimulation device arises potential false negative response when needle is in the correct perineural position but there is no corresponding motor response. This failure rate will result an inappropriate needle repositioning and the potential for unnecessary nerve injury and discomfort for the patient. It is found in a previous literature that 13.5% of the time, nerve stimulation failed to elicit a motor response despite the ultrasound confirmation of correct needle location during the performance of a supraclavicular block [5].The needle tip may be located intra-neurally, intravascularly, or on the other side of the fascia [6]. Moreover, any part of the axon may be depolarized and may propagate an action potential. So it is not possible to decide with certainty where the local anaesthetics are being injected. Besides, upon a visually confirmed needle–nerve contact, paresthesia is felt by only 38% of the patients and an electrical stimulation of 0.5mA elicits a visible muscle twitch only in 75% of them [7]. Therefore, a visual control of needle advancement in real time could improve needle placement and outcome precisely.

Ultrasound guided regional anaesthesia offers several potential advantages and this supported by many literature. For example, direct visualization of nerve trunks under ultrasound helps accurate localization. Likewise, it enables direct visualization of anatomical structures that is vessels, muscles, bones, fascias, tendons. This may help to assess individual variations in anatomy and facilitate identification of nerves correctly. Also, real-time control of needle advancement may reduce repeated needle penetration, block performance time and other potential complications e.g., vascular puncture, pneumothorax or neuropraxia. Assessment of local anaesthetics spread around the nerves can be done and immediate supplementary injections in case of insufficient spread can be possible. This may improve block effectiveness, shorten latency, prolong duration, allow local anaesthetics dose reduction and lower the risk of overdose [8]. Ultrasound frees the operator from using the anatomical landmarks. Nerves can be targeted at any point along their course where they can be seen. 'Blind techniques' rely on clicks, pops and twitches needing multiple trial and errors. Drawbacks like needle passes with lack of accuracy and reliability, longer placement times, patient discomfort and injury, can be avoided with imaging help. The aim of this study was to compare different parameters between ultrasound and peripheral nerve stimulator guided supraclavicular block with peripheral nerve stimulator guided block alone.

Methods:

This randomized study has been conducted in Anaesthesiology department of Bangabandhu

Sheikh Mujib Medical University after approved by the ethical review board of this hospital and also written informed consent obtained from all patients. This study was done on 66 adult patients, age above 18 yrs, male or female belonging to ASA I or II. Randomization was done by computer generated randomization technique with internet based software. (http://www.randomizer.org/form.htm). Total patient divided into two groups- Group USNS for Ultrasound guided nerve stimulation and Group BNS for only nerve stimulation. After entering into the Block execution place all basic monitoring were attached and with 18G cannulation port Inj. Prochlorperazine (0.25mg/Kg) then Inj. PethidineHydrocloride (0.5mg/kg) were injected. No other sedative or analgesics were used till evaluation of block up to 30 minutes. If even after 30 minutes block was not adequate for surgery, were supplemented. All these blocks were executed by, Residents who were in training phase for Ultrasound and Nerve stimulator guided regional anaesthesia, supervised by consultant anaesthesiologist.

Group USNS:

In this group patients were in supine position with 45° head up and tilted to opposite side. A pillow has placed below the shoulder & head in a way that operator could have sufficient space for USG probe movement. For all the cases SonositeMicromax HFL linear 38 probe (6-13 MHz) was used. Sterility of the probe maintained by a sterile plastic cover and Povidone Iodine was used as coupling agent. The probe placed in a coronal oblique plane to the supraclavicular fossa and tried to visualized subclavian artery and Brachial plexus in relation to the artery. Other spatial structures had been scanned to avoid injury to important structures. Next skin of the selected site was anaesthetized with 1-2ml of 1% Lignocaine. Then Nerve Stimulator attached with 20G 50mm stimulating needle and inserted from lateral to medial direction through in plane view. When needle entered between lower part of the plexus, stimulation been given at 0.5mA and observe the response. After negative aspiration 2/3 of total volume of drugs injected then repositions the needle at the upper part of the plexus to inject remaining 1/3 of the volume and spread of the drugs observed. When necessary needle reposition done to achieve adequate spread.

Group BNS:

In this group the positive electrode of the nerve stimulator was attached to an ECG led and stacked with a suitable site. Patient position was supine and head tilted to the opposite side and operator stand at the head end of the patient. Then identify the lateral boarder of the sternocledomastoid muscle by raising patient's head. After that rolled the index finger to identify Interscalene groove and in that groove go inferiorly to pulpatesubclavian artery and mark a point of needle entry. With 2ml of 1% lignocaine anaesthetized that point of needle entry. A 20G 50mm insulated needle attached with the negative electrode of the stimulator and inserted through the marked point to aanteroposterior direction towards ipsilateral nipple. Nerve stimulator was initially set at 1.5mA, 0.1ms with SENSE output and tried to elicit distal motor response. To obtain this end motor response needle repositioning had to be done. After end motor response, the current reduced till the presence of muscle twitch with 0.5mA and no twitch with a current of 0.2mA. The drugs than injected intermittently after negative aspiration.

Block execution time recorded for both groups. The sensory and motor block was assessed by observers who unaware of the technique for every 2 minutes till the onset of block and every 10 minutes thereafter for 30 minutes. Any failure in establishing the block was converted to GA. The sensory dermatomes were assessed by alcohol swab. The motor blocks were evaluated by the same observer in each joint[9]for every 2 minutes till onset than 10, 20 & at the end of 30 minutes.

Statistical analyses was carried out by using the Statistical Package for Social Sciences version 20.0 for Windows (SPSS Inc., Chicago, Illinois, USA). A descriptive analysis was performed for all data. The mean values were calculated for continuous variables. The quantitative observations were indicated by frequencies and percentages. The parametric data was analyzed by Student "t" test and the nonparametric data was analyzed by Chi-squre test. P value < 0.05 consider as significant.

Result:

Observations of this study were analyzed in the light of comparison among the subjects (Group USNS and Group BNS, each group having sample size of 33). All results were expressed as mean±SD or in frequencies or percentages as applicable. Statistical significance was considered if p value is <0.05. The studied groups became statistically matched for age, weight, sex, ASA class.

Table-I shows mean age distribution of the sample cases in Group USNS and Group BNS were 39.21±15.33 and 38.88±17.65 respectively. The mean weight of Group USNS was 61.67±10.19 kg and of Group BNS was 63.82±12.26 kg. The mean height of the patients in Group USNS was 1.64±0.09 meters and in Group BNS was 1.60±0.11meter. In Group USNS, male female ratio was 1:0.57 and in Group BNS it was 1:0.5. In the Group USNS, 24 (72.73%) patients were in ASA I and 9 (27.27%) were in ASA II. Again, in Group BNS, 22 (66.67%) were in ASA I and 11 (33.33%) in ASA II status. In all demographic variables and ASA Class, there were no differences in between the USNS group and BNS group.

Table-II represents distribution of cases according to onset of Sensory block expressed as mean±SD, and p value less than 0.05 are considered statistically significant. The time required for onset of sensory block in C5 dermatome of Group USNS was 3.64±1.29 min, in Group BNS it was 4.92±1.77 min and p value is 0.003 which imparted statistical significance. Likewise, in C6 dermatome of Group USNS was 3.81±1.28 min, in Group BNS it was 5.83±2.50 min and p value is 0.001 which imparted statistical significance. In C7, C8 and T1 dermatomes of Group USNS sensory onset time were 4.56±1.70 min, 5.19±1.82 min and 5.38±1.72 min and in Group BNS 6.17±2.50 min, 6.83±0.35 min and 7.08±2.28 min respectively. In each of the mentioned dermatomes, onset of sensory block is significantly lower in Group USNS than Group BNS.

Table-I *Demographic characteristicsand ASA class of the cases.*

Variables (N=66)		Groups		P value
		Group USNS n=33	Group BNS n=33	
Age (in years)		39.21±15.33	38.88±17.65	0.94
Weight (in kg)		61.67±10.19	63.82±12.26	0.44
Height (in meter)		1.64±0.09	1.60±0.11	0.15
BMI (in kg/m^2)		22.89±3.27	24.88±4.57	0.05
Sex	Male	21 (63.66%)	22 (66.66%)	1.00
	Female	12 (36. 36%)	11 (33.33%)	
ASA Class	I	24 (72.73%)	22 (66.67%)	0.79
	II	9 (27.27%)	11 (33.33%)	

Values are expressed in numbers(percentage) and mean±standard deviation. In case of Age, weight, height and BMI, P values are calculated by independent sample t test method. In case of sex and ASA class, P values are calculated by Chi square test.

Figure 1 shows block execution time in Group USNS was 403.09±66.63 seconds and in Group BNS was 468.12±83.35 seconds. This is statistically significant. The calculated P value is 0.001.

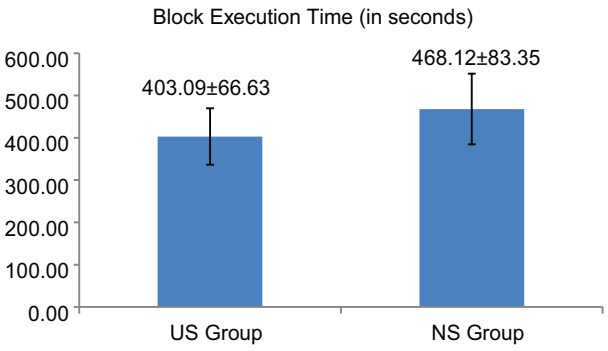

Fig 1: *Block Execution Time*

Table-II *Onset of Sensory Block in different dermatomes between two groups*

Dermatome	Group USNS (n=33) (in min)	Group BNS (n=33) (in min)	P Value
C5	3.64±1.29	4.92±1.77	0.003
C6	3.81±1.28	5.83±2.50	0.001
C7	4.56±1.70	6.17±2.50	0.006
C8	5.19±1.82	6.83±0.35	0.005
T1	5.38±1.72	7.08±2.28	0.002

Values are expressed in mean±SD. P values are calculated by Independent sample t test

Table III shows number of cases whether blocks have been achieved or not along each dermatome. In Group USNS, only one (3%) patient showed patchy block in C8 dermatome and one (3%) patient showed no block in T1 dermatome. All other dermatome showed no deviations after 30 minutes of onset of sensory block. But in Group BNS, 3 (9.1%) patients had no block in all of the dermatomes, one (3%) patient showed patchy sensation in C5, C6, C7 and C8 dermatome and six (18.2%) patient showed patchy sensation along the T1 dermatome after 30 minutes of onset of sensory block which was significantly higher than Group USNS (P value is 0.013).

Table IV represents distribution of cases according to onset of Motor Block expressed as mean±SD. In Group USNS, the onset of motor block was found 3.82±1.45 minutes in shoulder joint, 4.36±1.62 minutes in elbow joint and 4.97±1.94 minutes in wrist joint. In Group BNS, the onset of motor block was found 5.93±1.96 minutes in shoulder joint, 6.69±2.09 minutes in elbow joint and 7.86±2.56 minutes in wrist joint. In every joint, the time required for block was statistically significantly less in Group USNS compared to Group BNS (P value < 0.05).

Table-III *Distribution of cases according to Quality of Sensory Block.*

	Group USNS (n=33)			Group BNS (n=33)			P
	Blocked	Patchy	No Block	Blocked	Patchy	No Block	value
C5	33	0	0	29	1	3	0.114
C6	33	0	0	29	1	3	0.114
C7	33	0	0	29	1	3	0.114
C8	32	1	0	29	1	3	0.355
T1	32	0	1	24	6	3	0.013

Values are expressed in number. P values are calculated by Chi square test

Table-IV *Onset of Motor Block between two groups at different joints.*

Joints to evaluate onset of motor block	Groups		P value
	Group USNS (n=33) (in minutes)	Group BNS (n=33) (in minutes)	
Shoulder	3.82±1.45	5.93±1.96	0.015
Elbow	4.36±1.62	6.69±2.09	0.023
Wrist	4.97±1.94	7.86±2.56	0.014

Values are expressed in mean±SD. P values are calculated by Independent sample t test

Table V represents distribution of patients according to quality of Motor block. In Group USNS, only one (3.03%) patient showed patchy block over the elbow joint and another one (3.03%) had no block over the wrist joint. But in Group BNS, it was found that 3 (9.09%) patient had no block over all three joints, one (3.03%) had patchy block over shoulder joint, 2 (6.06%) over elbow joint and 3 (12.12%) had patchy block over wrist joint. In shoulder and elbow joint there is no statistical significance present but at wrist joint statistical significance present between two groups (p value < 0.05).

Table-V *Quality of Motor Block between two groups at different joints.*

	Group USNS (n=33)			Group BNS (n=33)			P
	Blocked	Patchy	No Block	Blocked	Patchy	No Block	value
Shoulder	33	0	0	29	1	3	0.114
Elbow	32	1	0	28	2	3	0.197
Wrist	32	0	1	26	4	3	0.054

Values are expressed in number. P values are calculated by Chi square test

Figure 2 shows that in Group USNS, the mean duration of analgesia was 236.36±20.89 min and in Group BNS it was 201.82±73.59. The duration of analgesia is significantly lower in Group BNS than Group USNS (P value is 0.012).

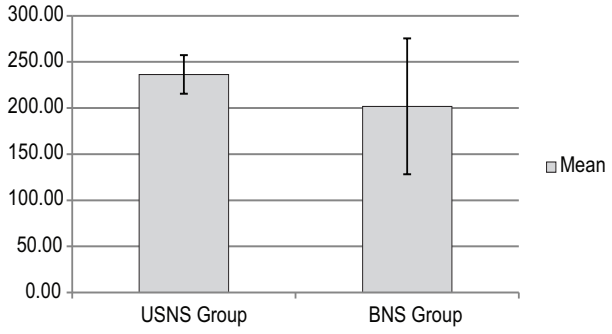

Figure 2 *Distribution of patients according to duration of analgesia*

Table VI representsdistribution of patients according to incidence of complication. In Group USNS, there was no complication. But in Group BNS, in 4 (12.12%) patient complication (all were vascular injury) were present. Although this data is not statistically significant (0.114).

Table VI *Complications between Group USNS and Group BNS.*

	Group		Total	P
	USNS (n=33)	BNS (n=33)		value
No Complication	33 (100%)	29 (87.88%)	62 (93.93%)	0.114
Complication	0 (0%)	4 (12.12%)	4 (6.06%)	

Values are expressed in numbers and percentage over column total. P value is achieve by Chi Square test

Table VII shows distribution of patient according to success rate. In Group USNS, only one (3.03%) patient needed supplementation. But in Group BNS 7 (21.21%) patients needed supplementation. According to the definition, these cases were regarded as failed case. The success rate is significantly higher in Group USNS (P value is 0.024).

Table VII *Success rate(according to operational definition) between two groups.*

	Group		Total	P
	USNS (n=33)	BNS (n=33)		value
Failed Block	1 (3.03%)	7 (21.21%)	8 (12.12%)	0.024
Successful Block	32 (96.97%)	26 (78.79%)	58 (87.88%)	

Values are expressed in numbers and percentage. P value was calculated by Chi Square test

Discussion:

For the last decade, the use of real time ultrasonography guided peripheral nerve block has been revitalized as there has been rapid improvement in transducer device, lessening of cost, availability and advancement of portable ultrasonogram device. The rapid evolution of the ultrasonogram device enables it's more elaborative use in the field of regional anaesthesia resulting in escalation of use of previously unpopular techniques like supraclavicular brachial plexus block due to visualization of plexus and its relationship with surrounding vessels, first rib and pleura.

The demographic variables in this study have imparted no statistical significance in between the two groups. The block execution time, expressed as mean±SD, for cases in Group USNS was 403.09±66.63 seconds and in Group BNS was 468.12±83.35 seconds. This was statistically highly significant as the calculated P value is 0.001. A review from Liu et al. (2009)[10] comparing US guided versus NS guided techniques, observed similar results in expert hand. The faster performance in ultrasound guidance blockade can be explained logically. Ultrasoundgraphy enables the performer to visualize the location, the spatial anatomy and ascertain the size and position of the plexus. Also it visualizes the needle, enabling its positioning and repositioning under direct real time vision. However, PNS guided technique is a blind technique needing speculation rather direct visualization of the surrounding structures and needle position.

In this study, the onset of sensory blockade was examined in each dermatome and found significantly lower in every dermatome as

compared to PNS guided group. In the series of Williams et al. (2003)[11] it was showed that significant decrease in the onset of blockade time in the USG group. Also in Lo et al. (2008)[12] reported that reduction of onset time when compared to PNS guided axillary blockade. The early onset of sensory blockade can be explained by the fact that, under direct vision of unltrasound, local anaesthetics can be placed very near to the nerve plexus.

In Group USNS, only one (3%) patient showed patchy block in C8 dermatome and one (3%) patient showed no block in T1 dermatome. All other dermatome showed no deviations after 30 minutes of onset of sensory block. But in Group BNS, 3 (9.1%) patients had no block in all of the dermatomes, one (3%) patient showed patchy sensation in C5, C6, C7 and C8 dermatome and six (18.2%) patient showed patchy sensation along the T1 dermatome after 30 minutes of onset of sensory block. In the series of Duncun et al. (2013)[9] it was reported that complete anaesthesia at 30 minutes was achieved more reliably and rapidly in the C6, C7, C8 and T1 dermatomes compared to C5 dermatomes. They had found no statistical significance in the degree of sparing of the C5 dermatome between the Group US and Group NS. Interestingly, in this study, sparing of T1 occurred more in Group BNS with statistical significance than that of Group USNS, probably due to confirmation of drugs distribution around lower trunks (corner pocket) in Group USNS.

In Group USNS, the onset of motor block was found 3.82±1.45 minutes in shoulder joint, 4.36±1.62 minutes in elbow joint and 4.97±1.94 minutes in wrist joint. In Group BNS, the onset of motor block was found 5.93±1.96 minutes in shoulder joint, 6.69±2.09 minutes in elbow joint and 7.86±2.56 minutes in wrist joint. In every joint, the time required for block was statistically significantly less in Group USNS compared to Group BNS (P values< 0.0001). This result was comparable to the study of Chan et al. (2003)[13]where the onset of motor blockade in ultrasound guided group was 5.40±1.80 minutes. Though in present study all blocks executed by a trainee but had faster motor onset, may be because of adequate drug distribution around the plexus which could not be confirmed by blind neurostimulation technique.

This study also examined the quality of motor block at the shoulder, elbow and wrist in each group. In Group USNS, only one (3.03%) patient showed patchy block over the elbow joint and another one (3.03%) over the wrist had no block. But in Group BNS, it was found that 3 (9.09%) patient had no block over all three joints, one (3.03%) had patchy over shoulder joint, 2 (6.06%) over elbow joint and 3 (12.12%) had patchy block over wrist joint. After statistical analysis it is found that at wrist joint statistical significance present which may be due to equal distribution of drugs in Group USNS.

In Group USNS, the mean duration of analgesia was 236.36±20.89 minutes and in Group BNS it was 201.82±73.59 minutes. The duration of analgesia is significantly lower in Group BNS than Group USNS (P value is 0.012). In the series of Thomas et al. (2011)[14] the duration of analgesia is indifferent in both groups. But in the series of Duncan, et al. (2013)[9] the duration of analgesia was much higher in both groups compared to this study which was 429.5±90.79 minutes in Group US and 401.1±105.65 minutes in Group NS. Importantly, their series indicated a shorter duration of analgesia in Group NS which was comparable to this study. Their longer duration can be explained by using different drugs combination during anaesthesia.

Reasonably, the Group USNS has fewer complication rates in this study. In Group USNS, there was no complication. But in Group BNS, in 4 (12.12%) patients complication (all were vascular injury) were present. This was in line with the series of Thomas et al. (2011)[14], Rupera et al. (2013)[15]and with Liu et al.(2013)[16]. In every above mentioned series, the complication rates were fewer or nil in the Group US compared to Group NS. Marhofer et al.(1998)[17]. also reported improved safety profile in USG guided three in one block than PNS guided block. This is because of real time visualization of vessels by ultrasound device.

Success rate in this study results was 96.97% in Group USNS as compared to Group BNS which was 78.79%. This result was comparable to the study of Williams et al. (2003)[11], who reported success rate of 85% in Group USNS and 78% in Group BNS. In the series of Rupera, et al. (2013)[15] success rate in Group USNS was 96.67% and in Group BNS was 80%. In this present study success rate is significanly higher in Group USNS because

all procedure performed by trainee and for a trainee it may take less experience and less time to learn ultrasonoguided plus PNS stimuladed brachial plexus block than landmark guided PNS stimulated brachial plexus block.

Under the condition of present study, it can be concluded that combined use of ultrasound and peripheral nerve stimulator increases success rate than peripheral nerve stimulator alone in supraclavicular brachial plexus block. This combined method also reduces block execution time, early onset of both sensory and motor block, improve quality of sensory and motor block and less incidence of complications.

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