Section: Anesthesia

Original Research Article

EFFECTIVENESS OF NERVE STIMULATOR-INDUCED EVOKED MOTOR RESPONSES AS A PREDICTOR FOR SUCCESSFUL SCIATIC NERVE BLOCKADE IN BELOW-KNEE SURGERIES – A PROSPECTIVE CLINICAL STUDY

Sundaram L N[1], Sathya Narayanan K[2], Rangarajan R[2], Om Rajeshkumar R[3], Rajalakshmy Arthi C[3], Nithyaa D[3]

[1]Associate Professor, Department of Anesthesia, ESIC Medical College & Hospital, KK Nagar, Chennai, Tamilnadu, India
[2]Assistant Professor, Department of Anesthesia, ESIC Medical College & Hospital, KK Nagar, Chennai, Tamilnadu, India.
[3]Resident, Department of Anesthesia, ESIC Medical College & Hospital, KK Nagar, Chennai, Tamilnadu, India.

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Corresponding Author:
Dr. Sathya Narayanan K,
Email: sathyavaan4444@gmail.com

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Abstract

Background: Sciatic nerve blocks relieve pain for below-knee surgeries like amputations, debridement, etc. This study aimed to predict the effectiveness of evoked motor responses by a nerve stimulator for a successful single-shot sciatic nerve block. **Materials and Methods:** This prospective interventional clinical study included a hundred ASA Grade I/II patients planned for below-knee surgeries under peripheral nerve block by nerve stimulation and evaluating the motor-evoked responses. A preoperative airway assessment was performed based on multiple parameters. The participants were classified into four groups based on the motor-evoked responses depending on nerve stimulation: Group I: Inversion, Group E: Eversion, Group PF: Plantarflexion, and Group DF: Dorsiflexion. **Result:** The sensory onset was earliest in the Inversion group (I) at 20.781± 3.386 min, followed by Eversion (E) at 36.428± 16.76 min. The Motor onset was earliest in Inversion group (I) at 14.531± 3.2 min, followed by Eversion (E) at 32.85± 19.11min, Dorsiflexion (D) at 36.73± 9.2673 min, and Plantar flexion (PF) 49.94±12.414. The duration of sensory block in the Inversion group (I) was 7.156± 1.761 hr, Dorsiflexion (D) was 6.75± 2.25 hr, Plantar flexion (PF) was 5.833±0.2886 hr, and Eversion (E) was 5.33±0.516 hr. The duration of motor block in the Inversion group (I) was 6.968± 1.66 hr, followed by Eversion (E) was 6.25±0.418 hr, Dorsiflexion (D) was 7.375±1.446 hr, and Plantar flexion (PF) was 6.5±0.387 hr. **Conclusion:** Nerve stimulation-guided nerve blocks are clinically inferred, cost-effective, and easier to carry, whereas ultrasound-guided nerve blocks are more reliable, and modern-day anaesthesia utilises both.

INTRODUCTION

In regional anaesthetic procedures, peripheral nerve blocks are considered relatively safe in haemodynamic stability. Peripheral nerve blocks in extremities do not cause significant hemodynamic constraints and successfully deliver extended postoperative analgesia and restore early normalcy in the postoperative period.[1] Different methods can be used to locate a nerve or a compartment that contains nerves so that local anaesthesia can be injected around the nerve or in that compartment to inhibit nerve conduction. The various methods include nerve stimulators, paraesthesia, and, most recently, ultrasonography.[2] Before the development of specialised locators, nerve blocks to induce paraesthesia were carried out using anatomical landmarks. The disadvantages of utilising a paraesthesia approach include a higher chance of nerve damage from the needle touching the nerve, its reliance on a subjective sensation, and the absence of an objective reaction that the anesthesiologist can use.[3] Additionally, some patients may find paraesthesia to be painful and intolerable.

The use of nerve block procedures has been transformed in recent years by ultrasonography. Seeing the nerves and the needle while administering a nerve block has the added benefit of being more effective.[4] The two main problems limiting ultrasound utilisation today are machine expense and training. The sciatic nerve block entails multiple

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difficulties starting from positioning the patient and locating the nerve, the long duration taken by the nerve to be completely blocked after drug administration, and the frequent sparing and patchy effects.[5] However, if these issues are resolved, sciatic nerve blocks would undoubtedly be selected more frequently for ankle and foot surgeries because of their low rate of complications, minimal impact on hemodynamics, sustained analgesia, enhanced wound healing, and quick return to normal life.[6]

This study aimed to increase the success rate of single-injection nerve block and to find out the sciatic nerve area that would permit better drug penetration with the help of evoked motor response. The primary outcome was to find out the type of evoked motor response which would give the maximum success rate, and the secondary outcomes were the onset and duration of block measured among the four groups.

MATERIALS AND METHODS

After obtaining IEC approval, this hospital-based prospective study was conducted over one year. After preoperative evaluation and discussion of anaesthetic options, the written informed patient consent for participation in the study and use of data for research was obtained.

Inclusion Criteria

One hundred adult patients of either sex from 18 to 60 years of age, weighing between 40 kgs to 80kgs, classified under American Society of Anaesthesiologists (ASA) physical status I, II, scheduled for below-knee surgeries like debridement, amputation and fracture fixations of the leg were included.

Exclusion Criteria

Participants in the age group <18 years and >60 years, anyone with known hypersensitivity to local anaesthetics, coagulopathy, severe cardiomyopathies, severe systemic diseases like uncontrolled asthma, COPD, pregnancy, and neuromuscular disease, neuro disorders or deficits, associated peripheral neuropathies, skin lesions at the site of the blockade, non-co-operative patients during positioning were also excluded along with patients with communication difficulties.

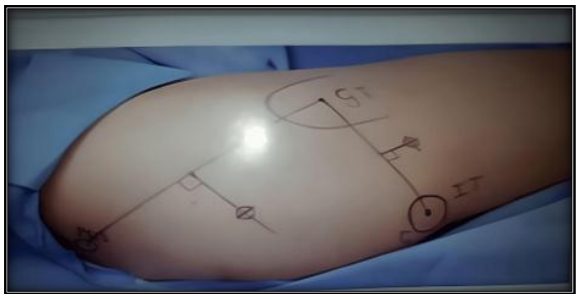

Figure 1: Labat's approach to sciatic nerve block

After ascertaining adequate fasting status inside the operation theatre, patients were cannulated with an 18G IV line and started on the ringer lactate. Oxygen was delivered via a face mask. They all received 0.02 mg/kg of iv Midazolam before the procedure. The sensory and motor examinations of the foot were carried out. Then the sciatic nerve blockade in the subgluteal area was performed by resident trainees supervised by faculty using the subgluteal-para biceps approach.[7] It includes three points, namely the Greater Trochanter (GT), Ischial tuberosity (IT) and a midpoint on the line connecting the first two points and two lines, namely 1st line connecting GT and IT and the 2nd line, a perpendicular line drawn from the midpoint of 1st line and extended 4 - 6 cm caudad [Figure 1].

The patient was placed in the Sims position, with the leg to be blocked, placed up and supported to permit unrestricted movement. The area was prepared with povidone-iodine solution, dried and draped. The nerve stimulator was used after marking the surface landmarks, and the sciatic nerve block was performed. The nerve stimulator needle's entry point is in the perpendicular line about 4 cm from the midpoint of 1st line. The Skin at the point of entry of the nerve stimulator needle is anaesthetised with 1ml of 1% lidocaine solution. A peripheral nerve stimulator identifies the sciatic nerve with 2 Hz, a pulse width of 100 ms, and the current was set to deliver 1.0mA [Figure 2].

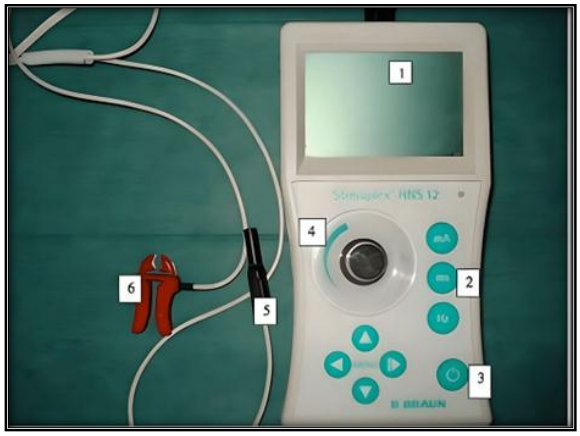

Figure 2: Nerve stimulator

The nerve stimulator needle (B-Braun) was used to identify the site triggering the muscular response to a stimulus between 0.6 and 0.4 mA. The tip was considered close to the nerve when the current strength was less than 0.6 mA. It was not recommended to administer the drug at a current strength below 0.3 mA to avoid intraneuronal injection risks. Intermittent aspirations were observed during drug administration. The evoked muscle response faded after 2-3 ml of the drug, and if it reappeared, another 5 ml was given without changing the needle's direction or position.

Participants were assigned into four groups according to the type of evoked motor response they exhibited I (Inversion), PF (Plantar flexion), DF (Dorsi flexion) and E (Eversion) [Figure 3]. The primary outcome was to find out the type of evoked motor response which would give the maximum success rate, and the

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secondary outcomes were the onset and duration of block measured among the four groups. The person who assessed the block parameters was blinded to the evoked motor response.

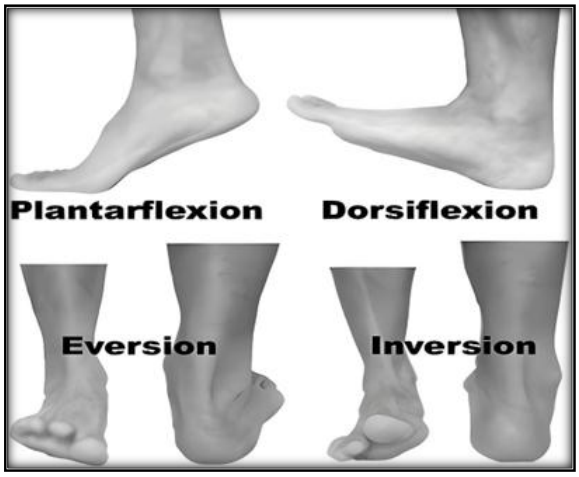

Figure 3: Motor evoked response of the foot

The study used an EMR of 0.4-0.6 mA to determine group assignment and motor responses. A block assessment was given for 1 hour by the drug administration, with failure determined at the end. If a blockade was complete before the time, it was considered successful, and surgery was advocated. Sensory blockade was defined as the loss of pinprick stimulation at terminal nerves. Motor block duration was defined as the time from onset until patients could not move their toes. Patients were evaluated at 0, 2, 4, 6, 8, 10, 15, 20, 25, and 30 minutes after the block, then every 10 minutes until one-hour post-block. Blockade's success was defined as complete analgesia and inability to move within 1 hour.

Absence of sensory and motor block at the end of 60 minutes after a block is defined as failure. Those patients underwent spinal or general anaesthesia, and the procedure was carried out. They will be maintained in the study and analysed for failure rate. The duration of the surgery ranged between 1-3 hours. Intraoperative supplementations with 0.02 mg/kg of iv midazolam and 1 microgram per kg of iv fentanyl were given to all the patients to maintain uniformity in the study and to avoid positional pain and discomfort. After the surgery, patients were transferred to the post anaesthetic care unit. The surgery duration, the type of surgery, the anaesthesia duration and the time in PACU were recorded.

Additionally, patients were continuously observed for symptoms of cardiovascular or central nervous system toxicity (such as perioral numbness, changes in blood pressure, heart rate, or rhythm, or CNS symptoms like convulsions). All patients with ongoing neurological symptoms who did not improve by the time follow-up phone calls or in-person visits were scheduled were sent for a neurologic evaluation and diagnostic testing using nerve conduction velocities and electromyography.

Statistical analysis:

IBM SPSS software was used for the analysis, and the alpha level was set at 0.05. The baseline characteristics of the samples were analysed using descriptive statistical analyses (Mean, Range, & Standard Deviation). Data is either presented in the form of pie charts or bar columns. The p-value less than or equal to 0.05 was considered significant.

RESULTS

A hundred patients participated in the study. According to their initial response, thirty-two patients were included in Group I (Inversion), Thirty-five patients in Group PF (Plantar flexion), twenty-six patients in Group DF (Dorsiflexion), and seven patients in Group E (Eversion). Six patients were excluded from the analysis due to failure to retain response < 0.6 mA, and eight patients were abandoned due to the inability to evoke a motor response even after multiple attempts to locate the nerve, given the patient's discomfort.

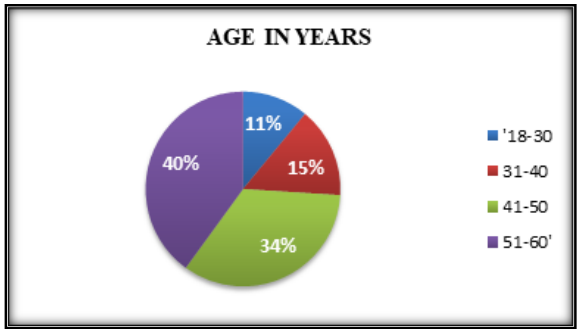

Figure 4: Statistical description of age and clinical variables

The above pie chart shows the percentage of age groups of patients enrolled. Most of the patients were in the age group of 40 to 60 years. Approximately one-fourth of the patients were found to be less than 40 years [Figure 4 and Table 1].

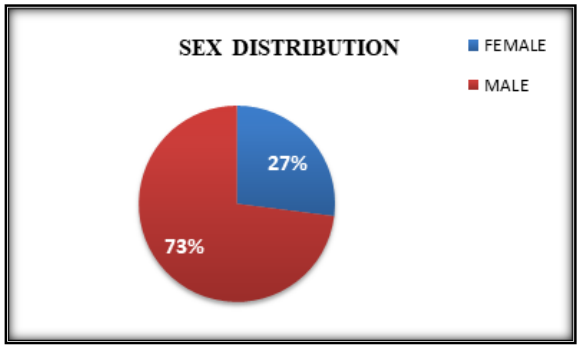

Figure 5: Statistical description of sex distribution and clinical variables

In the above chart, sex distribution is depicted. Among the hundred patients, three fourth were males, and one-fourth were females [Figure 5 and Table 2]. The mean age (in years) overall was 41.26 ± 8.14 (p-value> 0.05). The mean weight (in kg) overall was 63.79± 2.53 (p-value> 0.05). The mean height (in

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cm) overall was 170.54 ± 3.64 (p-value> 0.05). The BMI (in Kg/m2) overall was 22.16 ± 0.88 (p-value> 0.05) [Table 3].

Body mass index (kg/m^2):

Patients with a BMI of less than 18 and greater than 30 are avoided in the study population. Lower the BMI superficial was the location of the nerve, and it may at times evoke more than one response where the performer finds it difficult to hold the nerve stimulator needle in position [Table 4].

Nerve to Skin Distance

We were able to perform the block faster in patients with lower BMI, and at the same time, they had a shorter distance of needle travel from the Skin compared to those patients with a BMI of more than 25 [Table 4].

Local Anaesthetic Volume

The local anaesthetic used is bupivacaine in 0.5%. The toxic dose of bupivacaine is 3 mg/kg. So, we take 0.5 ml of 0.5% bupivacaine/kg body weight and administer it to patients enrolled.

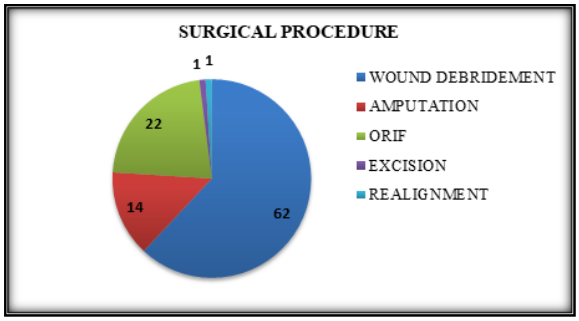

Figure 6: Surgical procedure

After ensuring complete blockade, the surgical procedures the patients were subjected to were mainly Wound debridement following trauma like a Degloving injury and Raw area leg and foot. Due concern was given to rule out preoperative diabetic neuropathy and disturbed neuromuscular integrity, in which cases were not enrolled in the study. The other half of the surgical procedures involved bony and soft tissue components. The surgical procedures in this regard include Amputations, Open reduction and fixation for fractures and certain miscellaneous procedures like excision and external fixator realignment. More than half of the patients who showed sensory blockade of grade 2 that could not feel the pinprick at the end of one-hour experienced discomfort while handling the bony components. But the discomfort was settled with rescue iv analgesics in minimal doses without needing conversion to General anaesthesia in the intraoperative period and without any hemodynamic disturbances. But no such problems were encountered with patients who underwent soft tissue procedures. Even though we could not demonstrate a statistical significance for this type of discomfort to any of the evoked motor responses, we did not come across an Inversion group of patients giving such a complaint. In contrast, all the other groups, including the Dorsiflexion group, had such a problem intraoperatively [Figures 6 & 7].

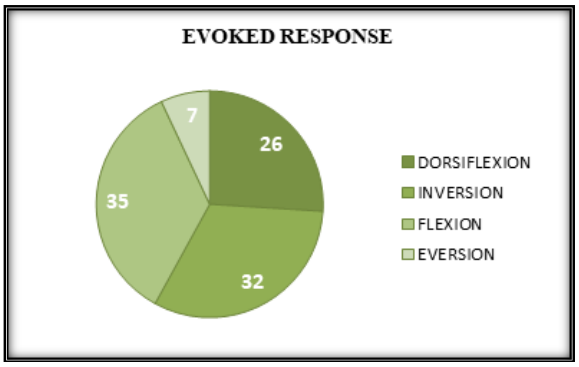

Figure 7: Evoked response

In Response group I (Inversion), the mean time of sensory onset was 14.531±3.2 mins, motor onset was 20.781±3.386 mins, mean duration of sensory block was 7.156±1.761 hours, and the mean duration of motor block was 6.968±1.66 hours, and the success rate of the block was 100%.

In the Response group PF (Plantarflexion), the mean time of sensory onset was 36.63±17.96 mins, and motor onset was 49.94±12.41 mins, mean duration of sensory block was 5.83±0.29 hours. The mean duration of the motor block was 6.5±0.39 hours, and the success rate of the block was 60%.

Table 1: Type of response in different age categories

Response	18-30	31-40	41-50	51-60
Inversion	1	6	13	12
Plantar flexion	4	6	10	15
Dorsiflexion	4	3	9	10
Eversion	2	-	2	3

Table 2: Type of response in males and females

Response	Male	Female
Inversion	21	11
Plantar flexion	27	8
Dorsi flexion	19	7
Eversion	6	1

Table 3: Demographical parameters

Variables	Minimum	Maximum	Mean	Std. Deviation
Age (Years)	30.00	58.00	42.36	8.14
Weight (Kg)	59.00	73.00	64.89	2.53

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Height (m)	166.00	182.00	171.55	3.64
BMI (Kg/m2)	21.01	23.46	22.06	0.88

Table 4: Type of response in different categories of BMI and nerve-to-skin distance

Response	**BMI**		
	< 20	**20-25**	**>25**
Inversion	6	26	-
Plantar flexion	-	29	6
Dorsi flexion	-	20	6
Eversion	1	6	-
Response	**Nerve-to-skin distance**		
	<4 cm	**4-6 cm**	**>6 cm**
Inversion	3	27	2
Plantar flexion	1	34	-
Dorsi flexion	1	23	2
Eversion	1	6	-

Table 5: Sensory onset, Motor onset, Sensory duration, and Motor duration

Response		**Number**	**Mean ± SD**	**P value**
Sensory onset	Inversion	32	14.531± 3.2	0.000
	Plantarflexion	35	36.628±17.96	
	Dorsiflexion	26	36.73± 9.2673	
	Eversion	7	32.85± 19.11	
Motor onset	Inversion	32	20.781± 3.386	0.000
	Plantarflexion	35	49.94±12.414	
	Dorsiflexion	26	44.423± 6.53	
	Eversion	7	36.428± 16.76	
Sensory duration	Inversion	32	7.156± 1.761	0.001
	Plantarflexion	35	5.833±0.2886	
	Dorsiflexion	26	6.75± 2.25	
	Eversion	7	5.33±0.516	
Motor duration	Inversion	32	6.968± 1.66	0.027
	Plantarflexion	35	6.5±0.387	
	Dorsiflexion	26	7.375±1.446	
	Eversion	7	6.25±0.418	

In the Response group DF (Dorsiflexion), the mean time of sensory onset was 36.73±9.27 mins, motor onset was 44.42±6.53 mins, the mean duration of sensory block was 6.75±2.25 hours, and the mean duration of motor block was 7.37±1.44 hours, and the success rate of the block was 88%.

In the Response group E (Eversion), the mean time of sensory onset was 32.85±19.11 mins, and motor onset was 36.43±16.76 mins, mean duration of sensory block was 5.33±0.52 hours. The mean duration of the motor block was 6.25±0.42 hours, and the success rate of the block was 71%.

The one-way ANOVA indicates a statistically significant difference in sensory onset, motor onset, sensory duration, and motor duration [Table 5].

DISCUSSION

This study deduced that the results of the evoked motor response of the Inversion type are associated with the fastest onset of complete sensory block within a mean time of fifteen minutes. The study by Benzon et al. supported this due to the location of sciatic nerve fibers in the nerve's central part, favouring local anaesthetic spread on both sides. The study also stated that they had no significant difference between the I and DF groups, contrary to our study, where there was a marked difference between the two because the DF group achieved complete onset only 45 minutes after drug administration. This increase in time duration was attributed to the adoption of a lateral position and subgluteal approach, due to which the DF fascicle was lateralised, whereas, in a prone position and popliteal approach, the deep peroneal nerve in the dorsiflexor bundle was relatively centralised.[8]

The findings of Sukhani et al. also revealed that Inversion is the EMR with the fastest onset of sensory block among the four groups. There was no difference in onset between PF and E groups.[9] From this study, it was also inferred that sensory onset precedes motor onset in all four EMR groups, which are not determined by EMR but rather by a difference in the diameter of nerve fibers as in other parts of the body.[10]

In a study by Casati et al., a combination of mepivacaine and ropivacaine was used for sciatic nerve blockade in both anterior and posterior approaches to elicit only two responses, namely plantar flexion and dorsiflexion responses.[11] The onset time for the complete sensory blockade was 30 minutes as compared to 37 minutes in our study which can be attributed to the usage of plain bupivacaine used in our study. These attributions from clinical studies on Sciatic nerve block are confirmed by Studies on fascicular anatomy done by Mckinley et al., Sunderland et al. and Upadhye et al. In the images they generated, they gave a central position for the Invertor bundle and occupied most of the area.[12-14]

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Limitations

Limitations of our study are that we have included only Physical status 1 and 2 cases. Only plain bupivacaine was used, and adding an adjuvant would have prolonged the duration of the block. Nerve blocks can be a safe alternative in high-risk cases where other anaesthesia modalities are relatively contraindicated due to comorbidities in emergency settings.[15] Factors like the patient's position and the nerve's approach also influence the outcome measure, which was not dealt with in this study.[16]

CONCLUSION

Although, In the era of never-ending technical advancements led by ultrasound which has revolutionised nerve blocks, nerve stimulator still holds their significance relevant by eliciting motor responses ensuring close needle-to-nerve proximity and hence a successful nerve blockade. More studies with a combination of nerve stimulators and USG are required to investigate failures encountered in dorsiflexion, plantar flexion and eversion groups.

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. The Institutional Ethics Committee, ESIC MEDICAL COLLEGE & PGIMSR, KK NAGAR, CHENNAI issued approval IEC/2013/2/14. The Institutional Ethics Committee met on 05.08.2013 between 1.45 PM and 5.30 PM. The below-mentioned proposal was considered in this meeting of the committee. The following is the decision of the Institutional Ethics Committee. IEC No. IEC/2013/2/14 Research Proposal Title Effectiveness of Nerve Stimulator Induced Evoked Motor Responses as a Predictor for Successful Sciatic Nerve Blockade in Below-Knee Surgeries – A Prospective Clinical Study Name of the Principal Investigator Dr. L.N. Sundaram Name of the Co-Investigator Dr. Sathya Narayanan. K Department Anaesthesiology Name and Address of the Institution ESIC Medical College & PGIMSR, KK Nagar, Chennai 600078 Type of Review Full Board Review Decision of the IEC Approved Period of validity of the approval 25.08.2013 to 24.08.2016. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organisation for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organisations that might be interested in the submitted work. Other relationships: All authors have declared that no other relationships or activities could appear to have influenced the submitted work.

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