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Comparative Efficacy of Dexamethasone Plus Bupivacaine versus Bupivacaine Alone in Ultrasound-Guided Supraclavicular Brachial Plexus Block for Upper Limb Surgeries: A Prospective Non-Randomized Controlled Clinical Trial.

Dr. Suryakumari Malothu[1*], Dr. Pannati Sireesh Kumar[1], Dr. G. Shravan Kumar[2], Dr. K. Sunil Kumar[2]
[1]Assistant Professor, Department of Anaesthesiology, Government Medical College/Government General Hospital, Mahabubabad, Telangana 506101, India.
[2]Professor, Department of Anaesthesiology, Government Medical College/Government General Hospital, Mahabubabad, Telangana 506101, India.

Abstract

Background:
Ultrasound-guided supraclavicular brachial plexus block is a dependable technique for upper limb surgery and offers airway-sparing anesthesia. Because plain bupivacaine provides limited postoperative analgesia, adjuncts that hasten onset and prolong block duration remain clinically relevant.

Objectives:
To compare the onset and duration of sensory and motor block produced by 0.5% bupivacaine with 4 mg dexamethasone versus 0.5% bupivacaine alone for supraclavicular brachial plexus block.

Methods:
This prospective comparative clinical study enrolled 60 patients aged 15-70 years with ASA physical status I/II undergoing elbow, forearm, hand, or finger surgery. Patients received an ultrasound-guided supraclavicular block with 24 mL of 0.5% isobaric bupivacaine plus 1 mL dexamethasone (Group D) or 1 mL normal saline (Group P). One patient in Group P dropped out, leaving 30 and 29 patients for analysis. Sensory onset, motor onset, recovery times, surgery duration, and perioperative complications were recorded.

Results:
Group D showed significantly faster sensory onset (3.23 ± 1.28 vs 8.21 ± 2.58 min) and motor onset (6.23 ± 2.31 vs 13.55 ± 2.85 min). Motor recovery (19.73 ± 5.21 vs 6.03 ± 1.23 h) and sensory recovery (23.38 ± 5.99 vs 6.88 ± 1.22 h) were markedly prolonged in Group D; all comparisons were statistically significant. Surgery duration was similar between groups. No drug-related, hemodynamic, neurologic, or procedural complications were documented; one patient in Group P required midazolam for intraoperative anxiety.

Conclusion:
Perineural dexamethasone added to bupivacaine improved block quality by accelerating onset and prolonging sensory and motor blockade in ultrasound-guided supraclavicular brachial plexus block.

Recommendations:
This combination can be considered for upper limb procedures when prolonged postoperative analgesia is desirable, provided patient selection, sterile technique, and postoperative monitoring are maintained.

Keywords: *bupivacaine; dexamethasone; supraclavicular brachial plexus block; ultrasound guidance; upper limb surgery.*
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Corresponding author: *Dr. Suryakumari Malothu*
Email: ***malothsuryakumari@gmail.com***
Assistant Professor, Department of Anaesthesiology, Government Medical College/Government General Hospital, Mahabubabad, Telangana 506101, India

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Introduction

Upper limb surgeries involving the elbow, forearm, wrist, hand, and fingers are well suited to regional anaesthetic techniques, particularly supraclavicular brachial plexus block. Compared with general anaesthesia, a successful brachial plexus block avoids airway instrumentation, preserves spontaneous ventilation, and provides early postoperative analgesia while allowing the patient to remain cooperative during surgery. With the increasing use of ultrasound guidance, the supraclavicular approach has become more accurate, more reproducible, and safer in routine practice, with high success rates and low frequencies of major complications such as pneumothorax or vascular puncture [1,2].

The supraclavicular approach is especially attractive because the plexus is compact at the level of the trunks and divisions near the clavicle, which facilitates dense anaesthesia for surgeries below the shoulder. High-frequency ultrasound allows clear delineation of the brachial plexus, first rib, pleura, and neighboring vascular structures, thereby improving needle guidance and visualization of local anaesthetic spread [3,4]. A sound understanding of sonoanatomy is therefore fundamental to efficient block performance and complication avoidance. These imaging advances have broadened the role of supraclavicular block in contemporary upper limb anaesthesia and postoperative pain management [1,3,4].

A persistent limitation of single-shot regional anaesthesia is its finite duration. Although bupivacaine provides dependable sensory and motor blockade, postoperative pain relief from plain local anaesthetic alone is often insufficiently prolonged for the first postoperative day. Continuous catheter techniques can extend analgesia, but they also introduce practical concerns such as migration, dislodgement, leakage, pump malfunction, and increased monitoring demands. This has stimulated interest in adjuvants that can improve block onset and duration without materially increasing procedural complexity [5,6].

Dexamethasone is one of the most widely evaluated adjuvants for peripheral nerve blocks. Experimental and clinical evidence suggests that it can reduce inflammatory signaling, suppress ectopic neuronal discharge, and prolong local anaesthetic action through effects on nociceptive C fibers and glucocorticoid-mediated pathways [5,7]. Systematic reviews and meta-analyses have shown that dexamethasone prolongs sensory and motor block and extends analgesia after brachial plexus blockade, with 4 mg appearing close to a ceiling dose in several analyses [5-8]. Clinical studies focused on supraclavicular block have likewise described faster onset and longer analgesia when dexamethasone is combined with bupivacaine or ropivacaine [9-13]. Head-to-head comparisons with dexmedetomidine show that other adjuvants can sometimes produce still longer blockade, but dexamethasone remains attractive because it is familiar, inexpensive, and hemodynamically stable [7,8,13,14].

Despite a growing evidence base, institution-specific evaluation remains important because block technique, local anaesthetic volume, patient selection, and perioperative workflows vary across settings. The present study was therefore undertaken in a teaching hospital to evaluate whether the addition of dexamethasone to bupivacaine improves block characteristics during ultrasound-guided supraclavicular brachial plexus block for upper limb surgeries. The objectives of the study were to compare the onset of sensory block, the onset of motor block, the duration of sensory block, and the duration of motor block between bupivacaine with dexamethasone and plain bupivacaine.

Methodology

Study design

This study was designed as a prospective non-randomized controlled clinical trial with a quasi-experimental comparative design. Two controlled treatment arms were evaluated: dexamethasone plus bupivacaine and bupivacaine alone. Since participants were allocated alternately rather than through concealed randomization, the study was classified as non-randomized. The study compared block onset, duration of sensory and motor blockade, surgical duration, and perioperative safety outcomes between the two groups.

Study setting

The study was conducted in the Department of Anaesthesiology, Government Medical College/Government General Hospital, Mahabubabad, Telangana, India, over 12 months from September 2024 to August 2025. The hospital is a government teaching hospital attached to Government Medical College, Mahabubabad, and functions as a multispecialty referral centre for the Mahabubabad district and surrounding rural and semi-urban areas. Available public sources describe the attached hospital as having approximately 330 beds and providing specialty and tertiary-care services. The hospital provides

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services in major clinical departments, including general surgery, obstetrics and gynaecology, paediatrics, emergency care, intensive care, dialysis, neonatal care, and perioperative services. The anaesthesiology department routinely supports elective and emergency surgical procedures, including upper limb surgeries requiring regional anaesthesia.

Sample size determination

The sample size was calculated for comparison of two independent means, considering duration of sensory block/analgesia as the primary efficacy outcome. Based on previous comparable supraclavicular brachial plexus block studies and institutional feasibility, a minimum clinically important difference of 5 hours between groups was assumed, with an estimated common standard deviation of 6 hours. Using a two-sided alpha error of 5% and a power of 80%, the required sample size was calculated using the formula:

$n = 2 \times (Z\alpha/2 + Z\beta)^2 \times \sigma^2 / d^2$

where $Z\alpha/2 = 1.96$, $Z\beta = 0.84$, $\sigma = 6$, and $d = 5$.

$n = 2 \times (1.96 + 0.84)^2 \times 6^2 / 5^2$

$n = 22.6$, rounded to 23 patients per group.

After allowing for approximately 20–25% attrition or protocol non-completion and to improve analytical precision, the final sample size was fixed at 30 participants per group. Therefore, 60 patients were enrolled. One participant in the bupivacaine-alone group did not complete the study protocol, leaving 59 patients for final analysis.

Sampling and recruitment

Eligible patients scheduled for elective or emergency upper limb surgeries involving the elbow, forearm, hand, or fingers were screened during the pre-anaesthetic evaluation. Consecutive sampling was used. All patients meeting the inclusion criteria during the study period were invited to participate until the required sample size was achieved. Patients were enrolled only after explaining the study procedure, potential benefits, possible risks, and alternative anaesthetic options. Written informed consent was obtained before block administration.

Allocation method

Participants were assigned alternately to two study groups. Group D received 24 mL of 0.5% isobaric bupivacaine with 1 mL of dexamethasone 4 mg. Group P received 24 mL of 0.5% isobaric bupivacaine with 1 mL of normal saline. Because allocation was alternate rather than random, allocation concealment was not performed. This design was selected for practical feasibility in a routine clinical setting, but the absence of randomization was recognized as a possible source of selection bias.

Blinding

This was not a fully blinded study. Participants and outcome assessors were not formally blinded to group allocation. The treating anaesthesiologist was aware of the drug preparation because the study was conducted in a pragmatic clinical setting with alternate allocation. Lack of blinding may have introduced observer bias, particularly for subjective outcomes such as sensory block onset and recovery. To reduce this risk, objective time-based outcome definitions, uniform assessment intervals, and standardized sensory and motor assessment scales were used for both groups. The absence of blinding has been acknowledged as a methodological limitation.

Outcome assessment. Sensory block onset was defined as the interval from local anaesthetic injection to complete loss of pinprick sensation in the ulnar, median, radial, and musculocutaneous nerve distributions. Sensory block was assessed every minute using a three-point scale: normal sensation, decreased sensation, and complete loss of sensation. Motor block onset was defined as the interval from injection to inability to move the fingers or raise the hand. Motor function was assessed every minute by elbow flexion, elbow or wrist extension, and thumb opposition movements using a modified three-point Bromage-style scale. Postoperatively, patients were monitored in the recovery area and ward. Sensory recovery time was derived from the duration of analgesia until rescue analgesia was required at a visual analogue scale score of 4 or more. Motor recovery time was recorded from the return of upper limb movements at the elbow, forearm, and hand.

Methods to minimize bias

Selection bias was minimized by using consecutive recruitment of eligible patients, applying predefined inclusion and exclusion criteria, and enrolling patients from the same surgical and anaesthesia setting during the same study period. Both groups underwent the same ultrasound-guided supraclavicular brachial plexus block technique, used the same total injectate volume, and received similar perioperative monitoring. Baseline variables such as age, sex, ASA physical status, and body weight were recorded and compared between groups. Any baseline imbalance was considered during the interpretation of results.

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Measurement bias was reduced by using predefined operational definitions for sensory onset, motor onset, sensory recovery, and motor recovery. Sensory block was assessed using the response to pinprick in standard nerve distributions, while motor block was assessed using predefined upper limb movements. Outcomes were recorded at fixed time intervals using the same assessment method for all participants. Standard monitoring, including non-invasive blood pressure, pulse oximetry, and electrocardiography, was applied uniformly in both groups.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using standard descriptive and inferential statistics. Continuous variables were summarized as mean ± standard deviation, whereas categorical variables were presented as frequency and proportion. The chi-square test was used for categorical comparisons and the unpaired t-test for continuous outcomes. A p-value of less than 0.05 was considered statistically significant, and values below 0.001 were interpreted as highly significant.

Ethical considerations

The study received Institutional Ethics Committee approval from the Government Medical College/Government General Hospital, Mahabubabad. Written informed consent was obtained from participants/guardians. Confidentiality, voluntary participation, standard monitoring, rescue care, and complication management were ensured throughout the study.

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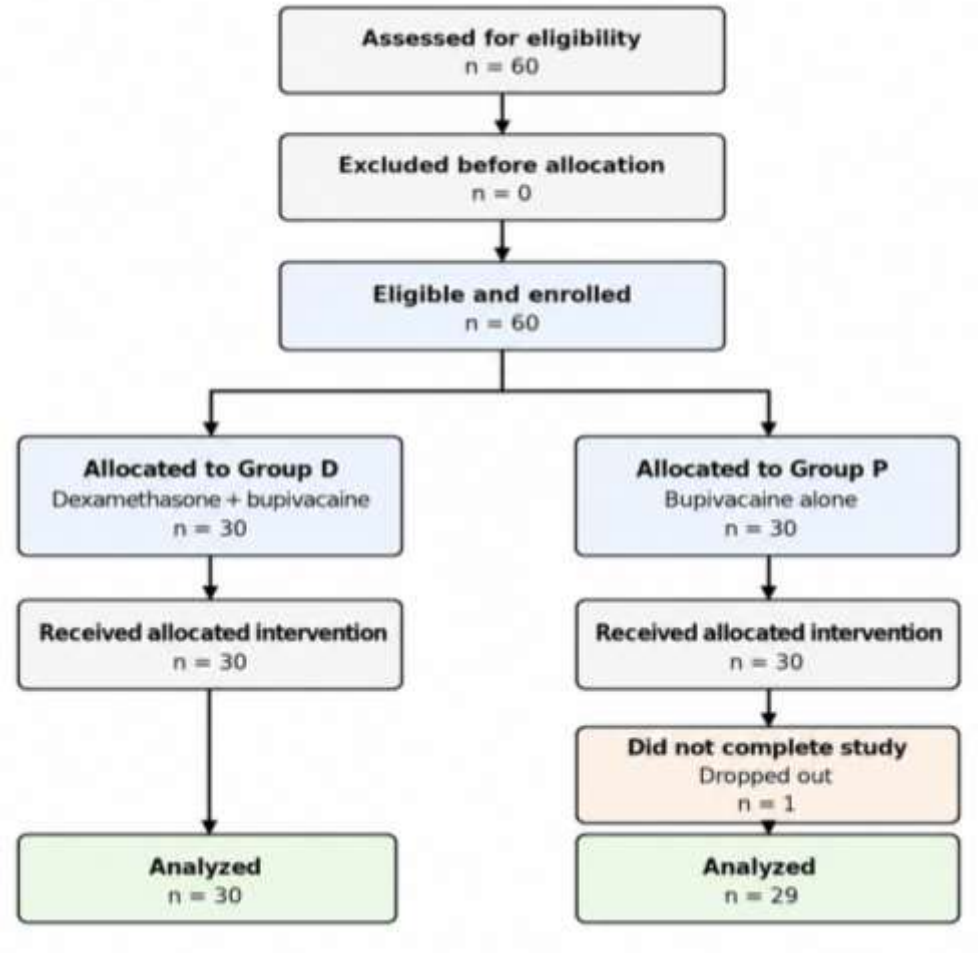
Results

Figure 1. Participant Flow Diagram



A total of 60 patients were enrolled in the study. One participant in the plain bupivacaine arm did not complete the study protocol; therefore, 59 patients were analyzed, including 30 in Group D and 29 in Group P (Figure 1). Baseline age, sex distribution, and ASA grade were broadly similar between groups, whereas mean body weight was lower in Group D than in Group P. The baseline demographic profile is summarized in Table 1.

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Table 1. Baseline demographic and clinical characteristics of the analyzed cohort

Parameter	Group D (n = 30)	Group P (n = 29)	P value	Interpretation
Age (years), mean ± SD	45.40 ± 17.31	41.97 ± 15.47	0.425	Not significant
Sex, n (female/male)	5 / 25	10 / 19	0.203	Not significant
Weight (kg), mean ± SD	56.47 ± 5.88	61.03 ± 5.38	0.003	Significant
ASA grade, n (I / II)	22 / 8	24 / 5	0.540	Not significant

The mean duration of surgery was comparable between Group D and Group P, indicating that operative time was unlikely to account for the observed differences in block characteristics. These data are shown in Table 2.

Table 2. Comparison of the duration of surgery between the two study groups

Parameter	Group D	Group P	P value	Interpretation
Duration of surgery (min), mean ± SD	49.00 ± 17.88	46.03 ± 13.62	0.476	Not significant

Block onset was significantly faster in the dexamethasone group. Mean sensory onset in Group D was 3.23 ± 1.28 minutes compared with 8.21 ± 2.58 minutes in Group P. Similarly, mean motor onset was 6.23 ± 2.31 minutes in Group D and 13.55 ± 2.85 minutes in Group P. Both differences were highly significant, as shown in Table 3.

Table 3. Onset of sensory and motor block

Outcome	Group D	Group P	P value	Interpretation
Sensory onset (min), mean ± SD	3.23 ± 1.28	8.21 ± 2.58	<0.001	Significant
Motor onset (min), mean ± SD	6.23 ± 2.31	13.55 ± 2.85	<0.001	Significant

Recovery times were substantially prolonged in the dexamethasone arm. Mean motor recovery time was 19.73 ± 5.21 hours in Group D versus 6.03 ± 1.23 hours in Group P. Mean sensory recovery time was 23.38 ± 5.99 hours in Group D compared with 6.88 ± 1.22 hours in Group P. Both outcomes strongly favored the dexamethasone group and are presented in Table 4.

Table 4. Recovery times for motor and sensory block

Outcome	Group D	Group P	P value	Interpretation
Motor recovery time (h), mean ± SD	19.73 ± 5.21	6.03 ± 1.23	<0.001	Significant
Sensory recovery time (h), mean ± SD	23.38 ± 5.99	6.88 ± 1.22	<0.001	Significant

Perioperative safety outcomes were favorable in both groups. No drug-related complications, procedure-related adverse events, hemodynamic instability requiring intervention, or neurologic complications were recorded. Only one patient in Group P developed intraoperative anxiety and received 1 mg midazolam. The complication profile is summarized in Table 5.

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Table 5. Perioperative complications

Complication/event	Group D	Group P
Drug-related complication	0	0
Procedure-related complication	0	0
Hemodynamic instability requiring intervention	0	0
Neurologic complication	0	0
Intraoperative anxiety requiring midazolam	0	1

Discussion

The present study showed that adding 4 mg dexamethasone to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block substantially improved block performance. Sensory and motor block developed earlier in the dexamethasone group, while both motor and sensory recovery times were markedly prolonged. Duration of surgery remained similar between groups, indicating that the observed differences were related to the drug combination rather than operative time. No major drug-related, neurologic, hemodynamic, or technical complications were recorded.

The study onset findings parallel prior supraclavicular block studies. Alarasan et al. demonstrated earlier sensory and motor onset after adding dexamethasone to a low-volume supraclavicular block [9]. Baloda et al., Kumar et al., and Kantharaja et al. likewise reported faster onset and longer analgesia when dexamethasone was combined with levobupivacaine, ropivacaine, or bupivacaine [10-12]. The magnitude of benefit in the present study supports the practical value of dexamethasone in reducing the interval between block placement and surgical readiness.

The marked prolongation of block duration in our series is also consistent with pooled evidence. Choi et al. showed in a meta-analysis that dexamethasone prolongs brachial plexus block effects without a clear rise in adverse events [5]. Kirkham et al. suggested that 4 mg approaches a ceiling dose in many brachial plexus block settings [6]. More focused analyses by Albrecht et al. and Sehmbi et al. confirmed that dexamethasone favorably alters sensory, motor, and analgesic durations in the supraclavicular block [7,8]. These data support the biological plausibility of the present findings.

Dexamethasone likely acts through complementary mechanisms, including attenuation of perineural inflammation, suppression of ectopic neural discharge, and prolongation of local anaesthetic action at nociceptive fibers [5,7]. Although dexmedetomidine has outperformed dexamethasone in some head-to-head supraclavicular studies by Singh et al. and Nagaraju et al. [13,14], dexamethasone still produced clinically meaningful prolongation with preserved hemodynamic stability in our cohort. That balance remains valuable in routine practice.

The safety profile was reassuring. No pneumothorax, vascular injury, neurologic deficit, or hemodynamic instability requiring intervention was observed. This likely reflects the advantage of ultrasound guidance, which improves visualization of the plexus, pleura, first rib, and needle path [1-4]. Interpretation should nonetheless remain careful because baseline body weight differed between groups, and alternate allocation is methodologically weaker than concealed randomization.

Generalizability

Because the study included ASA I/II patients aged 15-70 years undergoing common elbow, forearm, hand, and finger procedures under a standard ultrasound-guided supraclavicular technique, the findings are reasonably applicable to similar tertiary-care anaesthesia settings in which single-shot brachial plexus block is routinely performed. The clinical context closely reflects day-to-day regional anaesthesia practice. However, extrapolation to patients with major systemic disease, pediatric populations, pregnancy, markedly different drug regimens, or institutions using non-ultrasound techniques requires caution.

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Conclusion

In patients undergoing upper limb surgery under ultrasound-guided supraclavicular brachial plexus block, the addition of 4 mg dexamethasone to 0.5% isobaric bupivacaine produced a faster onset of both sensory and motor block and markedly prolonged block duration compared with plain bupivacaine. The duration of surgery was similar between groups, and no major procedural, neurologic, or hemodynamic complications were encountered. Taken together, these findings indicate that dexamethasone is a practical and effective perineural adjuvant for enhancing block efficiency and extending postoperative comfort in elbow, forearm, hand, and finger surgeries performed under regional anaesthesia in comparable hospital settings. The study therefore supports routine consideration of this combination when longer single-shot analgesia is desired.

Limitations

This was a single-center study with a modest sample size and alternate allocation instead of concealed randomization. One baseline imbalance in body weight was present between groups. Postoperative pain trajectories and total analgesic consumption were not presented in detail, and the analysis was limited to short-term perioperative outcomes without longer follow-up after discharge. These factors reduce precision and restrict external validity.

Recommendations

Future investigations should use larger multicenter samples, concealed randomization, and standardized postoperative pain assessment for at least 24 hours. Detailed recording of rescue analgesic consumption, patient satisfaction, and neurologic follow-up would strengthen clinical interpretation. In present practice, anaesthesiologists can consider 4 mg perineural dexamethasone with bupivacaine for ultrasound-guided supraclavicular block after screening for contraindications and maintaining meticulous asepsis. Departments should also adopt uniform regional anaesthesia documentation, block monitoring checklists, and follow-up protocols so that onset, recovery, analgesic benefit, and rare adverse events are captured consistently across patients. Institutional audit of outcomes should accompany implementation to support quality improvement and safer protocol refinement.

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Abbreviations

ASA - American Society of Anesthesiologists
ECG - Electrocardiogram
GA - General anaesthesia
NIBP - Non-invasive blood pressure
SD - Standard deviation
USG - Ultrasound-guided
VAS - Visual analogue scale

Source of funding

The study had no funding.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

SM -Concept and design of the study, results interpretation, review of literature, and preparation of the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. **PSK**- Design of the study, results interpretation, review of literature, preparing the first draft of the manuscript, and revision of the manuscript.**GSK**-design of the study, results interpretation, review of literature, and preparation of the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript.**KSK**-Results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of the manuscript

Data availability

Data Available

Author Biography

Dr. Suryakumari Malothu is an Assistant Professor in the Department of Anesthesiology at Government Medical College and Government General Hospital, Mahabubabad.

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She completed her MBBS from Gandhi Medical College, Diploma in Anesthesiology from Osmania Medical College, and MD in Anesthesiology from Mamata Medical College. She previously served as a Civil Assistant Surgeon Specialist in Anesthesiology and has clinical interests in regional anaesthesia, ultrasound-guided nerve blocks, airway management, and perioperative critical care. **ORCID iD**: https://orcid.org/0009-0002-5071-2199

Dr. Pannati Sireesh Kumar is an Assistant Professor in the Department of Anaesthesia at Government Medical College/Government General Hospital, Mahabubabad. He completed his MBBS from Deccan College of Medical Sciences, Hyderabad, in 2008 and MD in Anaesthesiology from SVS Medical College, Mahabubnagar, in 2014. He also served as Senior Resident at Osmania Medical College, Hyderabad, and has two publications to his credit.

Dr. G. Shravan Kumar is Professor of Anaesthesia at Government Medical College, Mahabubabad. He completed his MBBS from B.L.D.E.A.'s Medical College, Bijapur, Karnataka, Diploma in Anaesthesia from Kakatiya Medical College, Warangal, and MD in Anaesthesiology from NIMS, Hyderabad. He has served in academic anaesthesia as Assistant Professor, Associate Professor, and Professor, with extensive teaching and clinical experience.

Dr. K. Sunil Kumar is Professor of Anaesthesia at Government Medical College, Mahabubabad. He completed his MBBS and MD in Anaesthesiology from Osmania Medical College, Hyderabad. He has extensive academic and clinical experience in anaesthesia, having served as Assistant Professor and Associate Professor at CKM, Warangal, before joining as Professor at Government Medical College, Mahabubabad.

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