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Impact of Anaesthetic Technique (Neuraxial versus General Anaesthesia) on Pulmonary Complications and Early Mobilisation After Hip Fracture Surgery: A Prospective Observational Study.

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Abstract

Background: The elderly patients who undergo surgery for hip fracture are at a high risk of postoperative morbidity, especially of PPCs and delayed physical rehabilitation. This research examined the efficacy of down-regulating neuraxial anaesthesia (NA) as compared to general anaesthesia (GA) in reducing complications and promoting early mobilisation out of bed. ***Methods:*** A prospective observational cohort study was conducted for 6 months at a tertiary care hospital in Bengaluru. A total of 35 elderly patients (≥ 60 years) underwent surgical fixation or arthroplasty for acute hip fractures. Nineteen patients received NA (spinal or combined spinal-epidural) and sixteen patients received GA based on clinical indication and patient/anaesthesiologist preference. The development of PPCs (atelectasis, pneumonia or respiratory failure within 7 postoperative days) and time until first out-of-bed mobilization (hours) were primary outcomes. Postoperative pain scores (Visual analogue scale), total 24-hour opioid consumption, and length of stay (LOS) were secondary outcomes. ***Results:*** Groups had similar baseline demographic and clinical characteristics. The frequency of PPCs was less in the NA than GA group (10.5% vs. 37.5%, $p = 0.06$). In patients given NA, the time to the first out-of-bed mobilisation was significantly shorter (22.4 ± 4.6 hours vs. 31.8 ± 6.2 hours, $p < 0.001$). Moreover, 84.2% of patients in the NA group were able to mobilise on Postoperative Day 1 (POD 1) successfully while 50.0% of the patients in the GA group did ($p = 0.03$). NA group patients also had significantly lower 12-hour VAS pain score (2.8 ± 0.8 vs. 4.2 ± 1.1, $p < 0.001$), 24-hour morphine equivalent consumption (12.5 ± 4.2 mg vs. 22.4 ± 5.8 mg, $p < 0.001$), and overall LOS (6.2 ± 1.4 days vs. 7.4 ± 1.8 days, $p = 0.04$). ***Conclusion:*** neuraxial anaesthesia has been shown to allow for earlier postoperative mobilisation, improved acute pain control and reduced opioid use, when compared with general anaesthesia, in elderly patients with hip fracture, along with a clinically relevant reduction in pulmonary complication.

Keywords: Neuraxial Anaesthesia; General Anaesthesia; Hip Fracture Surgery; Postoperative Pulmonary Complications; Early Mobilisation.

INTRODUCTION

Hip fractures represent a serious public health concern in elderly populations associated with high levels of peri-operative morbidity, functional independence loss and mortality[1, 2]. With the rise in life expectancy, worldwide as well as in India, there has been a significant increase in cases of proximal femoral fractures presenting to tertiary trauma centres [1, 3]. In the elderly population, the primary contributors of long-term poor clinical outcomes are secondary complications due to immobility. These include postoperative pulmonary complications, venous thromboembolism, pressure ulceration and muscle conditioning loss.

Postoperative pulmonary complications (PPCs), such as atelectasis, infectious pneumonia and hypoxemic respiratory failure occur in up to 20% to 30% of older patients with a hip fracture and are independently associated with increased length of stay in the ICU and inpatient mortality.[2, 3] According to research, facilitation of early out-of-bed mobilisation, preferably within 24 hours of surgery is well recognized as the one most effective multidisciplinary intervention to maintain respiratory mechanics, enhance alveolar ventilation and hasten functional functional restoration [3, 4]. In contrast, achieving any degree of early mobilization, in any patient, is possible only with deep post-operative analgesia and minimal systemic sedation or ortho static instability. [4]

The choice of primary anaesthetic technique neuraxial anaesthesia versus general anaesthesia remains a continuing source of clinical controversy . The REGAIN trial by Neuman et al. [5], being a landmark randomized controlled trial, showed no difference in 60-day survival or ambulation recovery with spinal vs. general anaesthesia in a broad international cohort. However, various recent observational databases and prospective analyses have noted that neuraxial techniques avoid manipulation of the airway and systemic opioids, which may afford unique early postoperative advantages [6, 7]. It has been suggested that immediate respiratory injuries can be reduced, opioid induced sedation minimized and engagement in early physiotherapy can be made possible [6, 7] in the acute hospital setting.

Data regarding the association between the type of anaesthesia and acute respiratory complications and mobilization in Indian tertiary hospitals are very limited in the world literature, both prospective and otherwise [7, 8]. The present study was aimed to compare the effects of neuraxial versus general anaesthesia on postoperative pulmonary complications and early mobilization in patients who underwent hip fracture surgery in a tertiary hospital in Bengaluru.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational cohort study was conducted over a continuous 6-month period at a Level-I trauma and orthopaedic tertiary care hospital in Bengaluru, Karnataka. The study protocol was formally approved by the Institutional Ethics Committee prior to study initiation. Written informed consent was obtained from all participating patients or their legally authorized representatives in accordance with the ethical principles of the Declaration of Helsinki.

Patient Selection and Eligibility Criteria

A total of N = 35 elderly patients presented with acute proximal femoral fractures and underwent elective or semi-emergent surgical repair during the 6-month study window.
Inclusion Criteria: Patients aged ≥ 60 years of either sex, American Society of Anesthesiologists (ASA) physical status II or III, presenting with isolated acute closed hip fracture (femoral neck, intertrochanteric, or subtrochanteric fracture) scheduled for surgical fixation (proximal femoral nail, dynamic hip screw) or replacement (hemiarthroplasty or total hip arthroplasty) within 48 hours of admission.

Exclusion Criteria: Patients with polytrauma or multiple skeletal fractures, pathological fractures secondary to malignancy, pre-existing severe chronic obstructive pulmonary disease (COPD) requiring home oxygen therapy, severe dementia or cognitive impairment precluding reliable pain and mobilization assessment, absolute contraindications to neuraxial blockade (coagulopathy, local infection at lumbar site, severe aortic stenosis), or patient refusal of study participation.

Anaesthetic Technique and Group Allocation

As an observational study, group allocation was not randomized but determined by clinical indication, patient preference, and the attending anaesthesiologist's evaluation. Patients were stratified into two study cohorts: Neuraxial Anaesthesia Group (NA Group, n = 19): Comprising 19 patients who received subarachnoid (spinal) block or combined spinal-epidural (CSE) anaesthesia. Spinal anaesthesia was administered in the sitting or lateral decubitus position using 2.5 to 3.0 mL of hyperbaric bupivacaine 0.5% with 15 mcg of adjuvant fentanyl via a 25-gauge or 27-gauge Whitacre needle at the L3–L4 or L4–L5 interspace. Intraoperative sedation, if requested, was maintained lightly using low-dose propofol or midazolam infusions, preserving spontaneous respiration. General Anaesthesia Group (GA Group, n = 16): Comprising 16 patients who received balanced general anaesthesia. Induction was achieved using intravenous propofol (1.5–2.0 mg/kg) and fentanyl (1.5–2.0 mcg/kg), facilitated by atracurium or rocuronium for airway control. The airway was secured via endotracheal intubation (ETI) or a second-generation supraglottic airway device (SAD). Anaesthesia was maintained using sevoflurane or isoflurane in an oxygen-air mixture with volume-controlled mechanical ventilation targeting normocapnia.

Postoperative Management and Rehabilitation Protocol

All patients received standardized multimodal postoperative analgesia comprising scheduled intravenous paracetamol (1 g every 6 hours) and short-term non-steroidal anti-inflammatory drugs (NSAIDs) or tramadol unless contraindicated. Intravenous morphine or subcutaneous fentanyl was administered as intravenous patient-controlled analgesia (PCA) or nurse-administered rescue analgesia for breakthrough pain (Visual Analogue Scale [VAS] score > 4). Standardized chest physiotherapy and incentive spirometry were initiated on Postoperative Day 0 (POD 0) in the recovery room. A dedicated orthopaedic physiotherapy team, blinded to the specific anaesthetic induction details where feasible, conducted standardized mobilization trials twice daily starting on Postoperative Day 1 (POD 1).

Variables Analyzed and Outcome Measures

The primary endpoints of the study were:
1. Postoperative Pulmonary Complications (PPCs): Defined as the development of any of the following within 7 postoperative days: atelectasis confirmed on chest X-ray, infectious pneumonia (fever > 38°C, purulent sputum, new

pulmonary infiltrates, and leukocytosis), bronchospasm requiring nebulized bronchodilators, or hypoxemic respiratory failure requiring supplemental oxygen therapy for > 48 hours post-surgery.
2. Time to First Mobilisation: Measured as the elapsed time in hours from surgical incision closure to the patient's first assisted out-of-bed standing or chair sitting with a physiotherapist.
Secondary endpoints included the percentage of patients successfully mobilized on POD 1, postoperative pain severity assessed via a 10-point Visual Analogue Scale (VAS) at 12 and 24 hours, total 24-hour opioid consumption converted to intravenous morphine milligram equivalents (MME), and total hospital length of stay (LOS, in days).

Statistical Analysis
Collected data were compiled and analyzed using standard statistical software. Continuous variables were tested for normality using the Shapiro-Wilk test. Normally distributed continuous data were expressed as mean ± standard deviation (SD) and compared between groups using Student's independent two-tailed t-test. Non-parametric continuous data were compared using the Mann-Whitney U test. Categorical variables were presented as absolute numbers and percentages (%) and analyzed using Pearson's χ^2 test or Fisher's exact test as appropriate. Relative risks (RR) or Odds Ratios (OR) with 95% confidence intervals (CI) were calculated for categorical clinical complications. A two-tailed p-value < 0.05 was considered statistically significant.

RESULTS
During the 6-month investigation at the tertiary care hospital in Bengaluru, 35 elderly patients completing the study protocol were analyzed (19 in the Neuraxial Anaesthesia group and 16 in the General Anaesthesia group). The baseline demographic and clinical profiles, including age, gender distribution, body mass index (BMI), ASA physical status classification, and distribution of fracture types, were comparable between the two cohorts without statistically significant differences (Table 1). The mean age of the total cohort was 72.8 ± 6.4 years, and intertrochanteric fractures represented the most frequent surgical indication (54.3%).

Table 1: Baseline Demographic and Clinical Characteristics of Elderly Patients Stratified by Anaesthetic Technique (N = 35)

Clinical / Demographic Parameter	NA Group (n=19)	GA Group (n=16)	p-value
Age (years), Mean ± SD	72.4 ± 6.1	73.3 ± 6.8	0.68
Male / Female Sex, n (%)	9 (47.4%) / 10 (52.6%)	7 (43.8%) / 9 (56.3%)	0.83
Body Mass Index (BMI, kg/m²)	23.6 ± 3.2	24.1 ± 2.9	0.63
ASA Physical Status II / III, n (%)	11 (57.9%) / 8 (42.1%)	8 (50.0%) / 8 (50.0%)	0.64
Fracture Type, n (%)			
Femoral Neck Fracture	7 (36.8%)	6 (37.5%)	0.96
Intertrochanteric Fracture	10 (52.6%)	9 (56.3%)	0.83
Subtrochanteric Fracture	2 (10.5%)	1 (6.3%)	0.65
Type of Surgery, n (%)			
Internal Fixation (PFN / DHS)	12 (63.2%)	10 (62.5%)	0.96
Arthroplasty (Hemi / Total)	7 (36.8%)	6 (37.5%)	0.96
Surgical Duration (minutes), Mean ± SD	84.5 ± 18.2	88.2 ± 16.5	0.54

Evaluation of postoperative clinical outcomes revealed notable respiratory and analgesic differences between the anaesthetic techniques (Table 2). Overall postoperative pulmonary complications occurred in 2 patients (10.5%) in the neuraxial anaesthesia group compared to 6 patients (37.5%) in the general anaesthesia group. While this difference showed a strong trend toward clinical superiority for neuraxial blockade, it marginally missed formal statistical significance in this small cohort (Relative Risk = 0.28, 95% CI: 0.06–1.24, p = 0.06). Among specific complications, atelectasis requiring intensive physiotherapy was documented in 1 NA patient versus 3 GA patients, and infectious pneumonia occurred in 1 NA patient versus 2 GA patients.

Regarding postoperative pain and analgesia, patients receiving neuraxial anaesthesia demonstrated significantly superior acute pain relief. Mean VAS pain scores at 12 hours post-surgery were significantly lower in the NA group (2.8 ± 0.8 vs. 4.2 ± 1.1, p < 0.001). Concurrently, cumulative 24-hour opioid consumption was markedly reduced in the neuraxial group, with NA patients requiring a mean of 12.5 ± 4.2 mg of intravenous morphine equivalents compared to 22.4 ± 5.8 mg in the general anaesthesia group (p < 0.001).

Table 2: Postoperative Pulmonary Complications and Analgesic Outcomes Following Neuraxial Versus General Anaesthesia

Clinical Complication / Analgesic Metric	**NA Group (n=19)**	**GA Group (n=16)**	**Relative Risk / Difference**	**p-value**
Total Pulmonary Complications (PPCs), n (%)	2 (10.5%)	6 (37.5%)	RR = 0.28 (0.06–1.24)	**0.06**
Atelectasis on Chest X-ray, n (%)	1 (5.3%)	3 (18.8%)	RR = 0.28 (0.03–2.46)	0.30
Infectious Pneumonia, n (%)	1 (5.3%)	2 (12.5%)	RR = 0.42 (0.04–4.31)	0.58
Hypoxemia / Oxygen > 48 Hours, n (%)	1 (5.3%)	3 (18.8%)	RR = 0.28 (0.03–2.46)	0.30
VAS Pain Score at 12 Hours (0–10)	2.8 ± 0.8	4.2 ± 1.1	-1.4 (95% CI: -2.0 to -0.7)	**< 0.001**
VAS Pain Score at 24 Hours (0–10)	3.1 ± 0.9	3.6 ± 1.0	-0.5 (95% CI: -1.1 to 0.1)	0.13
Total 24h Opioid Use (Morphine Equiv, mg)	12.5 ± 4.2	22.4 ± 5.8	-9.9 (95% CI: -13.4 to -6.4)	**< 0.001**
Postoperative Delirium / Confusion, n (%)	1 (5.3%)	4 (25.0%)	RR = 0.21 (0.02–1.72)	0.14

Physical rehabilitation tracking demonstrated that neuraxial anaesthesia significantly accelerated early postoperative mobilization timelines (Table 3). The mean time elapsed from surgical completion to first out-of-bed assisted mobilisation was almost 10 hours shorter in the neuraxial group compared to the general anaesthesia group (22.4 ± 4.6 hours vs. 31.8 ± 6.2 hours, $p < 0.001$).

Furthermore, successful out-of-bed mobilisation on Postoperative Day 1 (POD 1) was achieved by 16 of the 19 patients (84.2%) receiving neuraxial blockade, compared to exactly half (8 of 16, 50.0%) of the patients receiving general anaesthesia (Odds Ratio = 5.33, 95% CI: 1.14–24.9, $p = 0.03$). The primary clinical reasons documented for failed POD 1 mobilization in the GA group included residual sedation/drowsiness, orthostatic dizziness, and uncontrolled breakthrough pain. Accelerated rehabilitation directly impacted hospital discharge timelines, with total hospital length of stay being significantly shorter in the neuraxial group (6.2 ± 1.4 days vs. 7.4 ± 1.8 days, $p = 0.04$).

Table 3: Postoperative Mobilization Timelines and Hospital Length of Stay Stratified by Anaesthetic Technique

Mobilisation / Hospital Recovery Metric	**NA Group (n=19)**	**GA Group (n=16)**	**Difference / Odds Ratio**	**p-value**
Time to First Mobilisation (Hours), Mean ± SD	22.4 ± 4.6	31.8 ± 6.2	-9.4 (95% CI: -13.1 to -5.7)	**< 0.001**
Successful Mobilisation on POD 1, n (%)	16 (84.2%)	8 (50.0%)	OR = 5.33 (1.14–24.9)	**0.03**
Successful Mobilisation by POD 2, n (%)	18 (94.7%)	13 (81.3%)	OR = 4.15 (0.38–45.2)	0.33
Total Hospital Length of Stay (Days)	6.2 ± 1.4	7.4 ± 1.8	-1.2 (95% CI: -2.3 to -0.1)	**0.04**

DISCUSSION

This prospective observational study done in a tertiary care hospital in Bengaluru demonstrates that use of neuraxial anaesthesia compared to general anaesthesia in elderly patients undergoing hip fracture surgery speeds up early physical rehabilitation and decreases acute analgesic consumption. Our main results suggest that patients receiving spinal/combined spinal-epidural anaesthesia are able to mobilise out-of-bed almost ten hours earlier than patients receiving general anaesthesia (22.4 ± 4.6 hours vs 31.8 ± 6.2 hours), with 84.2% successful on Postoperative Day 1 [6, 7]. In addition, neuraxial blockade led to a clinically significant reduction in postoperative pulmonary complications (10.5% versus 37.5%) with a significant reduction in hospital length of stay (6.2 versus 7.4 days). Our empirical findings support the contemporary literature of orthopaedic anaesthesia and provide a specific context to acute rehabilitation. We recognize the landmark discovery from the international REGAIN randomized clinical trial, conducted by Neuman and colleagues [5], which randomized 1,600 older adults and reported that the primary composite outcomes of death or inability to walk independently at 60 days were no different between spinal and general anaesthesia. Pragmatic multicentre RCTs confirm that baseline frailty and pre-injury functional reserve (rather than anaesthetic technique alone) largely dictate longer-term mortality and functional disability at 2 to 6 months [5, 8]. Conversely, we found that the selected anaesthetic modality influenced recovery milestones in the immediate acute hospital setting [6, 7]. Findings of the present study were comparable to that of the recent national databank evaluations by Chen et al. [8] and Sharma et al. [7] in which they showed that avoidance of GA reduced early in-hospital complications, systemic opioid consumption and discharge readiness. The neuraxial group has early rehabilitation benefits for which the reason is multi-factorial [2, 4]. First, general anaesthesia with endotracheal intubation or positive pressure mechanical ventilation directly impairs respiratory mucociliary clearance, causes atelectasis and irritates the bronchial tree, factors which may increase postoperative respiratory distress in frail elderly lungs [2, 6]. Keeping spontaneous ventilation with neuraxial blockade reduces this lung injury [6, 7]. Furthermore, noted researches have shown that neuraxial anesthesia leads to an intense blockage of sensory and somatic motor functions preventing pain relief. Consumption on 24-hours morphine equivalent was nearly halved in the NA group at 12.5 mg as compared to 22.4 mg. Preventing heavy opioid loading will directly make postoperative sedation, nausea, and orthostatic hypotension less likely. They were the key physiological obstacles preventing Postoperative Day 1 physical therapy in our general anaesthesia group [4, 8].

These findings have important clinical implications for tertiary care in India itself. The geriatric patients in high-volume trauma centres like those of Bengaluru invariably get exposed to hospital-acquired pneumonias, pressure sores and prolonged hospitalisation costs because of delayed mobilisation and prolonged bed rest [1, 3]. Implementing neuraxial anaesthesia within standardised multidisciplinary hip fracture pathways can allow clinical teams to optimise analgesia in the immediate postoperative period, promote patient compliance with early physiotherapy and safely reduce hospital length of stay [3, 7]. We must also consider limitations of this study. To begin, this study is a single-center prospective observational with a relatively small sample size of N = 35 patients. Although the study was statistically powered to detect significant differences in continuous mobilization timelines and opioid scores, larger randomized studies are needed to confirm any differences in categorical pulmonary complication rates. Furthermore, as group allocation was non-randomized and clinically preferred, selection bias could not be entirely excluded; anaesthesiologists may have preferentially selected general anaesthesia for patients with severe spine deformity and anticoagulation, or greater risk of baseline orthopnoea [5, 8]. Our follow-up was limited to the period of acute inpatient hospitalization; a functional assessment at 60 and 180 days looking at functional recovery, ambulatory independence and mortality could provide a fuller picture [5, 8].

CONCLUSION

Neuraxial anesthesia may be dose surprisingly advantageous for the elderly with hip fracture surgery. The obtained data showed that neuraxial anesthesia had significantly earlier postoperative out-of-bed mobilization, acute pain, and systemic opioid consumption. Furthermore, this was associated with a clinically important reduction in early pulmonary complications as well as reduced hospitalization. Neuraxial techniques should be the preferred treatment in multidisciplinary geriatric trauma protocols when clinically feasible and not contraindicated to maximize early rehabilitation and improve acute recovery.

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