ORIGINAL RESEARCH

Comparative Analysis of Anesthesia Protocols on Post-Surgical Recovery Outcomes

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ABSTRACT

Aim: This study aimed to compare the effects of general, regional, and combined anesthesia protocols on post-surgical recovery outcomes in patients undergoing elective surgeries. **Material and Methods:** A prospective, randomized, controlled study was conducted with 150 patients aged 18–65 years undergoing elective surgeries. Participants were randomized into three groups: General anesthesia (Group G, n=50), Regional anesthesia (Group R, n=50), and Combined general and regional anesthesia (Group C, n=50). Data collected included demographics, intra-operative parameters, recovery times, post-operative pain scores (VAS), opioid consumption, and complications. Statistical analysis was performed using ANOVA, Chi-square tests, and p-values <0.05 were considered significant. **Results:** The groups were comparable in baseline characteristics ($p > 0.05$). The Regional group had the shortest recovery time (145 ± 20 minutes), followed by the Combined group (160 ± 22 minutes), and the General group (180 ± 25 minutes; $p < 0.001$). Pain scores at 6, 12, and 24 hours were significantly lower in the Regional group, followed by the Combined and General groups ($p < 0.001$). Opioid consumption and hospital stays were also lowest in the Regional group, followed by the Combined and General groups ($p < 0.001$ and $p < 0.05$, respectively). Post-operative complications, including nausea and vomiting, were least common in the Regional group ($p = 0.02$). **Conclusion:** Regional anesthesia demonstrated superior outcomes, including shorter recovery times, better pain control, and fewer complications. Combined anesthesia offered intermediate benefits, while general anesthesia was associated with longer recovery times and higher opioid use. Tailoring anesthesia protocols based on patient and surgical needs can optimize recovery outcomes.

Keywords: Anesthesia protocols, post-surgical recovery, regional anesthesia, general anesthesia, pain management

INTRODUCTION

Anesthesia plays a pivotal role in modern surgical practice, enabling complex procedures to be performed with patient safety and comfort as priorities. Over the years, advancements in anesthetic techniques have led to a variety of options, each tailored to the specific needs of patients and surgical procedures. Among these, general anesthesia, regional anesthesia, and combined anesthesia protocols are the most commonly utilized. Each technique carries unique benefits and limitations, influencing both intraoperative management and post-surgical recovery outcomes. Understanding these differences is crucial for optimizing patient care and enhancing recovery experiences.[1]General anesthesia involves the administration of drugs that induce unconsciousness, immobility, and analgesia, creating a controlled environment for surgery. While it is versatile and widely applicable, general anesthesia is associated with certain drawbacks, such as longer recovery times, higher risks of post-operative complications like nausea and vomiting, and increased reliance on systemic opioids for pain control. These challenges have prompted interest in alternative or complementary techniques that may offer more favorable recovery profiles.Regional anesthesia, which includes spinal, epidural, and peripheral nerve blocks, provides localized analgesia and muscle

relaxation by targeting specific nerve pathways. Unlike general anesthesia, regional techniques allow patients to remain awake or mildly sedated during surgery, avoiding the systemic effects of general anesthetics. This approach has been associated with faster recovery times, superior pain control, reduced opioid consumption, and fewer complications such as post-operative nausea and vomiting. However, regional anesthesia is not suitable for all types of surgeries or patients, and its efficacy depends heavily on the skill and experience of the anesthetist.[2]The combined use of general and regional anesthesia represents an increasingly popular approach, integrating the benefits of both techniques. By combining systemic and localized analgesia, this method aims to optimize intraoperative conditions while minimizing post-operative pain and complications. For instance, an epidural catheter used in conjunction with general anesthesia can provide continuous pain relief during and after surgery, reducing the need for systemic opioids and enhancing recovery outcomes.Despite the advantages associated with each technique, selecting the optimal anesthesia protocol remains complex. Factors such as the type of surgery, patient characteristics, and institutional resources all play a role in determining the most appropriate approach. Moreover, the impact of these techniques on specific recovery outcomes, including time to ambulation, post-operative pain, opioid requirements, length of hospital stay, and the incidence of complications, requires further exploration to inform evidence-based practices.[3]This study focuses on a comparative analysis of general, regional, and combined anesthesia protocols, with an emphasis on their effects on post-surgical recovery outcomes in patients undergoing elective surgeries. By evaluating key parameters such as recovery time, pain scores, opioid consumption, and complication rates, this research aims to provide insights into the strengths and limitations of each technique. Furthermore, it seeks to identify trends that may guide clinical decision-making and promote optimal recovery experiences for patients.The rationale for conducting this analysis lies in the growing emphasis on patient-centered care and enhanced recovery after surgery (ERAS) protocols. As surgical advancements continue to push boundaries, the role of anesthesia in facilitating smooth and efficient recovery processes has become increasingly critical. Understanding how different anesthesia protocols influence recovery outcomes can help clinicians tailor their approach to individual patients, reducing the burden of post-operative complications and improving overall quality of care.[4,5]Additionally, the findings of this study may contribute to ongoing efforts to reduce healthcare costs associated with prolonged hospital stays and opioid-related complications. Regional and combined anesthesia techniques, which have been shown to reduce opioid consumption and shorten recovery times, hold promise as cost-effective alternatives to traditional general anesthesia. However, their wider adoption requires robust evidence demonstrating their safety, efficacy, and feasibility in various clinical settings.

MATERIAL AND METHODS

This was a prospective, randomized, controlled study designed to compare the effects of different anesthesia protocols on post-surgical recovery outcomes in adult patients undergoing elective surgeries. Ethical approval was obtained from the Institutional Review Board, and informed consent was secured from all participants.A total of 150 patients aged 18–65 years undergoing elective surgeries were enrolled in the study. Participants were randomized into three groups of 50 patients each, based on the anesthesia protocol:

- **Group G**: General anesthesia (n=50)
- **Group R**: Regional anesthesia (n=50)
- **Group C**: Combined general and regional anesthesia (n=50)

Inclusion Criteria

- Patients aged 18–65 years
- ASA physical status I–III
- Scheduled for elective surgeries lasting between 1–4 hours

Exclusion Criteria

- Emergency surgeries
- Known allergies to anesthetic agents
- History of neurological or psychiatric disorders
- Chronic pain or long-term use of analgesics
- Significant cardiovascular or pulmonary comorbidities

Methodology

Participants were randomized using a computer-generated randomization sequence. Allocation was concealed through sealed, opaque envelopes, and both patients and recovery unit staff were blinded to the assigned anesthesia protocol.

Anesthesia Protocols

General Anesthesia (Group G): Induction was performed using intravenous propofol (2 mg/kg) and fentanyl (2 µg/kg). Anesthesia was maintained with isoflurane (1–2%) in a mixture of oxygen and nitrous oxide. Neuromuscular blockade was achieved with rocuronium (0.6 mg/kg) to facilitate surgical procedures.

Regional Anesthesia (Group R): Spinal anesthesia was administered using 0.5% bupivacaine (15 mg). Patients in this group did not receive general anesthesia or sedatives during the procedure. Hemodynamic parameters were monitored continuously to ensure stability.

Combined General and Regional Anesthesia (Group C): Patients in this group underwent induction and maintenance of general anesthesia as described in Group G. Additionally, an epidural catheter was

placed for intraoperative analgesia using a continuous infusion of 0.125% bupivacaine. This approach aimed to provide enhanced intraoperative pain control and reduce systemic opioid requirements.

The primary outcome of the study was the time to recovery, defined as the duration from the end of surgery to the patient's ability to ambulate independently or with minimal assistance. Secondary outcomes included post-operative pain scores assessed using the Visual Analog Scale (VAS) at 6, 12, and 24 hours post-surgery, total opioid consumption within the first 24 hours, the incidence of post-operative complications such as nausea, vomiting, and hypotension, and the length of hospital stay measured in days. Data were collected at various time points, including pre-operative assessments for demographics, comorbidities, and baseline pain scores; intra-operative monitoring for the duration of surgery, anesthetic drugs used, and hemodynamic parameters; and post-operative evaluations for pain scores, opioid consumption, time to recovery, and complications.

Statistical Analysis

All statistical analyses were conducted using SPSS 25.0. Continuous variables, including recovery time and pain scores, were expressed as mean ± standard deviation (SD) and compared across groups using one-way ANOVA or Kruskal-Wallis tests. Categorical variables, such as the incidence of complications, were reported as frequencies or percentages and analyzed using Chi-square tests or Fisher's exact test. A p-value of <0.05 was considered statistically significant. Post hoc analyses were conducted to identify significant differences between specific groups. Subgroup analyses were also performed to explore potential factors influencing recovery outcomes.

RESULTS

Table 1: Demographic and Baseline Characteristics of Patients

The demographic data showed no significant differences among the three groups in terms of age, BMI, gender distribution, or ASA status ($p > 0.05$ for all comparisons). The mean age ranged from 44.8 to 46.1 years across the groups, with similar BMI values (24.7–25.1 kg/m²). Gender ratios (M/F) and ASA status distribution were also comparable, indicating that the groups were well-matched at baseline.

Table 2: Intra-Operative Parameters

The duration of surgery was comparable across the three groups, ranging from 118 ± 14 minutes in the Regional group to 123 ± 15 minutes in the General group. Anesthetic drug consumption differed based on the anesthesia protocol. In the General group, the mean propofol consumption was 150 ± 20 mg, while the Regional group used 15 ± 2 mg of bupivacaine. In the Combined group, propofol consumption was slightly lower (130 ± 18 mg) due to the adjunct use of bupivacaine (10 ± 3 mg). These findings highlight the variability in anesthetic drug requirements depending on the protocol used.

Table 3: Time to Recovery

The time to recovery differed significantly among the groups ($p < 0.001$). Patients in the Regional group had the shortest recovery time (145 ± 20 minutes), followed by the Combined group (160 ± 22 minutes). The General group exhibited the longest recovery time (180 ± 25 minutes). These results suggest that regional anesthesia facilitates faster recovery compared to general or combined anesthesia protocols.

Table 4: Post-Operative Pain Scores (VAS)

Post-operative pain scores, measured using the Visual Analog Scale (VAS) at 6, 12, and 24 hours post-surgery, showed significant differences among the groups ($p < 0.001$ for all time points). The Regional group consistently reported the lowest pain scores, with values of 3.8 ± 1.0, 2.9 ± 0.9, and 2.2 ± 1.0 at 6, 12, and 24 hours, respectively. The Combined group reported intermediate scores, while the General group exhibited the highest pain scores, ranging from 5.2 ± 1.1 at 6 hours to 3.8 ± 1.2 at 24 hours. These findings indicate better pain control with regional and combined anesthesia compared to general anesthesia alone.

Table 5: Opioid Consumption and Length of Stay

Opioid consumption in the first 24 hours post-surgery was significantly higher in the General group (35 ± 5 mg) compared to the Regional (20 ± 4 mg) and Combined (25 ± 4 mg) groups ($p < 0.001$). Similarly, the length of hospital stay was longest in the General group (3.5 ± 0.8 days), followed by the Combined group (3.0 ± 0.7 days), with the Regional group having the shortest stay (2.8 ± 0.6 days; $p < 0.05$). These results highlight the potential for regional anesthesia to reduce opioid use and hospital stay duration.

Table 6: Post-Operative Complications

The incidence of post-operative complications varied among the groups. Nausea and vomiting were most frequent in the General group (12 cases) compared to the Regional (4 cases) and Combined (6 cases) groups ($p = 0.02$). Hypotension was observed in a few patients across all groups (5 in General, 3 in Regional, and 4 in Combined), with no significant differences ($p = 0.53$). Other complications, such as headaches, were rare and comparable among the groups ($p = 0.87$). These findings suggest that regional and combined anesthesia may reduce the risk of nausea and vomiting compared to general anesthesia.

Table 1: Demographic and Baseline Characteristics of Patients

Characteristic	Group G (n=50)	Group R (n=50)	Group C (n=50)	p-value
Age (years, Mean ± SD)	45.2 ± 10.3	44.8 ± 11.2	46.1 ± 9.8	0.87
BMI (kg/m², Mean ± SD)	24.7 ± 3.5	25.1 ± 3.7	24.9 ± 3.4	0.81
Gender (M/F)	27/23	25/25	28/22	0.92
ASA Status (I/II/III)	15/25/10	18/22/10	14/26/10	0.88

Table 2: Intra-Operative Parameters

Group	Surgery Duration (Mean ± SD, minutes)	Anesthetic Drug Consumption (mg)
General	123 ± 15	Propofol: 150 ± 20
Regional	118 ± 14	Bupivacaine: 15 ± 2
Combined	120 ± 16	Propofol: 130 ± 18 / Bupivacaine: 10 ± 3

Table 3: Time to Recovery

Group	Time to Recovery (Mean ± SD, minutes)
General	180 ± 25
Regional	145 ± 20
Combined	160 ± 22
p-value	**<0.001**

Table 4: Post-Operative Pain Scores (VAS)

Group	6 Hours (Mean ± SD)	12 Hours (Mean ± SD)	24 Hours (Mean ± SD)
General	5.2 ± 1.1	4.5 ± 1.0	3.8 ± 1.2
Regional	3.8 ± 1.0	2.9 ± 0.9	2.2 ± 1.0
Combined	4.2 ± 1.1	3.4 ± 0.8	2.5 ± 0.9
p-value	**<0.001**	**<0.001**	**<0.001**

Table 5: Opioid Consumption and Length of Stay

Group	Opioid Consumption (mg, Mean ± SD)	Length of Stay (Days, Mean ± SD)
General	35 ± 5	3.5 ± 0.8
Regional	20 ± 4	2.8 ± 0.6
Combined	25 ± 4	3.0 ± 0.7
p-value	**<0.001**	**<0.05**

Table 6: Post-Operative Complications

Complication	General (n=50)	Regional (n=50)	Combined (n=50)	p-value
Nausea and Vomiting	12	4	6	**0.02**
Hypotension	5	3	4	0.53
Others (e.g., Headache)	3	2	3	0.87

DISCUSSION

The findings of this study underscore the benefits of regional and combined anesthesia protocols over general anesthesia in enhancing post-surgical recovery outcomes.

The demographic characteristics in this study showed no significant differences among the groups, ensuring a balanced comparison. Similar findings have been reported in prior studies, such as by Zhang et al. (2016), who emphasized the importance of matched baseline characteristics in randomized anesthesia studies to eliminate potential confounding factors.[6] The mean age and BMI ranges in our study align closely with those observed in regional anesthesia trials for elective surgeries (Smith et al., 2015), suggesting external validity.[7]

The duration of surgery was comparable across all groups, which is consistent with findings from Ekinci et al. (2015), who noted that anesthesia type minimally affects surgical duration in elective procedures.[8] However, the variability in anesthetic drug consumption aligns with Gupta et al. (2014), who observed reduced propofol requirements when regional techniques were used adjunctively. This reduction reflects the efficacy of multimodal anesthesia in lowering systemic anesthetic use.[9]

The significantly shorter recovery times in the Regional and Combined groups (145 ± 20 and 160 ± 22 minutes, respectively) compared to the General group (180 ± 25 minutes) highlight the advantage of regional techniques in minimizing recovery delays. These results are consistent with Huang et al. (2016), who found a 20–30% reduction in recovery time with spinal anesthesia compared to general anesthesia. The shorter recovery times may be attributed to the absence of residual effects from systemic anesthetics in regional protocols.[10]

Post-operative pain was markedly lower in the Regional group, with the Combined group showing intermediate results. This aligns with the findings of Chan et al. (2015), who demonstrated superior analgesic control with spinal anesthesia due to its direct effect on nociceptive pathways.[11] Additionally, combined approaches, as described by Li et al. (2017), offer better pain management than general anesthesia alone by providing localized analgesia without systemic opioid dependence.[12]

Patients in the Regional group had significantly lower opioid consumption (20 ± 4 mg) and shorter hospital stays (2.8 ± 0.6 days), consistent with the findings of Wu et al. (2014). Reduced opioid requirements in regional techniques mitigate opioid-related side effects such as nausea and sedation, contributing to shorter recovery periods and hospital stays.[13] The Combined group also showed reduced opioid use compared to the General group, corroborating studies that emphasize the additive benefits of combining regional and general anesthesia for opioid-sparing effects (Singh et al., 2017).[14]

The incidence of nausea and vomiting was significantly lower in the Regional group (4 cases) compared to the General group (12 cases), consistent with the meta-analysis by Jansen et al. (2015), which found that regional anesthesia reduces the risk of post-operative nausea and vomiting (PONV) by over 50%.[15] Hypotension rates were low and comparable across groups, aligning with the findings of Kumar et al. (2016), who reported that intraoperative fluid management can mitigate this risk regardless of anesthesia type.[16]

CONCLUSION

This study highlights the advantages of regional and combined anesthesia protocols over general anesthesia in enhancing post-surgical recovery outcomes. Regional anesthesia demonstrated the shortest recovery times, superior pain control, reduced opioid consumption, and fewer complications, while combined techniques offered a balanced approach with intermediate benefits. General anesthesia, though versatile, was associated with longer recovery times and higher post-operative pain and complications. These findings underscore the importance of tailoring anesthesia protocols to individual patient and surgical needs to optimize recovery.

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