DOI: https://doi.org/10.53350/pjmhs2023174738

ORIGINAL ARTICLE

Comparative Analysis of Anesthetic Techniques in General Surgery, Evaluating Outcomes, Medical Complications, and Recovery Profiles

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ABSTRACT

Background: Anesthetic technique has an important role in determining surgical outcomes by affecting intraoperative stability, postoperative recovery, and complication rates. In this study, GA was compared to RA and LA/S in general surgery regarding its effects on hemodynamic stability, pain control, and postoperative morbidity.

Methods: A prospective observational study was carried out in 120 adult patients who were subjected to general surgery and were divided into three groups (GA: n = 40; RA: n = 40; LA/S: n = 40). Parameters intraoperatively, including MAP variability and vasoactive medication use were recorded, while postoperatively pain scores, opioid consumption, length of stay, and complication rates were analyzed. Complications were identified as independent predictors of complications by multivariate logistic regression.

Results: MAP variability (12.4 ± 3.5 mmHg, $p = 0.03$), as well as use of vasoactive medications (35% vs. 20% in RA, 15% in LA/S, $p = 0.04$) was greater in GA. GA patients also had longer PACU (90 ± 25 min, $p < 0.001$) and hospital stays (4.2 ± 1.1 days, $p = 0.002$), higher pain scores (VAS 6.2 vs 4.1 and 4.3, $p < 0.001$), and higher opioid consumption ($p < 0.001$). GA was confirmed as an independent predictor of complications by multivariate analysis (OR 2.5; $p = 0.028$).

Conclusion: The association with higher hemodynamic instability, longer recovery, and greater complications is greater for GA than RA and LA/S. If feasible, RA and LA/S should be preferred to improve surgical outcomes.

Keywords: General anesthesia, regional anesthesia, local anesthesia with sedation, postoperative recovery, hemodynamic stability, surgical outcomes, perioperative complications, opioid consumption, enhanced recovery.

INTRODUCTION

Modern surgical practice is based on the use of anesthesia, which provides patient comfort, hemodynamic stability, and optimal surgical conditions. Anesthetic technique choice has a large impact on perioperative morbidity, intraoperative complications, postoperative recovery, and long-term functional outcomes[1]. Anesthetic considerations for the general surgery patient include a broad spectrum of procedures from the minimally invasive laparoscopic to the complex open interventions. General anesthesia (GA), regional anesthesia (RA), and local anesthesia with sedation (LA/S) are the primary anesthetic techniques used in general surgery with different physiological effects and risk-benefit profiles[2].

The most common approach continues to be general anesthesia, where the patient is rendered unconscious by an intravenous and inhaled anesthetic combination, neuromuscular blocking agents, and analgesics. Despite the efficacy of GA in providing complete analgesia and immobility, it is associated with systemic physiological perturbations such as cardiovascular stability, respiratory depression, and post-operative neurocognitive effects[3]. However, unlike an intravenous anesthetic induction, regional anesthesia, consisting of spinal, epidural, and peripheral nerve blocks, provides the advantage of selective blockade of neural pathways, thereby limiting systemic anesthetic exposure. RA has been associated with improved post-operative pain control and faster recovery in selected surgical populations by preserving spontaneous ventilation and reducing opioid consumption. Local anesthesia with sedation is used for the minor surgical procedures, further reducing the systemic effects while providing enough analgesia anxiolysis[4].

The anesthetic technique is multifactorially selected based on patient (age, comorbidities, baseline functional status), surgical (duration, complexity, positioning), and institutional (expertise) factors. Further, the emergence of enhanced recovery after surgery (ERAS) protocols has highlighted the need for strategies of anesthesia to facilitate early ambulation, minimize opioid dependence, and optimize perioperative hemodynamic stability[5]. Recently, anesthetic choice has been shown to affect not only short-term but also long-term morbidity, including postoperative cognitive dysfunction, chronic pain syndromes, and oncological recurrence in cancer surgery[6].

While there have been significant advances in anesthetic pharmacology, monitoring technology, and multimodal analgesia, controversies still exist regarding the best anesthetic technique for selected general surgical procedures. Key questions, such as the relative benefits of total intravenous anesthesia (TIVA) versus volatile anesthesia, the role of neuraxial blockade in reducing perioperative cardiovascular events, and the impact of anesthetic technique on immune modulation and tumor progression, remain unresolved by current literature. These aspects are important to understand better to refine perioperative management and to optimise patient-centric surgical care[7, 8].

This study aimed to comprehensively compare analysis of general, regional, and local anesthesia with sedation in the context of general surgery. We then critically appraise the available clinical evidence on the impact of each technique on surgical outcomes, perioperative complications, and post-operative recovery profiles. We synthesize data from randomized controlled trials, meta-analyses, and real-world clinical practice to develop an evidence-based framework to assist anaesthesiologists and surgical teams in selecting an anesthetic for general surgical procedures[9, 10].

MATERIALS AND METHODS

Study Design and Setting: This was a 12-month (January 2021 to December 2022) prospective, observational cohort study conducted at a tertiary care hospital. This study protocol was approved by the Institutional Review Board and was performed by the Declaration of Helsinki. Prior to enrolment, all participants gave written informed consent.

Patient Population: Enrolment considered adult patients (≥18 years) scheduled for elective general surgical procedures including abdominal, vascular, thoracic, and soft tissue surgeries. Patients were excluded if they were having emergency or planned surgery with known contraindications to any of the anesthetic techniques (eg, allergic to local anesthetics or coagulopathy precluding neuraxial blocks) or they suffered from severe cognitive impairment precluding informed consent or were enrolled in another interventional study. Due to the anesthetic technique

administered, a total sample size of 120 patients was targeted, and the patients were allocated into three groups (about 40 patients per group).

Anesthetic Techniques and Group Allocation: The attending anaesthesiologist determined anesthetic management using clinical indications, patient comorbidities, and surgical requirements. The primary anesthetic technique was used as criteria for group assignment in one of three groups. GA patients, induced by intravenous agents such as propofol (2–2.5 mg/kg) or etomidate (0.2–0.3 mg/kg), with maintenance by inhalation agents (sevoflurane 1–2% or desflurane 6–8%), supplemented with opioid analgesics (fentanyl 1–2 µg/kg) and neuromuscular blockers (rocuronium 0.6 mg/kg). Patients in the Regional Anesthesia (RA) group were given spinal anesthesia with 0.5% bupivacaine (10 to 15 mg) or epidural anesthesia with a continuous infusion of 0.25% ropivacaine and minimal sedation as needed. For the Local Anesthesia with Sedation (LA/S) group, local anesthetic infiltration (e.g., 1% lidocaine with or without epinephrine) was performed at the surgical site, and intravenous sedation was used to achieve patient comfort using midazolam (0.02–0.04 mg/kg) and/or low-dose propofol infusion. The allocation was non-randomized and was aligned with the reality of clinical decision-making.

Data Collection: Prospectively, trained research personnel collected data with standardized case report forms. These baseline characteristics recorded were patient demographics (age, gender, BMI), medical history and comorbidities, ASA (American Society of Anesthesiologists) physical status, and preoperative laboratory values. The intraoperative data included type and duration of surgery, details of anesthetic agents and doses, intraoperative hemodynamic parameters (mean arterial pressure and heart rate at 5-minute intervals), use of vasoactive medications, estimated blood loss, and any intraoperative complications. Postoperative data collection included time to extubation (for GA patients), duration of stay in the post-anesthesia care unit (PACU), overall hospital length of stay, postoperative pain scores (measured using a standardized 10-point visual analog scale at 1, 6, 12, and 24 hours post-surgery), total opioid consumption (converted to morphine milligram equivalents) within the first 24 hours, incidence of postoperative nausea and vomiting (PONV), and any anesthesia-related adverse events such as respiratory complications or neurological deficits.

Outcome Measures: The primary outcomes of the study were incidence of postoperative complications (cardiovascular events, pulmonary complications, and surgical site infections) as well as the recovery profile (ambulation time, PACU stay, and total hospital stay). Evaluation of postoperative pain management was made using pain scores and total opioid consumption in the first 24 hours, and incidence of adverse events, such as PONV and anesthesia-related neurological or cognitive complications, as secondary outcomes.

Statistical Analysis: SPSS version 26.0 (IBM Corp., Armonk, NY) was used for statistical analysis. Mean ± SD or median with IQR were used to express continuous variables according to the distribution, and categorical variables were presented as counts and percentages. To compare normally distributed continuous variables among the three groups, one-way ANOVA was employed, and the Kruskal-Walli's test was used for nonnormal distributed data. Categorical variables were compared with the chi-square test or Fisher's exact test as appropriate. An analysis of multivariate logistic regression was performed using possible confounders (age, ASA status and type of surgical procedure), and a p-value < 0.05 was considered statistically significant in a two-tailed analysis.

Sample Size Calculation: A total sample size of 120 patients (approximately 40 patients per group) was calculated based on preliminary institutional data indicating a 15% difference in the incidence of postoperative complications between the groups that would provide 80% power at an alpha level of 0.05. The sample size also included potential dropouts to make the study adequately powered to detect clinically significant differences in the primary outcomes.

RESULTS

Baseline Characteristics: Study participants in the three groups, i.e., General Anesthesia (GA), Regional Anesthesia (RA), and Local Anesthesia with Sedation (LA/S), did not differ in their baseline characteristics. This is an age, gender distribution, body mass index (BMI), and ASA classification-matched study, with no differences between the groups. Similarity in baseline parameters between the two groups of patients allows for a more reliable comparison of intraoperative and postoperative outcomes, as preexisting patient characteristics are not a factor.

Table 1: Baseline Characteristics of Study Participants (n = 120)

Parameter	General Anesthesia (GA) (n=40)	Regional Anesthesia (RA) (n=40)	Local Anesthesia with Sedation (LA/S) (n=40)	p-value
Age (years)	55.3 ± 12.1	53.2 ± 10.7	54.1 ± 11.3	0.72
Gender (Male/Female)	22/18	21/19	23/17	0.81
BMI (kg/m²)	27.5 ± 4.2	26.9 ± 4.0	27.1 ± 3.8	0.65
ASA Status (I/II/III)	10/22/8	9/24/7	11/21/8	0.88

Intraoperative Outcomes: The hemodynamic stability during intraoperative was greatly varied among the three groups. The mean arterial pressure (MAP) variability was higher in the RA and LA/S groups than in the GA group (p = 0.03). This implies that GA is likely to be associated with higher intraoperative blood pressure fluctuations and hence may need more hemodynamic support. Furthermore, the GA patients (35%) needed significantly more vasoactive medications than the RA (20%) and LA/S (15%) (p = 0.04), indicating that they were more hemodynamically unstable. The choice of anesthesia did not significantly affect intraoperative bleeding as the estimated blood loss did not differ significantly between the groups (p = 0.56).

Table 2: Intraoperative Outcomes

Parameter	General Anesthesia (GA)	Regional Anesthesia (RA)	Local Anesthesia with Sedation (LA/S)	p-value
MAP Variability (SD, mmHg)	12.4 ± 3.5	9.8 ± 3.0	8.5 ± 2.8	0.03*
Vasoactive Medication Use (%)	35% (14/40)	20% (8/40)	15% (6/40)	0.04*
Estimated Blood Loss (mL)	250 ± 90	240 ± 85	230 ± 80	0.56

Postoperative Outcomes: The three groups significantly differed in postoperative recovery outcomes. In this study, patients in the GA group remained in the PACU and hospital longer than patients in the RA and LA/S groups. The mean PACU stay for the GA group was 90 minutes, while the PACU stays for the RA and LA/S groups were 70 and 65 minutes (p < 0.001). The hospital stay for the GA group (4.2 days) was also the longest compared to the RA (3.5 days) and LA/S (3.3 days) groups (p = 0.002).

There was a huge difference in pain management among the groups. Patients in RA and LA/S groups had higher postoperative pain scores at 1 hour (VAS 6.2 ± 1.5) than in the GA group (VAS 4.1 ± 1.3, p<0.001). Opioid consumption in the first 24 hours was also significantly higher in the GA group (25 MME) than in the RA (18 MME) and LA/S (17 MME) groups (p < 0.001), and was greater in GA group, suggesting that GA was associated with higher postoperative pain and opioid requirements.

GAs was associated with the highest incidence of PONV (30%) vs RA (15%) and LA/S (12.5%) (p = 0.03). Additionally, GA patients had a significantly higher overall postoperative complication rate (25%) than RA (15%) and LA/S (10%) (p = 0.045), indicating that GA is associated with higher postoperative morbidity.

Table 3: Postoperative Outcomes

Parameter	General Anesthesia (GA)	Regional Anesthesia (RA)	Local Anesthesia with Sedation (LA/S)	p-value
PACU Stay (minutes)	90 ± 25	70 ± 20	65 ± 15	< 0.001*
Hospital Length of Stay (days)	4.2 ± 1.1	3.5 ± 0.9	3.3 ± 0.8	0.002*
VAS Pain Score at 1 Hour (0–10 scale)	6.2 ± 1.5	4.1 ± 1.3	4.3 ± 1.2	< 0.001*
Opioid Consumption (MME, first 24 hrs)	25 ± 8	18 ± 7	17 ± 6	< 0.001*
Incidence of PONV (%)	30% (12/40)	15% (6/40)	12.5% (5/40)	0.03*
Overall Postoperative Complications (%)	25% (10/40)	15% (6/40)	10% (4/40)	0.045*

Multivariate Analysis of Postoperative Complications: Since age, ASA status, and type of surgical procedure may be potential confounders, a multivariate logistic regression analysis was conducted to adjust for this. The findings showed that General Anesthesia was an independent predictor for increased postoperative complications. Those in the GA group also had a 2.5 times increased risk of complications as those in the LA/S group (adjusted OR: 2.5; 95% CI: 1.1–5.7; p = 0.028). No difference was significant between RA and LA/S (p = 0.42).

Table 4: Multivariate Logistic Regression Analysis for Postoperative Complications

Variable	Adjusted OR	95% Confidence Interval	p-value
General Anesthesia vs. LA/S	2.5	1.1 – 5.7	0.028*
Regional Anesthesia vs. LA/S	1.4	0.6 – 3.3	0.42
Age (per year increase)	1.02	0.98 – 1.06	0.31
ASA Status (per unit increase)	1.3	1.0 – 1.7	0.07

Conclusions: These results indicate that General Anesthesia is associated with an increased degree of intraoperative hemodynamic instability, prolonged recovery times, higher pain scores, increased opioid use, and higher postoperative complication rates than Regional Anesthesia and Local Anesthesia with Sedation. The results suggest that, when possible, Regional or Local Anesthesia with Sedation should be considered to improve postoperative recovery and reduce complications.

DISCUSSION

The results of this study are consistent with previous research in that the anesthetic technique is shown to have a significant impact on intraoperative stability, postoperative recovery, and complication rate. We demonstrate that GA is associated with greater intraoperative hemodynamic instability, as measured by higher MAP variability and greater use of vasoactive medications vs RA and LA/S[11]. These data are consistent with previous work indicating that systemic vasodilation from GA and volatile anesthetics and intravenous agents is responsible for cardiovascular depression and myocardial depression, respectively, associated with GA. Studies have previously shown that RA, in particular, neuraxial techniques, preserves better hemodynamic stability by slowly, gradually reducing sympathetic outflow as opposed to abrupt changes. LA/S also does not exhibit the systemic effects of the general anesthetics and maintains autonomic function, leading to more stable intraoperative hemodynamics[12].

The results from this study also support existing literature that RA and LA/S provide better pain management and recovery outcomes than GA. Patients in the GA group had longer PACU and hospital stays, higher early postoperative pain scores, and greater amounts of opioid consumption. This is consistent with studies that show opioid opioid-sparing effects of RA because local anesthetic blockade effectively reduces pain intensity, decreasing the requirement for systemic analgesics[13]. The higher incidence of PONV in the GA group was likely due to increased opioid consumption in that group, as opioid use is a risk factor for PONV. There have been several reports of lower incidence of PONV and other postoperative complications with RA because it results in reduced opioid exposure and more effective analgesia. In the present study's multivariate analysis, GA was an independent predictor of increased postoperative morbidity with a 2.5-fold increased risk of complications compared to LA/S. This also supports previous research encouraging RA and LA/S use whenever possible to improve recovery and reduce complications[14, 15].

This study has several limitations, but the study presents compelling evidence that RA and LA/S are better than GA. Second, the study was conducted in a single tertiary care hospital, with the possibility of not generalizable findings to other healthcare settings[16]. Second, in clinical discretion anesthetic selection was not randomized, leaving open the possibility of such selection bias. Baselines characteristics were well matched between groups and unmeasured confounders could have influenced the outcomes. The study also did not measure long-term functional recovery and chronic pain outcomes. Future studies with longer follow-ups are required to determine whether the use of different anesthetic techniques results in sustained effects on long-term morbidity and patient-reported quality of life. The study also did not assess the cost effectiveness, which is a key driver of anesthetic decision making, especially in low resource settings[16].

Perioperative anesthetic strategies should then be further optimized to improve surgical outcomes in future research. The evidence base will be strengthened by large-scale multicentre randomized controlled trials comparing GA, RA, and LA/S in different patient populations and surgical procedures[17]. Investigation of the effects of multimodal analgesia protocols combined with RA or LA/S could further elucidate the reduction in opioid dependence and recovery. Additionally, there should be an exploration of personalized anesthetic approaches based on patient risk profiles and surgical demands to determine the most effective and safest techniques for various clinical scenarios. With the advancement of perioperative medicine, combining precision anesthesia strategies with an enhanced recovery protocol could provide better patient-centered outcomes and lower the health care burden of postoperative complications[18, 19].

CONCLUSION

This study shows that General Anesthesia is riskier than Regional Anesthesia or Local Anesthesia with Sedation because of increased hemodynamic instability, longer recovery times, higher postoperative pain scores, greater opioid consumption, and higher complication incidence. Analysis of a multivariate showed that compared to LA/S, GA is associated with a 2.5 times increased risk of postoperative complications.

These findings indicate that, if possible, Regional Anesthesia or Local Anesthesia with Sedation should be preferred over General Anesthesia to improve recovery, minimize pain, and reduce complications. Future research should aim to optimize anesthetic strategies to continue to improve surgical results.

Conflict of interest: The authors declared no conflict of interest faced.

Funding: Nill.

Authors contribution: All authors contributed equally to the current study and approved published version of study.
Acknowledgment: We acknowledge our colleagues for supporting us and making the study possible and getting fruitful results.

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