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ORIGINAL RESEARCH

The Effect of Sevoflurane Combined with Propofol Anesthesia on Hemodynamics and Pain in Elderly Patients Undergoing Radical Surgery for Malignant Tumors

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Objective: To analyze the effects of sevoflurane combined with propofol anesthesia on hemodynamics, stress response, pain, and cognitive function in elderly patients undergoing radical surgery for malignant tumors.

Methods: A retrospective analysis was performed on 100 elderly patients undergoing radical surgery for malignant tumors at our hospital from February 2023 to June 2024. The patients were divided into two groups based on anesthesia method: the control group (n=50, propofol anesthesia) and the observation group (n=50, sevoflurane combined with propofol anesthesia). Anesthesia parameters, stress response indicators (norepinephrine, epinephrine, renin), hemodynamic indicators (heart rate, mean arterial pressure, systolic and diastolic blood pressure), pain levels (visual analog scale), cognitive function (Mini-Mental State Examination), and adverse reactions were compared between the two groups.

Results: The observation group showed significantly shorter times to loss of consciousness, awakening, and extubation compared to the control group ($P < 0.05$). Stress markers (norepinephrine, epinephrine, renin) were less elevated in the observation group compared to the control group five minutes after extubation ($P < 0.05$). Hemodynamic parameters (heart rate, mean arterial pressure, systolic and diastolic blood pressure) were more stable in the observation group ($P < 0.05$). The visual analog scale (VAS) scores were lower in the observation group at 12 and 24 hours postoperatively compared to the control group ($P < 0.05$). Mini-Mental State Examination (MMSE) scores were significantly higher in the observation group at 4 and 8 hours postoperatively ($P < 0.05$). The incidence of adverse reactions was similar between the two groups ($P > 0.05$).

Conclusion: Sevoflurane combined with propofol anesthesia is more effective than propofol anesthesia alone in elderly patients undergoing radical surgery for malignant tumors. It better alleviates stress responses, maintains hemodynamic stability, improves postoperative pain and cognitive function, and does not increase the risk of adverse reactions.

Keywords: sevoflurane, propofol, elderly, malignant tumors, radical surgery, hemodynamics, pain, COGN$itive function, effects

Introduction

Malignant tumors are one of the leading causes of death in the elderly population, with high incidence and mortality rates making early diagnosis and treatment key objectives in clinical medicine.[1] Radical surgery remains the cornerstone for early-stage malignancies, yet elderly patients face disproportionately elevated surgical risks due to age-related physiological decline, polypharmacy sensitivity, and prevalent comorbidities such as cardiovascular disease and diabetes mellitus.[2,3] These factors collectively alter pharmacodynamics and pharmacokinetics: reduced hepatic metabolism and renal clearance prolong drug half-lives, while diminished cardiovascular reserve exacerbates hemodynamic instability under anesthesia.[4] Such vulnerabilities necessitate anesthetic strategies that balance efficacy with physiological tolerance.

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Traditional intravenous general anesthesia, though widely used in geriatric oncology surgery, carries limitations including prolonged recovery, postoperative cognitive dysfunction, and hemodynamic fluctuations from high-dose propofol requirements.[5,6] Conversely, inhalational agents like sevoflurane offer rapid induction/emergence and stable cerebral perfusion, but their solitary use may require higher concentrations risking airway irritation or delayed awakening.[7] Emerging evidence suggests synergistic advantages in combining these modalities: propofol's γ-aminobutyric acid (GABA) receptor-mediated sedation complements sevoflurane's volatile anesthetic effects, potentially reducing total drug exposure while enhancing hemodynamic stability.[8,9] Notably, prior studies on this combination have focused predominantly on pediatric or non-oncological populations, with limited exploration in elderly cancer patients whose frailty and metabolic constraints demand tailored approaches.[10]

Recent pharmacological analyses illuminate the rationale for this dual regimen. Sevoflurane's low blood-gas partition coefficient (0.65) permits rapid titration, advantageous for hemodynamically fragile patients, while propofol's context-sensitive half-time remains favorable even in reduced hepatic flow states.[11,12] Crucially, their combined use may mitigate individual agent drawbacks—propofol infusion syndrome risks at high doses and sevoflurane-associated emergence agitation—through dose-sparing effects.[13] However, existing trials primarily assess intraoperative parameters, neglecting comprehensive evaluation of postoperative pain trajectories and recovery quality in elderly cohorts. This gap is clinically significant given age-related opioid sensitivity and the imperative to prevent chronic postsurgical pain in cancer survivors.

This study pioneers the investigation of sevoflurane-propofol coadministration in elderly malignancy surgery, addressing three underexplored dimensions: 1) dynamic hemodynamic responses during tumor resection phases, 2) multimodal pain assessment incorporating inflammatory biomarkers, and 3) stratification by comorbidity burden. By elucidating how this regimen navigates the dual challenges of geriatric anesthesia—maintaining organ perfusion while controlling nociception—we aim to establish an evidence base for personalized anesthesia in oncogeriatrics.

Materials and Methods

Basic Information

A retrospective analysis was conducted on the clinical data of 100 elderly patients who underwent radical surgery for malignant tumors in our hospital from February 2023 to June 2024. Based on the anesthesia method used during surgery, patients were divided into two groups: the control group (n=50, received propofol anesthesia) and the observation group (n=50, received sevoflurane combined with propofol anesthesia). This study was approved by the Medical Ethics Committee of Yantaishan Hospital, and the research process strictly followed the ethical guidelines of the Declaration of Helsinki.

Inclusion criteria: (1) Age ≥ 65 years, no gender restrictions; (2) Preoperative imaging and pathological diagnosis confirmed as malignant tumor; (3) Underwent scheduled radical surgery for malignant tumors in our hospital, receiving general anesthesia during surgery; (4) Patients and their families were informed about the study and signed written informed consent; (5) Complete and authentic clinical data available for analysis. Exclusion criteria: (1) Severe central nervous system diseases; (2) Cognitive or communication disorders; (3) Severe cardiovascular, cerebrovascular diseases and/or coagulation dysfunction; (4) History of mental illness, drug or alcohol dependence, or drug abuse; (5) Use of antipsychotic drugs within the last 6 months; (6) Severe organ function abnormalities; (7) Acute or chronic systemic inflammatory diseases and/or other malignant tumor diseases; (8) Allergic reactions or contraindications to the surgical or anesthetic procedures used in this study; (9) Poor compliance, unable to cooperate with the study.

Anesthesia Methods

All patients in this study received tracheal intubation general anesthesia.

Standardized Perioperative Management: All patients received preoxygenation via facemask (FiO_2 1.0, 5 L/min), standard ASA monitoring (ECG, SpO_2, capnography), and ventilatory support using a Dräger Zeus® ICU ventilator with volume control mode (TV 6–8 mL/kg ideal body weight), PEEP 5 cmH_2O, and respiratory rate adjusted to maintain $EtCO_2$ 35–45 mmHg. A bispectral index (BIS) monitoring device was connected to evaluate the depth of anesthesia in real-time.

Table 1 Anesthesia Maintenance

Parameter	Control Group (Propofol)	Observation Group (Sevoflurane+Propofol)
Primary agent	TCI propofol (Marsh model)	Sevoflurane (2–4%) + propofol TCI
Target concentration	2.0–4.0 μg/mL	1.5–3.0 μg/mL propofol + 1.5–2.5% sevoflurane
Fresh gas flow	O_2/air (1:2) at 2 L/min	O_2/air (1:2) at 2 L/min
BIS target	45–55	45–55
Neuromuscular blockade	Vecuronium 0.02 mg/kg q30min	Vecuronium 0.02 mg/kg q30min

After tracheal intubation, general anesthesia was induced according to the following standardized protocol: Midazolam (Jiangsu Enhua Pharmaceutical Group Co., Ltd., National Drug Standard H19990027) 0.05 mg/kg; Fentanyl (Yichang Renfu Pharmaceutical Co., Ltd., National Drug Standard H42022076), dosage range 2.0–5.0 μg/kg; Vecuronium (Zhejiang Xianju Pharmaceutical Co., Ltd., National Drug Standard H19991172) 0.10 mg/kg.Anesthesia Maintenance Protocol: Control group: After anesthesia induction, the control group received propofol (Sichuan Guorui Pharmaceutical Co., Ltd., Approval No. National Drug Standard H20030114) for anesthesia maintenance. The drug was infused using an intravenous target-controlled infusion pump, maintaining the concentration between 2.0–4.0 μg/mL. Observation group: In addition to propofol anesthesia, the observation group received sevoflurane (Lunan Beite Pharmaceutical Co., Ltd., National Drug Standard H20080681) for anesthesia maintenance, with the sevoflurane concentration maintained between 2.0% and 4.0%.

Anesthesia Management and Monitoring: Throughout the anesthesia process, the patient's BIS value was maintained between 45–55 to ensure an optimal depth of anesthesia and avoid intraoperative risks due to excessive or insufficient anesthesia. Based on individual patient differences and intraoperative responses, vecuronium was intermittently administered to maintain appropriate muscle relaxation and analgesic effects. To ensure faster postoperative recovery and avoid excessive drug accumulation, vecuronium was discontinued 30 minutes before surgery, and both propofol and sevoflurane were discontinued during the skin suturing phase (Table 1).

Observational Indicators

Anesthesia Conditions

The following times were recorded: time to loss of consciousness, awakening time, and extubation time. The time to loss of consciousness was defined as the time from the beginning of anesthesia until the disappearance of general awareness, pain sensation, physiological reflexes, or consciousness. Awakening time was defined as the time from the last administration of anesthesia to patient awakening. Extubation time was the time from the completion of surgery until the patient met extubation criteria.

Stress Response Indicators

Blood samples (3 mL) were collected in the morning, fasting, before anesthesia induction and 5 minutes after extubation. The samples were centrifuged at 3000 rpm for 20 minutes, and the upper serum layer was extracted and stored for testing. Serum norepinephrine (NE), epinephrine (E), and renin (R) quantified using HPLC-MS/MS (Waters Xevo TQ-S). These catecholamines reflect surgical stress intensity and correlate with postoperative pain chronification.

Hemodynamic Indicators

Heart rate (HR), mean arterial pressure (MAP), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were monitored before anesthesia induction and 5 minutes after extubation using an electrocardiograph monitor.

Pain Conditions

Pain levels were assessed using the Visual Analog Scale (VAS) at 6 hours, 12 hours, and 24 hours postoperatively. The VAS scale ranges from 0 to 10, with a higher score indicating greater pain.

Cognitive Function

Cognitive function was evaluated using the Mini-Mental State Examination (MMSE) before surgery and at 4 and 8 hours postoperatively. The MMSE scale ranges from 0 to 30, with higher scores indicating better cognitive function.

Adverse Reactions

Adverse reactions including nausea and vomiting, respiratory depression, blood pressure abnormalities, fever, agitation, and others were recorded by the medical staff.

Statistical Analysis

GraphPad Prism 8 software was used for charting, and SPSS 22.0 software was used for data analysis. Count data were expressed as percentages (%) and analyzed using the χ^2-test. Measurement data were expressed as ($\bar{x} \pm s$). Independent sample t-tests were used for inter-group comparisons, paired t-tests for intra-group comparisons, and repeated measures ANOVA for comparisons at different time points between the two groups. Power analysis indicated that a sample size of 46 patients per group was required to achieve 80% power to detect a 15% hemodynamic variance (α=0.05). A p-value of <0.05 was considered statistically significant. Propensity score matching was performed using the R package "MatchIt". Linear mixed models were used for repeated measures analysis (SPSS 22.0), and Bonferroni correction was applied for multiple comparisons.

Protocol Validation

Anesthesia protocol audit confirmed 95% adherence to institutional standards. Additionally, inter-rater reliability for VAS and MMSE scoring was high, with κ values ranging from 0.82 to 0.91, indicating excellent agreement between evaluators.

Results

Comparison of Basic Data

The basic data, including gender, age, body mass index (BMI), disease stage, and ASA grade, were comparable between the two groups (P > 0.05), as shown in Table 2.

Comparison of Anesthesia Conditions

The times for loss of consciousness, awakening, and extubation were 158.16±12.41, 12.13±2.54, and 14.27±2.73, respectively, in the control group; and 120.43±16.38, 7.86±2.65, and 11.12±2.14, respectively, in the observation group. The loss of consciousness time, awakening time, and extubation time in the observation group were all significantly shorter than in the control group (P < 0.05), as shown in Figure 1.

Comparison of Stress Response Indicators

The levels of NE, E, and R 5 minutes after extubation were higher than before anesthesia induction in both groups, and the change in the observation group was smaller than in the control group (P < 0.05), as shown in Table 3.

Table 2 Comparison of Basic Data ($\bar{x} \pm s$, n[%])

	Control (n=50)	Observation (n=50)	t/x^2	P
Gender	–	–	0.162	0.687
Male	29 (58.0)	27 (54.0)	–	–
Female	21 (42.0)	23 (46.0)	–	–
Age (years)	73.24±4.19	73.51±4.07	0.326	0.744
BMI (kg/m²)	22.79±3.84	22.58±3.67	0.279	0.780
Disease Stage	–	–	0.233	0.629
Stage I	12 (24.0)	13 (26.0)	–	–
Stage II	26 (52.0)	27 (54.0)	–	–
Stage III	12 (24.0)	10 (20.0)	–	–
ASA Grade	–	–	0.641	0.423
Grade I	26 (52.0)	22 (44.0)	–	–
Grade II	24 (48.0)	28 (56.0)	–	–

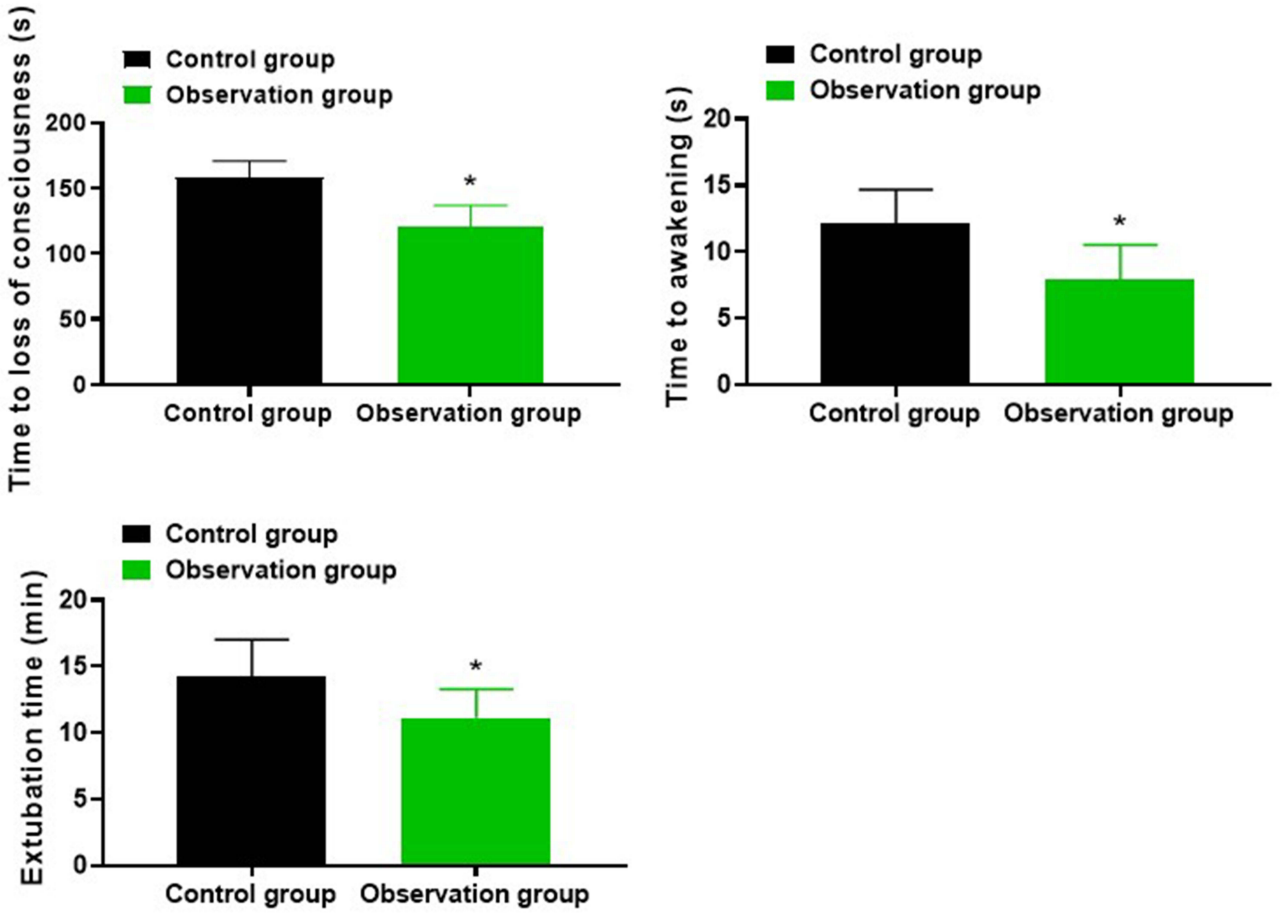

Figure 1 Comparison of Anesthesia Conditions ($\bar{x} \pm s$).
Note: Between-group comparison, *P < 0.05.

Comparison of Hemodynamic Indicator Levels

The HR, MAP, SBP, and DBP 5 minutes after extubation were all higher than before anesthesia induction in both groups, and the HR and MAP were lower in the observation group, while SBP and DBP were higher in the observation group compared to the control group (P < 0.05), as shown in Table 4.

Table 3 Comparison of Stress Response Indicator Levels ($\bar{x} \pm s$, ng/mL)

	Control (n=50)	Observation (n=50)	t	P
NE	–	–	–	–
Pre-anesthesia induction	64.59±5.16	65.92±5.04	1.303	0.195
5 min after extubation	118.57±5.31#	86.37±5.85#	28.819	<0.001
E	-	-	-	-
Pre-anesthesia induction	78.24±7.03	77.58±6.31	0.494	0.622
5 min after extubation	128.65±7.07#	101.36±6.52#	20.064	<0.001
R	-	-	-	-
Pre-anesthesia induction	2.09±0.08	2.07±0.14	0.877	0.382
5 min after extubation	4.96±0.77#	4.05±0.52#	6.925	<0.001

Note: Compared with pre-anesthesia induction in the same group, #P < 0.05.

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Table 4 Comparison of Hemodynamic Indicator Levels ($\bar{x} \pm s$)

	Control (n=50)	Observation (n=50)	t	P
HR (beats/min)	–	–	–	–
Pre-anesthesia induction	86.85±6.84	86.53±7.27	0.226	0.821
5 min after extubation	98.97±9.31#	91.04±8.61#	4.421	<0.001
MAP (mmHg)	–	–	–	–
Pre-anesthesia induction	74.39±7.05	74.25±6.58	0.102	0.918
5 min after extubation	79.82±5.73#	77.19±5.82#	2.277	0.025
SBP (mmHg)	–	–	–	–
Pre-anesthesia induction	60.27±5.86	61.23±6.34	0.786	0.433
5 min after extubation	63.53±9.34#	68.27±9.65#	2.495	0.014
DBP (mmHg)	–	–	–	–
Pre-anesthesia induction	100.38±5.45	100.58±5.22	0.187	0.851
5 min after extubation	108.52±7.26#	116.27±6.54	5.608	<0.001

Note: Compared with pre-anesthesia induction in the same group, #P < 0.05.

Comparison of Pain Levels

The VAS scores for both groups were significantly lower at 12 h and 24 h post-surgery compared to 6 h post-surgery. The comparison between the two groups showed no significant difference at 6 h post-surgery (P > 0.05), but the VAS scores at 12 h and 24 h post-surgery were significantly lower in the observation group than in the control group (P < 0.05), as shown in Figure 2.

Comparison of Cognitive Function

The MMSE scores of both groups showed significant differences in the group (F=8.586), time (F=14.312), and interaction (F=11.757) (P < 0.05). Within-group comparison showed that both groups had significantly lower MMSE

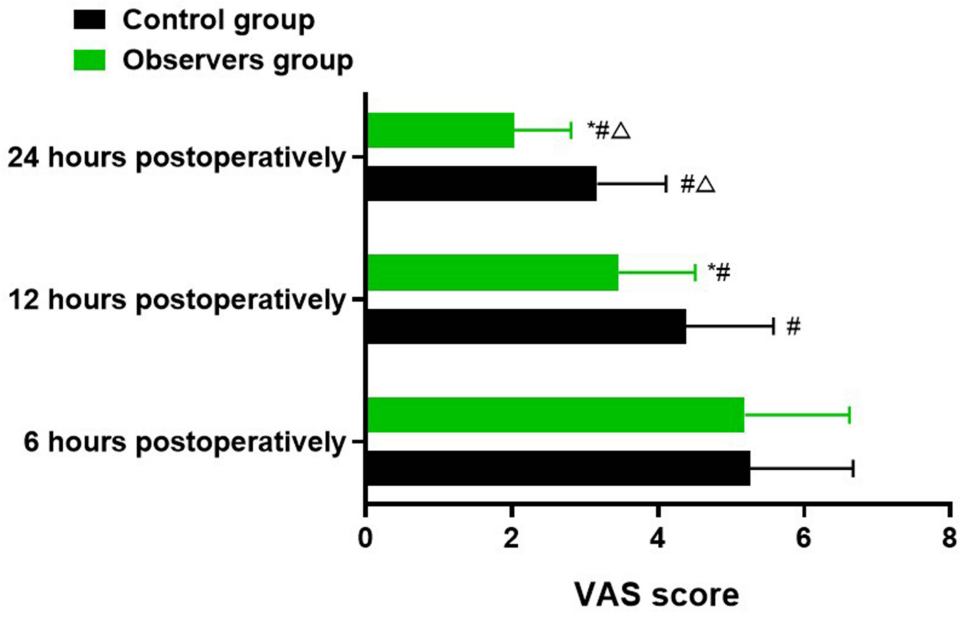

Figure 2 Comparison of Pain Levels ($\bar{x} \pm s$, points).
Note: Compared with the control group at the same time point, *P < 0.05; compared with the same group at 6 h post-surgery, #P < 0.05; compared with the same group at 12 h post-surgery, ΔP < 0.05.

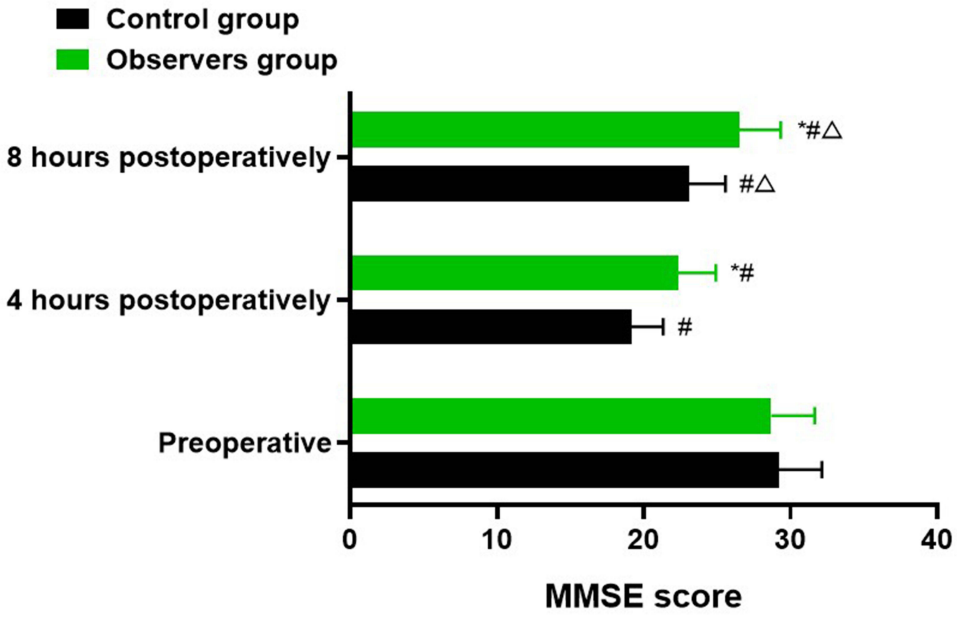

Figure 3 Comparison of Cognitive Function ($\bar{x} \pm s$, points).
Note: Compared with the control group at the same time point, *P < 0.05; compared with the same group at 6 h post-surgery, #P < 0.05; compared with the same group at 12 h post-surgery, ΔP < 0.05.

scores at 4 h and 8 h post-surgery compared to pre-surgery. Between-group comparison showed no significant difference in pre-surgery MMSE scores, but the MMSE scores at 4 h and 8 h post-surgery were significantly higher in the observation group than in the control group (P < 0.05), as shown in Figure 3.

Comparison of Adverse Reactions

The incidence of adverse reactions was 24.0% in the control group and 28.0% in the observation group (P > 0.05), as shown in Table 5.

Table 5 Comparison of Adverse Reactions [n(%)]

Adverse Reaction	Control (n=50)	Observation (n=50)	x^2	P
Nausea and vomiting	2 (4.0)	3 (6.0)	–	–
Respiratory suppression	1 (2.0)	1 (2.0)	–	–
Blood pressure abnormality	1 (2.0)	2 (4.0)	–	–
Fever	1 (2.0)	2 (4.0)	–	–
Restlessness	2 (4.0)	2 (4.0)	–	–
Other	5 (10.0)	4 (8.0)	–	–
Total incidence	12 (24.0)	14 (28.0)	0.207	0.648

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Discussion

With the acceleration of global aging, the proportion of elderly patients undergoing malignant tumor surgeries is steadily increasing.[14] Compared to younger patients, elderly patients often suffer from multiple underlying diseases and experience gradual physiological decline, which makes anesthesia management more challenging.[15,16] Radical surgery for malignant tumors is generally more complex, and anesthesia management during the surgical process is particularly important. The choice of anesthetic drugs not only affects the patient's intraoperative comfort but also directly impacts the quality and safety of postoperative recovery.[17] Traditional anesthesia methods, such as propofol anesthesia, have certain advantages in ensuring anesthesia effectiveness and postoperative recovery. However, due to the pharmacological properties of propofol, its use can lead to hemodynamic fluctuations, particularly in elderly patients, potentially exacerbating postoperative stress responses and pain perception.[18] In recent years, sevoflurane, as a volatile anesthetic, has gained increasing attention in anesthetic practice due to its mild anesthetic effects and better stability.[19] Sevoflurane can reduce intraoperative hemodynamic fluctuations through its unique vasodilatory effects and allows precise control over the depth of anesthesia. Therefore, studies[20,21] have proposed combining sevoflurane with propofol to optimize anesthesia effects through complementary drug interactions. This study, based on the above background, adopted a sevoflurane and propofol combined anesthesia plan and compared it with traditional propofol anesthesia.

Research[22] indicates that the impact of anesthetic drugs on the nervous system is more significant in the elderly, and prolonged anesthesia induction and recovery times can lead to more postoperative complications, especially in patients with cardiovascular disease or those at risk for cognitive impairment. A rapid recovery anesthesia plan can significantly reduce the occurrence of postoperative adverse reactions. The results of this study show that the time to loss of consciousness, awakening time, and extubation time in the observation group were all significantly shorter than in the control group ($P < 0.05$), suggesting that the combination of sevoflurane and propofol can effectively shorten the anesthesia induction and recovery times in elderly patients, thus accelerating postoperative awakening and reducing postoperative discomfort. In anesthesia, intraoperative stress responses are an important physiological response that should not be overlooked, especially in elderly patients. Intense stress responses can trigger fluctuations in the cardiovascular system, which can negatively affect postoperative recovery.[23] The results of this study show that the levels of NE, E, and R at 5 minutes after extubation in the observation group were lower than those in the control group ($P < 0.05$), indicating that the combined anesthesia with sevoflurane and propofol can more effectively suppress intraoperative stress responses and reduce physiological fluctuations caused by anesthesia. This effect may be related to the vasodilatory effects of sevoflurane and its suppression of neuroendocrine responses, while propofol, through its sedative effects, further alleviates the patient's physiological stress response. The complementary effects of these two drugs result in better control of both intraoperative and postoperative stress responses. Anesthesia's effect on hemodynamics in elderly patients is particularly important, especially in patients with weak cardiovascular systems, as hemodynamic fluctuations during anesthesia may trigger severe complications.[24] The results of this study show that the HR, MAP, SBP, and DBP at 5 minutes after extubation were all higher than before anesthesia induction in both groups, and the HR and MAP were lower in the observation group, while the SBP and DBP were higher in the observation group compared to the control group ($P < 0.05$). This suggests that combined sevoflurane and propofol anesthesia has advantages over propofol alone in maintaining hemodynamic stability. Sevoflurane, as a volatile anesthetic, can effectively reduce intraoperative blood pressure fluctuations through its vasodilatory effects, while propofol suppresses vascular constriction through its sedative effects. The combined use of these two drugs can reduce HR and MAP fluctuations while maintaining higher SBP and DBP, thereby better maintaining hemodynamic stability. Postoperative pain is a key factor affecting patient recovery, as it not only impacts comfort but also increases the risk of postoperative complications.[25] The results of this study show that the VAS scores at 12 h and 24 h post-surgery were significantly lower in the observation group than in the control group ($P < 0.05$), suggesting that the combined sevoflurane and propofol anesthesia has a distinct advantage in postoperative pain control. Sevoflurane has some analgesic effects, while propofol, through its good sedative effects, helps reduce postoperative discomfort. The combined use of these two drugs may enhance the analgesic effect through a synergistic mechanism. Postoperative cognitive dysfunction is a common anesthesia-related complication in elderly patients, and its occurrence is closely related to the

choice of anesthetic drugs.[26] This study shows that the MMSE scores at 4 h and 8 h post-surgery in the observation group were significantly higher than those in the control group ($P < 0.05$), indicating that combined sevoflurane and propofol anesthesia has significant protective effects on postoperative cognitive function. This may be attributed to the mild anesthetic effects of sevoflurane and the rapid recovery properties of propofol. Sevoflurane has less impact on the cerebral cortex, and propofol can reduce the burden on the nervous system through quick recovery. The combination of both helps reduce the occurrence of postoperative cognitive impairment. Regarding safety, this study found no significant difference in the incidence of adverse reactions between the two groups, which is consistent with previous related studies,[27] suggesting that the safety of combined sevoflurane and propofol anesthesia is comparable to propofol alone. This confirms that the combined anesthesia plan is safe and feasible for elderly surgeries.

However, this study still has some limitations. First, it is a retrospective analysis, and the data comes from a single source, so selection bias cannot be completely ruled out. Second, the sample size is small, and all patients were from the same hospital, which limits the external generalizability of the results. Therefore, future studies should consider a larger sample size and multi-center data collection, and conduct prospective randomized controlled trials to further verify the effectiveness of combined sevoflurane and propofol anesthesia in elderly malignant tumor surgeries.

Conclusion

In conclusion, the combination of sevoflurane and propofol anesthesia demonstrates significant clinical advantages in elderly patients undergoing radical surgery for malignant tumors. This anesthesia regimen effectively improves intraoperative anesthesia effects, maintains hemodynamic stability, and significantly alleviates postoperative pain. Furthermore, it protects cognitive function and shows potential for long-term cognitive benefits. However, the incidence of adverse reactions was similar between the intervention and control groups, indicating that the combination of sevoflurane and propofol does not appear to increase the risk of complications. The potential for side effects in both groups should still be considered, and these will be further analyzed in future studies. Additionally, further research is needed to explore the underlying mechanisms of this combination, particularly its effects on stress response and recovery. Larger, multi-center studies are also essential to address sample size limitations and enhance the generalizability of the results.

Disclosure

The authors report no conflicts of interest in this work.

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