# Propofol total intravenous anesthesia vs. sevoflurane inhalation anesthesia: Effects on post-operative cognitive dysfunction and inflammation in geriatric patients undergoing laparoscopic surgery

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**Abstract.** Propofol total intravenous anesthesia (TIVA) or sevoflurane inhalation anesthesia (IA) affects post-operative cognitive dysfunction in geriatric patients undergoing laparoscopic surgery; however, relevant real-world clinical evidence on the matter is limited. The present study aimed to compare the effects of propofol TIVA and sevoflurane IA on post-operative cognitive dysfunction in the aforementioned type of patients. The present prospective study enrolled 197 geriatric patients undergoing laparoscopic surgery. Patients were assigned to the propofol TIVA group (n=97) and sevoflurane IA group (n=100) according to the actual anesthesia regimens. The mini-mental state examination (MMSE) score was assessed before surgery and on day (D)1, D3 and D7 following surgery in both groups. The MMSE score on D1 was higher in the TIVA group compared with the IA group (P=0.006). The change in the MMSE scores from before surgery to D1 (P<0.001), D3 (P=0.011) and D7 (P=0.003) was smaller in the TIVA group vs. the IA group. Multivariate linear regression analyses suggested that the anesthesia method of TIVA (vs. IA) was independently related to the increased MMSE score on D1 (b=0.803; P=0.001) and D7 (b=0.472; P=0.025). The levels of interleukin (IL)-17A, IL-6 and tumor necrosis factor-α on D1, D3 and D7 exhibited a slightly decreasing trend in the TIVA group vs. the IA group, although the difference was not statistically significant (all P>0.05). Notably, the levels of IL-17A before surgery (P=0.015), on D3 (P=0.016) and D7 (P=0.002), as well as those of IL-6 on D1 (P=0.027), were negatively associated with the MMSE score at the corresponding time points. Overall, the present study demonstrates that propofol TIVA ameliorates post-operative cognitive dysfunction on D1 compared with sevoflurane IA and exerts a potentially suppressive effect on inflammation in geriatric patients undergoing laparoscopic surgery.

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## Introduction

General anesthesia may lead to the development of cognitive dysfunction (1,2); furthermore, due to the declined body functions with age, it is difficult for geriatric patients (aged ≥60 years) to metabolize anesthetics (3,4). Subsequently, in geriatric patients, these anesthetics remain in the body and sustainably affect the central nervous system, contributing to a high risk of developing post-operative cognitive dysfunction, which is a major cause of the reduced quality of life of these patients (2,5-7). Therefore, exploring potential anesthesia regimens that may reduce the risk of post-operative cognitive dysfunction is fundamental for geriatric patients.

Propofol total intravenous anesthesia (TIVA) and sevoflurane inhalation anesthesia (IA) are two anesthetic regimes used for laparoscopic surgery (8-10). Previous studies have compared the effects of propofol TIVA and sevoflurane IA on post-operative cognitive dysfunction in geriatric patients undergoing laparoscopic surgery (5,6). For instance, a previous study reported that the incidence of post-operative cognitive dysfunction was 16.8% in geriatric patients undergoing laparoscopic abdominal surgery receiving propofol TIVA, while it was 20.8% in those receiving sevoflurane IA (5). Another study reported that propofol TIVA led to a reduced incidence of post-operative cognitive dysfunction compared with sevoflurane IA in geriatric patients undergoing cholecystectomy (6). It should be clarified that the existing relevant studies are randomized controlled trials, and there is a lack of real-world clinical studies on the matter (5,6). On the other hand, although there are numerous studies comparing the effects of propofol TIVA and sevoflurane IA on reducing cognitive dysfunction in geriatric patients (5,6,11,12), the

optimal anesthetic is still disputable. Therefore, this aspect should be further explored.

Inflammation plays a fundamental role in the pathology and progression of cognitive dysfunction (13). In detail, the increased secretion of proinflammatory cytokines, such as tumor necrosis factor (TNF)-alpha, interleukin (IL)-6 and IL-1β, leads to the disruption of the blood-brain barrier permeability allowing the cytokines to enter the central nervous system, which further facilitates the activation of microglia. Subsequently, the activated microglia amplify neuroinflammation and release reactive oxygen species, which ultimately aggravates cognitive dysfunction (13). Considering the role of inflammation in cognitive dysfunction (13,14), the association between inflammation and cognitive dysfunction should be explored in geriatric patients at different time points after laparoscopic surgery.

Accordingly, the present prospective study aimed to compare the effects of propofol TIVA and sevoflurane IA on post-operative cognitive dysfunction and the expression of inflammatory cytokines, as well as the intercorrelation between inflammatory cytokines and cognitive dysfunction before and after surgery in geriatric patients undergoing laparoscopic surgery.

## Patients and methods

*Patients*. The present study was a prospective cohort study. Geriatric patients undergoing laparoscopic surgery who received propofol TIVA (97 cases) and or sevoflurane IA (100 cases) were enrolled from Daqing Oil Field General Hospital (Daqing, China), between April 2019 and March 2023. In the IA group 15 (15.0%), 81 (81.0%) and 4 (4.0%) patients had a surgical location of the upper, middle and lower abdomen. In the TIVA group, 11 (11.3%), 80 (82.5%) and 6 (6.2%) patients had a surgery location of upper, middle, and lower abdomen. The inclusion criteria were as follows: i) Patients who would need to undergo laparoscopic surgery; ii) the duration of the surgery was expected to be >2 h; iii) patients were ≥60 years old; iv) the American Society of Anesthesiologists (ASA) classification of the patients was I-II (15); v) patients were to receive propofol TIVA or sevoflurane IA as anesthesia methods; and vi) patients were willing to participate in the present study. The exclusion criteria were the following: i) Patients who had severe heart, liver or kidney failure; ii) those who had active infections; iii) those with allergies to the drugs used in the study; iv) those with mental illness, cognitive impairment, Parkinson's disease or Alzheimer's disease before surgery; and v) those with a history of sedative addiction. The Ethics Committee of Daqing Oil Field General Hospital approved the present study (approval no. 20190125). All patients provided written informed consent.

*Anesthesia methods*. The present study was a real-world clinical study and no randomization was performed. According to the aforementioned inclusion criterium v, the present study only enrolled patients who were to receive propofol TIVA or sevoflurane IA as anesthesia methods. However, the present study did not intervene in the choice of anesthesia methods of the patients. The anesthesia methods were decided by recommendations of the doctors and the willingness of the patients. Therefore, patients were assigned to corresponding groups according to actual anesthesia methods. All patients received anesthesia induction using fentanyl (intravenously, 3-4 $\mu$g/kg), lidocaine (intravenously, 1.5 mg/kg), propofol (intravenously, 1-1.5 mg/kg) and cisatracurium (intravenously, 0.1-0.15 mg/kg). For anesthesia maintenance, patients who received propofol TIVA (50-150 $\mu$g/kg/min) and intravenous injection of remifentanil (0.1-0.5 $\mu$g/kg/min) were assigned to the TIVA group; patients who received sevoflurane IA (1.0-1.5 minimum alveolar concentration) and intravenous injection of remifentanil (0.1-0.5 $\mu$g/kg/min) were assigned to the IA group. The intravenous injection of remifentanil was performed using a micro-pump.

*Data collection*. The clinical characteristics of the patients were documented; these included age, sex, body mass index (BMI), smoking status, hypertension, diabetes mellitus, ASA classification, location of surgery, duration of surgery and duration of anesthesia. Moreover, serum samples were obtained from the patients 24 h prior to surgery, as well as on day (D)1, D3 and D7 following surgery. Subsequently, the levels of IL-17A, IL-6 and TNF-α were detected using enzyme-linked immunosorbent assay with Human Quantikine ELISA kits (cat. nos. D1700, D6050B and DTA00D; R&D Systems, Inc.). The assays were performed according to the instructions provided by the manufacturer.

*Assessment*. The mini-mental state examination (MMSE) was used to assess the cognitive function of patients prior to surgery and on D1, D3 and D7, as previously described (16). The MMSE was scored as 0-30, with a lower score indicating improved cognitive function.

*Statistical analysis*. Statistical analyses were performed using SPSS v22.0 software (IBM Corp.). Normal distributed continuous variables are presented as the mean value ± standard deviation, and categorized variables are presented as n (%). The experiment was replicated three times. Comparisons were made using unpaired Student's t-test, $\chi^2$ test and Fisher's exact test. Correlations were performed using Spearman's rank correlation analysis. Factors related to the MMSE score were analyzed using multivariate linear regression analysis with the enter mode. $P<0.05$ was considered to indicate a statistically significant difference.

## Results

*Clinical information of the TIVA and IA groups*. There were 97 patients in the TIVA group and 100 patients in the IA group. The mean age of the patients in the TIVA and IA groups was 68.5±5.3 and 67.2±4.7 years, respectively (P=0.072). There were 29 (29.9%) female and 68 (70.1%) male patients in the TIVA group and 37 (37.0%) female and 63 (63.0%) male patients in the IA group (P=0.291). All clinical features, including BMI (P=0.531), smoking status (P=0.289), hypertension (P=0.364), diabetes mellitus (P=0.166), ASA classification (P=0.587), surgery location (P=0.625), operation time (P=0.163) and anesthesia time (P=0.149), were not different between the two groups. The specific clinical data of the two groups are presented in Table I.

Table I. Clinical characteristics of the patients.

| Characteristic | IA group (n=100) | TIVA group (n=97) | P-value |
|---|---|---|---|
| Age, years (mean ± SD) | 67.2±4.7 | 68.5±5.3 | 0.072 |
| Sex, n (%) | | | 0.291 |
| Female | 37 (37.0) | 29 (29.9) | |
| Male | 63 (63.0) | 68 (70.1) | |
| BMI, kg/m$^2$ (mean ± SD) | 22.1±2.6 | 22.3±2.5 | 0.531 |
| Smoker, n (%) | | | 0.289 |
| No | 71 (71.0) | 62 (63.9) | |
| Yes | 29 (29.0) | 35 (36.1) | |
| Hypertension, n (%) | | | 0.364 |
| No | 70 (70.0) | 62 (63.9) | |
| Yes | 30 (30.0) | 35 (36.1) | |
| Diabetes mellitus, n (%) | | | 0.166 |
| No | 91 (91.0) | 82 (84.5) | |
| Yes | 9 (9.0) | 15 (15.5) | |
| ASA classification, n (%) | | | 0.587 |
| I | 26 (26.0) | 22 (22.7) | |
| II | 74 (74.0) | 75 (77.3) | |
| Surgery location, n (%) | | | 0.625 |
| Upper abdomen/stomach | 15 (15.0) | 11 (11.3) | |
| Middle abdomen/colon | 81 (81.0) | 80 (82.5) | |
| Lower abdomen/uterus | 4 (4.0) | 6 (6.2) | |
| Operation time, min (mean ± SD) | 177.4±26.4 | 183.2±31.5 | 0.163 |
| Anesthesia time, min (mean ± SD) | 199.9±26.9 | 206.0±31.9 | 0.149 |

IA, inhalation anesthesia; TIVA, total intravenous anesthesia; BMI, body mass index; ASA, American Society of Anesthesiologists.

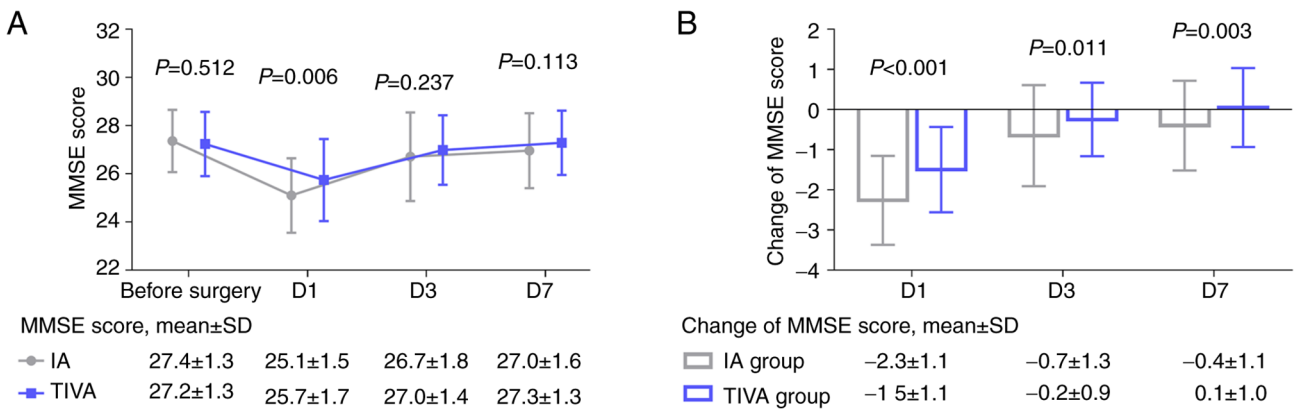


Figure 1. MMSE score prior to surgery and on D1, D3 and D7 in the TIVA and IA groups. (A) Comparison of the MMSE score prior to surgery and on D1, D3 and D7 between the TIVA and IA groups. (B) Comparison of the change in the MMSE score from before surgery to D1, D3 and D7 between the TIVA and IA groups. MMSE, mini-mental state examination; D1, D3 and D7, day 1, 3 and 7 following surgery; TIVA, total intravenous anesthesia; IA, inhalation anesthesia.

*Comparison of MMSE score and its change between the TIVA and IA groups*. The MMSE score before surgery did not differ significantly between the two groups (P=0.512). Of note, the MMSE score on D1 was higher in the TIVA group compared with the IA group (P=0.006). However, the MMSE score on D3 (P=0.237) and D7 (P=0.113) did not differ significantly between the two groups (Fig. 1A). The change in the MMSE score from before surgery to D1 (P<0.001), D3 (P=0.011) and D7 (P=0.003) was less prominent in the TIVA group compared with the IA group (Fig. 1B).

*Independent factors are associated with the MMSE score on D1, D3 and D7*. The anesthesia method of TIVA (vs. IA) was independently related to a higher MMSE score on D1 (b=0.803;

P=0.001). By contrast, diabetes mellitus (vs. non-diabetes mellitus) (b=-0.965; P=0.009) was independently associated with a lower MMSE score on D1 in geriatric patients undergoing laparoscopic surgery (Table II).

The anesthesia method of TIVA (vs. IA) exhibited a trend for an association with a higher MMSE score on D3, which did not achieve statistical significance (b=0.434; P=0.071). By contrast, diabetes mellitus (vs. non-diabetes mellitus) (b=-0.770; P=0.041) was independently associated with a lower MMSE score on D3 in geriatric patients undergoing laparoscopic surgery (Table II).

The anesthesia method of TIVA (vs. IA) (b=0.472; P=0.025) was independently associated with a higher MMSE score on D7. By contrast, diabetes mellitus (vs. non-diabetes mellitus) (b=-0.842; P=0.011) was independently associated with a lower MMSE score on D7 in geriatric patients undergoing laparoscopic surgery (Table II).

However, age (years), male (vs. female), BMI (kg/m$^2$), smoker (vs. non-smoker), hypertension (vs. non-hypertension), ASA classification of II (vs. I), surgical location of the middle or lower abdomen (vs. upper abdomen) and operation time (min) was not associated with MMSE score on D1, D3 and D7 in geriatric patients undergoing laparoscopic surgery (all P>0.05) (Table II).

*Comparison of IL-17A, IL-6 and TNF-α levels between the TIVA and IA groups*. The IL-17A levels on D1 (P=0.160), D3 (P=0.416) and D7 (P=0.421) exhibited a slightly decreasing trend in the TIVA group compared with the IA group, but did not achieve statistical significance (Fig. 2A). Similarly, the IL-6 levels on D1 (P=0.428), D3 (P=0.127) and D7 (P=0.558) (Fig. 2B), as well as the TNF-α levels on D1 (P=0.205), D3 (P=0.355) and D7 (P=0.491) (Fig. 2C), exhibited a reducing trend to a certain extent in the TIVA group compared with the IA group, but did not achieve statistical significance.

*Correlation between IL-17A, IL-6 or TNF-α and the MMSE score before surgery, on D1, D3 and D7 in all geriatric patients*. The IL-17A levels prior to surgery (P=0.015), on D3 (P=0.016) and on D7 (P=0.002) were negatively correlated with the MMSE score at the corresponding time points (Fig. S1A). IL-6 levels on D1 (P=0.027) were inversely correlated with the MMSE score on D1 (Fig. S1B). However, TNF-α levels prior to surgery and on D1, D3 or D7 were not correlated with the MMSE score in geriatric patients undergoing laparoscopic surgery (all P>0.05) (Fig. S1C).

## Discussion

Anesthesia affects the central nervous system inducing post-operative cognitive dysfunction, and previous studies have compared the effects of propofol TIVA and sevoflurane IA on cognitive dysfunction in geriatric patients undergoing laparoscopic surgery (5,6). According to previous studies, propofol TIVA exhibits a smaller rate of cognitive dysfunction induction compared with sevoflurane IA in geriatric patients (6,11,17). Of these three studies, two have focused on geriatric patients undergoing different types of surgeries, such as major cancer surgery and general thoracic surgery (11,17). Therefore, more evidence regarding geriatric patients undergoing laparoscopic surgery is required. Additionally, although the surgery type was laparoscopic cholecystectomy in one study, this was a randomized controlled trial (6). Thus, there is a lack of real-world clinical evidence on the effect of propofol TIVA and sevoflurane IA on post-operative cognitive dysfunction.

Therefore, the present study collected real-world evidence data to explore the effect of propofol TIVA and sevoflurane IA on post-operative cognitive dysfunction in geriatric patients undergoing laparoscopic surgery. In line with the aforementioned previous studies (6,11,17), the present study revealed that the MMSE score was higher, and the change in the MMSE score from before surgery to D1, D3 and D7 was less prominent in the geriatric patients undergoing laparoscopic surgery who received propofol TIVA compared with those who received sevoflurane IA; these findings suggested that the effects of propofol TIVA on post-operative cognitive function were less prominent compared with those of sevoflurane IA in geriatric patients undergoing laparoscopic surgery.

The potential reasons for this may be the following: i) Sevoflurane acts on the cerebral cortex via pulmonary inhalation, which induces neurotoxicity, enhances β-amyloid accumulation and damages neuronal cells, thereby leading to cognitive dysfunction, while propofol may exert a less prominent effect (18,19); ii) pain plays a fundamental role in post-operative cognitive dysfunction (20,21), and the use of propofol may lead to less post-operative pain compared with sevoflurane (11,22); and iii) laparoscopic surgery can induce neuroinflammation, and sevoflurane can further facilitate the production of pro-inflammatory cytokines, leading to a high risk of post-operative cognitive dysfunction, while propofol may only have a limited effect (18,23,24). Taken together, the risk of post-operative cognitive dysfunction was reduced in geriatric patients undergoing laparoscopic surgery who received propofol TIVA compared with those who received sevoflurane IA.

The present study further conducted multivariate linear regression analyses to explore the independent factors that can affect post-operative cognitive dysfunction in geriatric patients undergoing laparoscopic surgery. Of note, it was revealed that propofol TIVA (vs. sevoflurane IA) was independently associated with a higher MMSE score in geriatric patients undergoing laparoscopic surgery; this finding is in accordance with that of a previous study (6). It was also demonstrated that diabetes mellitus (vs. non-diabetes mellitus) was independently associated with a lower MMSE score in geriatric patients undergoing laparoscopic surgery. A potential explanations for this may involve the following: i) Insulin resistance can facilitate inflammation and β-amyloid deposition, but decreases synaptic plasticity, leading to post-operative cognitive dysfunction (25); and ii) diabetes mellitus induces an increase in the levels of glycation end products and their precursor, methylglyoxal, which further impairs the dopaminergic system, thereby contributing to post-operative cognitive dysfunction (26).

Inflammation is involved in the occurrence and progression of post-operative cognitive dysfunction (2). According to a previous study, propofol exhibits a limited effect in lowering the levels of IL-1β, IL-6 and TNF-α compared with sevoflurane, but without statistical significance (6). In accordance with this previous study, the present study revealed that the levels

Table II. Multivariate linear regression analyses.

A, Model for MMSE score on D1

| Item | Unadjusted b | SE | Adjusted b | t-value | P-value | VIF |
|---|---|---|---|---|---|---|
| Anesthesia method of TIVA (vs. IA) | 0.803 | 0.233 | 0.243 | 3.443 | 0.001 | 1.048 |
| Age, year | -0.030 | 0.027 | -0.093 | -1.141 | 0.255 | 1.396 |
| Male (vs. female) | -0.444 | 0.270 | -0.127 | -1.646 | 0.101 | 1.248 |
| BMI, kg/m$^2$ | -0.055 | 0.057 | -0.086 | -0.969 | 0.334 | 1.640 |
| Smoker (vs. non-smoker) | 0.069 | 0.258 | 0.019 | 0.266 | 0.791 | 1.122 |
| Hypertension (vs. non-hypertension) | 0.038 | 0.275 | 0.011 | 0.139 | 0.890 | 1.287 |
| Diabetes mellitus (vs. non-diabetes mellitus) | -0.965 | 0.365 | -0.191 | -2.641 | 0.009 | 1.100 |
| ASA classification II (vs. I) | -0.350 | 0.338 | -0.091 | -1.036 | 0.302 | 1.622 |
| Surgery location of middle or lower abdomen (vs. upper abdomen) | -0.209 | 0.342 | -0.043 | -0.609 | 0.543 | 1.034 |
| Operation time, min | -0.001 | 0.004 | -0.009 | -0.125 | 0.901 | 1.072 |

B, Model for MMSE score on D3

| Item | Unadjusted b | SE | Adjusted b | t-value | P-value | VIF |
|---|---|---|---|---|---|---|
| Anesthesia method of TIVA (vs. IA) | 0.434 | 0.239 | 0.131 | 1.814 | 0.071 | 1.048 |
| Age, years | -0.031 | 0.027 | -0.095 | -1.132 | 0.259 | 1.396 |
| Male (vs. female) | -0.316 | 0.276 | -0.090 | -1.142 | 0.255 | 1.248 |
| BMI, kg/m$^2$ | -0.068 | 0.058 | -0.105 | -1.159 | 0.248 | 1.640 |
| Smoker (vs. non-smoker) | 0.056 | 0.264 | 0.016 | 0.211 | 0.833 | 1.122 |
| Hypertension (vs. non-hypertension) | -0.059 | 0.282 | -0.017 | -0.209 | 0.835 | 1.287 |
| Diabetes mellitus (vs. non-diabetes mellitus) | -0.770 | 0.374 | -0.153 | -2.057 | 0.041 | 1.100 |
| ASA classification II (vs. I) | -0.314 | 0.346 | -0.082 | -0.907 | 0.366 | 1.622 |
| Surgery location of middle or lower abdomen (vs. upper abdomen) | -0.309 | 0.351 | -0.063 | -0.881 | 0.379 | 1.034 |
| Operation time, min | -0.001 | 0.004 | -0.014 | -0.194 | 0.847 | 1.072 |

C, Model for MMSE score on D7

| Item | Unadjusted b | SE | Adjusted b | t-value | P-value | VIF |
|---|---|---|---|---|---|---|
| Anesthesia method of TIVA (vs. IA) | 0.472 | 0.209 | 0.163 | 2.262 | 0.025 | 1.048 |
| Age, years | -0.017 | 0.024 | -0.060 | -0.729 | 0.467 | 1.396 |
| Male (vs. female) | -0.323 | 0.241 | -0.105 | -1.340 | 0.182 | 1.248 |
| BMI, kg/m$^2$ | -0.028 | 0.051 | -0.050 | -0.551 | 0.582 | 1.640 |
| Smoker (vs. non-smoker) | 0.031 | 0.230 | 0.010 | 0.133 | 0.894 | 1.122 |
| Hypertension (vs. non-hypertension) | -0.098 | 0.246 | -0.032 | -0.400 | 0.690 | 1.287 |
| Diabetes mellitus (vs. non-diabetes mellitus) | -0.842 | 0.327 | -0.190 | -2.578 | 0.011 | 1.100 |
| ASA classification II (vs. I) | -0.262 | 0.302 | -0.078 | -0.868 | 0.387 | 1.622 |
| Surgery location of middle or lower abdomen (vs. upper abdomen) | -0.348 | 0.306 | -0.081 | -1.135 | 0.258 | 1.034 |
| Operation time, min | -0.002 | 0.004 | -0.040 | -0.553 | 0.581 | 1.072 |

Anesthesia time was not included in the analyses due to the strong covariance with operation time. SE, standard error; VIF, variance inflation factor; TIVA, total intravenous anesthesia; IA, inhalation anesthesia; BMI, body mass index; ASA, American Society of Anesthesiologists; D, day; MMSE, mini-mental state examination.

of IL-17A, IL-6 and TNF-α on D1, D3 and D7 were lower in the geriatric patients undergoing laparoscopic surgery who received propofol TIVA compared with those who received sevoflurane IA; however, the difference between the two

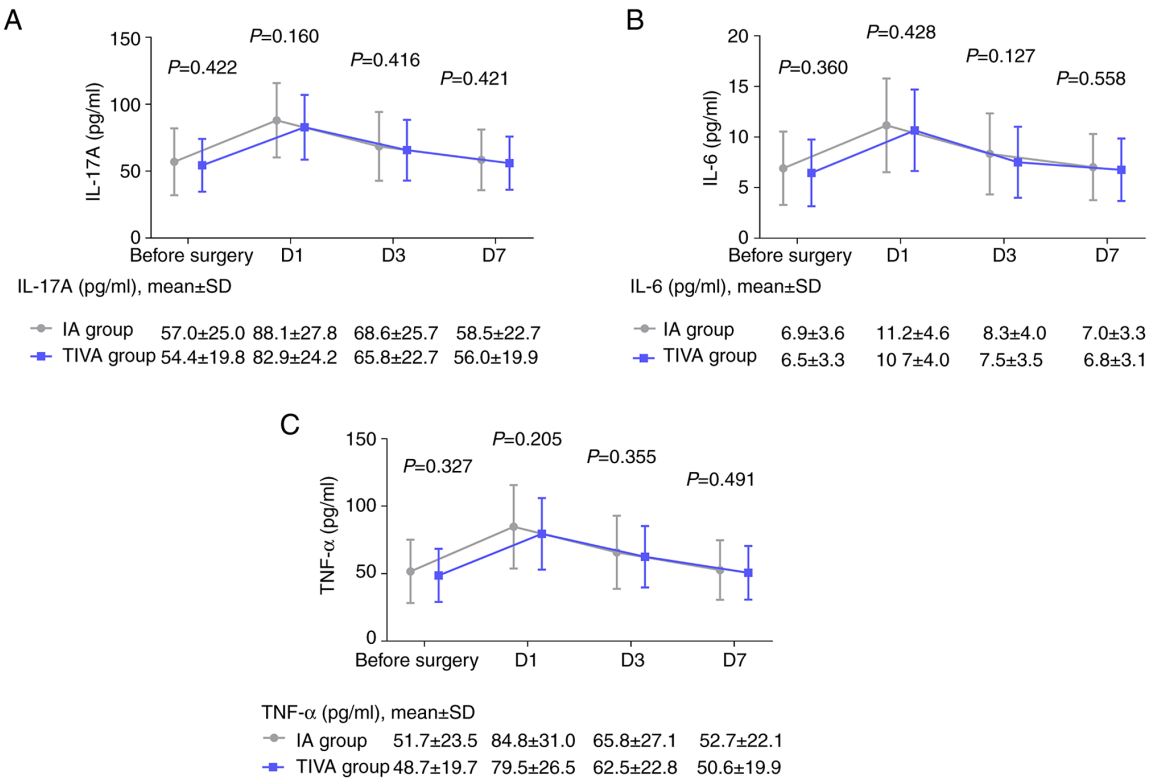


Figure 2. IL-17A, IL-6 and TNF-α levels prior to surgery and on D1, D3 and D7 in the TIVA and IA groups. Comparison of (A) IL-17A, (B) IL-6 and (C) TNF-α levels prior to surgery and on D1, D3 and D7 in the TIVA and IA groups. IL, interleukin; TNF, tumor necrosis factor; D1, D3 and D7, day 1, 3 and 7 following surgery; TIVA, total intravenous anesthesia; IA, inhalation anesthesia.

groups of patients was not statistically significant. A potential reason for this may be that, as aforementioned, sevoflurane may facilitate the production of pro-inflammatory cytokines following laparoscopic surgery, while propofol may have a less prominent effect (18).

In addition, the present study also observed that IL-6 was negatively associated with the MMSE score on D1 in geriatric patients undergoing laparoscopic surgery. This finding is partly in line with that of a previous study (5). In addition, the present study revealed that the level of IL-17A was negatively associated with the MMSE score before surgery, on D3 and on D7 in geriatric patients undergoing laparoscopic surgery. It was hypothesized that the reasons for this may be the following: i) IL-17A may exacerbate neuroinflammation and oxidative stress by activating the nuclear factor-κB pathway, leading to cognitive dysfunction (27); and ii) IL-17A may induce β-amyloid accumulation by activating the transforming growth factor-β/Smad pathway, which further promotes cognitive dysfunction (28).

Of note, a number of previous studies have compared the effects of propofol TIVA and sevoflurane IA on cognitive dysfunction in geriatric patients (5,6,11,12,29). However, the optimal anesthetic is still disputable. For instance, certain studies have indicated that post-operative cognitive dysfunction is reduced by propofol TIVA compared with sevoflurane IA (6,11), while another study revealed the opposite outcome (29). Moreover, certain studies hypothesized that post-operative cognitive dysfunction is not influenced by either propofol TIVA or sevoflurane IA (5,12). In line with previous studies (6,11), the present study revealed that propofol TIVA reduced post-operative cognitive dysfunction compared with sevoflurane IA in geriatric patients undergoing laparoscopic surgery. The present findings provided additional evidence to support the benefit of propofol TIVA in reducing post-operative cognitive dysfunction compared with sevoflurane IA in geriatric patients undergoing laparoscopic surgery.

There were some limitations to the present study, which should be mentioned. Firstly, the present study was limited by the sample size and study region; thus, the generalizability of the results needs to be confirmed in subsequent studies. Secondly, a single evaluation scale may not accurately reflect the situation of post-operative cognitive dysfunction in geriatric patients undergoing laparoscopic surgery, and further studies could consider applying both MMSE and the Montreal Cognitive Assessment to assess post-operative cognitive dysfunction. Thirdly, the surgical locations were not unified, which may have influenced the results of the present study. Fourthly, to reduce the effect of potential confounding factors, further randomized-controlled trials are required to validate the findings of the present study. Lastly, the current study did not record the depth of anesthesia. However, the depth of anesthesia could influence post-operative cognitive dysfunction (30). Therefore, further studies should explore the correlation between the depth of anesthesia and cognitive dysfunction in geriatric patients undergoing laparoscopic surgery.

In conclusion, the present study demonstrated that propofol TIVA has potential value in attenuating post-operative cognitive dysfunction on D1 compared with sevoflurane IA in geriatric patients undergoing laparoscopic surgery. In addition, propofol TIVA also exerted a potential suppressive effect on

inflammation in geriatric patients undergoing laparoscopic surgery. Moreover, it was also observed that IL-6 was correlated with MMSE score on D1, and IL-17A was correlated with MMSE score before surgery, on D3 and on D7 in geriatric patients undergoing laparoscopic surgery. The present study indicated the benefit of propofol TIVA in reducing post-operative cognitive dysfunction in geriatric patients undergoing laparoscopic surgery, and may provide theoretical evidence for the clinical application of propofol TIVA in this patient population. However, more large-scale studies or meta-analyses are required to validate the findings of the present study.

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**Availability of data and materials**

The data generated in the present study may be requested from the corresponding author.

**Authors' contributions**

JL substantially contributed to the conception and the design of the study. JY acquired the data. ZG was responsible for the analysis and interpretation of the data. WQ contributed to methodology and statistical analysis. All authors were involved in manuscript drafting or critical revisions of the intellectual content. JL and JY confirm the authenticity of all the raw data. All authors read and approved the final manuscript.

**Ethics approval and consent to participate**

The Ethics Committee of Daqing Oil Field General Hospital (Daqing, China) approved the present study (approval no. 20190125). All patients provided written informed consent.

**Patient consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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