Am J Transl Res 2023;15(5):3607-3615
www.ajtr.org /ISSN:1943-8141/AJTR0147867

Original Article

The effect of propofol combined with sufentanil on anesthetic effect, cognitive function, and hemodynamics in patients undergoing intertrochanteric fracture surgery evaluated by propensity score matching

Jiannan Ren, Lei Wang, Xiaofeng Sun

Department of Anesthesiology, Central Hospital Affiliated to Shenyang Medical College, Shenyang 110024, Liaoning, China

Received November 19, 2022; Accepted March 23, 2023; Epub May 15, 2023; Published May 30, 2023

Abstract: Objective: Surgery is the most common treatment for intertrochanteric fractures of the femur. Hemodynamic fluctuations caused by general anesthesia may lead to poor prognosis in patients. Residual anesthetic drugs reduce cognitive functions in patients. We investigated the effects of propofol combined with sufentanil on the anesthetic effect, cognitive function, and hemodynamics of patients undergoing intertrochanteric fracture surgery. Methods: The clinical data of elderly patients undergoing intertrochanteric fracture surgery were retrospectively collected. Patients were divided into a control group (propofol + fentanyl) versus a combined group (propofol + sufentanil) according to the anesthesia protocol. Propensity score matching was used to analyze the specific effects of different anesthetic regimens on patients. Results: For patients with intertrochanteric fracture, propofol combined with sufentanil had a quick onset of anesthesia, a short postoperative recovery time, and low pain compared with combined anesthesia using propofol and fentanyl. Propofol combined with sufentanil can maintain the relative stability of patients' hemodynamics and reduce the damage to patients' cognitive function compared with combined anesthesia using propofol and fentanyl. Propofol combined with sufentanil anesthesia does not increase the incidence of adverse reactions after surgery. Conclusion: The anesthesia scheme of propofol combined with sufentanil is effective and safe in elderly patients with intertrochanteric fractures of the femur.

Keywords: Propensity score matching, intertrochanteric fracture of femur, propofol, sufentanil, cognitive function

Introduction

Femoral intertrochanteric fracture, known as an intertrochanteric fracture, refers to the fracture from the base of the femoral trochanteric neck to the position above the level of the lesser trochanter. This section belongs to the category of hip fracture [1, 2]. Due to osteoporosis and inflexibility of limbs, the elderly are prone to intertrochanteric fracture of the femur when the lower limbs suddenly twist [3]. The main symptoms of intertrochanteric fracture of the femur are hip pain, inability to stand or walk, and significant lower limb shortening and lateral rotation deformity [4]. Femoral intertrochanteric fracture seriously threatens the health and quality of life of the elderly. Surgery is the best way to treat intertrochanteric fractures of the femur. Patients should be able to receive surgical treatment within 48 hours after the fracture [5]. For patients with intertrochanteric fractures of the femur, the traditional methods of anesthesia are general anesthesia and intrathecal anesthesia. Elderly patients with intervertebral space stenosis, calcification and deformity of vertebrae and ligaments, and post-fracture trauma pain make them difficult to complete satisfactory puncture position [6]. Elderly patients with intertrochanteric fractures of the femur usually use general anesthesia during the operation [7, 8].

The standard general anesthesia needs four elements: loss of consciousness, perfect analgesia, muscle relaxation, and inhibition of adverse nerve reflexes [9]. There is not a single

anesthetic that can meet the four requirements listed above concurrently. Combined anesthesia with two or more drugs has become a common anesthesia method in surgery. The rational use of the synergy between multiple anesthetic drugs can maximize the positive effects of anesthetic drugs and reduce the negative effects. The physical function of elderly patients decreases. They have high requirements for the quality of surgical anesthesia [10]. Selecting the best anesthesia scheme for elderly orthopedic patients has become the focus of clinical research [11, 12].

Propofol is a short acting intravenous anesthetic commonly used in clinical surgery. It has the advantages of rapid onset, short postoperative recovery time, and fewer postoperative complications [13, 14]. Propofol is painless and widely used in clinical examinations and surgeries [13, 14]. The analgesic effect of propofol is poor. It often needs to be used together with analgesic drugs. Sufentanil is a new type of opioid analgesics. A reasonable dose of sufentanil can maintain stable hemodynamics of patients. It is widely used in general anesthesia for various surgical operations [15, 16]. We wanted to explore the effect of propofol combined with sufentanil anesthesia scheme on anesthetic effect, cognitive function, and hemodynamics of patients undergoing intertrochanteric fracture surgery. This study was based on the propensity score matching method to explore the application value of propofol combined with sufentanil in the surgical treatment of intertrochanteric fracture of femur.

Methods

Study design and patients

A retrospective analysis was conducted using the clinical data of elderly patients with intertrochanteric fracture of femur who received surgical treatment in Central Hospital Affiliated to Shenyang Medical College from January 2020 to June 2022. Inclusion criteria of patients: (1) X-ray examination confirmed intertrochanteric fracture of femur; (2) The American Society of Anesthesiologists [17] Grade I-II; (3) The clinical data required for this study were completed (gender, age, body mass index, preoperative bedtime, history of cardiovascular disease, history of diabetes, operation method, length of operation, amount of intraoperative bleeding, intraoperative non-invasive arterial pressure, intraoperative heart rhythm, intraoperative electrocardiogram, bispectral index, onset time of anesthesia, postoperative recovery time, extubation time, postoperative pain 3 hours, postoperative cognitive function, postoperative blood pressure and heart rate, and postoperative adverse reactions); (4) Age ≥60 years old. Exclusion criteria: (1) History of intertrochanteric fracture of femur; (2) Accompanied by malignant tumor; (3) Accompanied by mental illness or cognitive dysfunction. This study was approved by the Ethics Committee of Central Hospital Affiliated to Shenyang Medical College.

Data collection

Patients meeting the inclusion and exclusion criteria were retrieved from the electronic medical records of our hospital. The following data of patients were collected: (1) The anesthesia effects of patients, the main evaluation indicators were: the onset time of anesthesia, the time of awakening after surgery, the time of decannulation, and the pain situation 3 hours after the surgery. The pain level 3 hours after the operation was evaluated using the Visual Pain Simulation Scale (VAS) [18]. The total score of VAS is 0-10. The higher the score, the higher the pain. (2) The short-term cognitive function of patients (Mini mental State Examination (MMSE) [19] 1 day before and 1 day after operation). The total score of MMSE is 0~30. The higher the score, the better the cognitive function. (3) Hemodynamic indexes. The changes of blood pressure and heart rate were collected before and after anesthesia induction, tracheal intubation, and at the end of surgery. (4) Postoperative complications such as atelectasis, hypoxemia, gastrointestinal reaction (nausea and vomiting), and dizziness.

Propensity scores match

In this study, data of a total of 163 patients were collected retrospectively, including 102 cases in the control (propofol + fentanyl) and 61 cases in the combined (propofol + sufentanil) group. The propensity score matching method was used to analyze the sex, age, body mass index (BMI), bedridden time before surgery, history of cardiovascular disease, history of diabetes, operation mode, operation duration, and intraoperative blood loss. The two

Table 1. General characteristics of patients with different anesthesia protocols

Characteristic	Control (n = 102)	Combine (n = 61)	χ^2/t	*P*
Gender			1.435	0.231
male	42 (57.53)	31 (42.47)		
female	60 (66.67)	30 (33.33)		
Age	67.22±3.59	69.11±3.94	3.135	0.002
BMI (kg/m^2)	23.42±1.07	23.83±1.19	2.269	0.025
Bedrest time before operation (d)			4.595	0.032
>3	24 (50.00)	24 (50.00)		
≤3	78 (67.83)	37 (32.17)		
Cardiovascular disease			3.208	0.073
yes	39 (72.22)	15 (27.78)		
no	63 (57.80)	46 (42.20)		
Diabetes			9.089	0.003
yes	42 (51.22)	40 (48.78)		
no	60 (74.07)	21 (25.93)		
Operation mode			3.942	0.086
replacement of artificial femoral head	27 (52.94)	24 (47.06)		
proximal femoral anti rotation intramedullary nail	75 (66.96)	37 (33.04)		
Operation duration (min)	130.90±25.67	142.89±25.63	2.887	0.004
Intraoperative bleeding volume (mL)	271.88±50.11	277.67±48.33	0.723	0.471

groups of patients were matched according to the 1:1 ratio. These indicators were matched because they may affect the anesthetic effect. After matching these factors, the comparability of anesthetic effects between the two groups can be improved to the maximum extent. The nearest matching method (Nearest neighbor 1:1 match) and caliper matching method (Caliper = 0.25σ) were used for inter-group matching. The standard mean difference (SMD) was used for inter-group balance test after the propensity score matching.

Statistical analysis

In this study, SPSS 25.0 statistical software was used to analyze the research data, and R 4.0 was used for propensity score matching. The counted data was expressed in the form of n (%) and the difference between the groups was texted by χ^2 text. The measured data conforming to the normal distribution were expressed in the form of (mean ± standard deviation). The difference between the two groups was tested by independent samples *t* test. The comparison between the two groups at different times was made by repeated measurement ANOVA. Bonferroni test. $P<0.05$ means the difference was significant.

Results

General characteristics of patients

Table 1 shows the general characteristics of the patient. There were significant differences in the patient's age, BMI, bedtime before surgery, diabetes history, and operation duration between the control group and the combine group (all $P<0.05$).

Distribution of patients' characteristics after propensity score matching

The general characteristics of the two groups of patients were matched by the tendency score. There were 42 patients matched in each group. After matching, there was no great difference between the two groups in terms of gender, age, BMI, bedtime before operation, cardiovascular disease history, diabetes history, operation mode, operation duration, and intraoperative blood loss (all $P>0.05$), as shown in **Table 2**.

Anesthetic effect of different anesthesia schemes

When comparing the anesthetic effects of different anesthesia schemes, it was found that

Table 2. Distribution of patients' characteristics after matching

Characteristic	Control (n = 42)	Combine (n = 42)	χ^2/t	*P*
Gender			0.431	0.512
male	21 (53.58)	18 (46.15)		
female	21 (46.67)	24 (53.33)		
Age	68.31±3.48	69.02±3.89	0.885	0.381
BMI (kg/m^2)	23.52±1.13	23.73±1.09	0.867	0.389
Bedrest time before operation (d)			0.233	0.629
>3	13 (54.17)	11 (45.83)		
≤3	29 (48.33)	31 (51.67)		
Cardiovascular disease			0.000	1.000
yes	13 (50.00)	13 (50.00)		
no	29 (50.00)	29 (50.00)		
Diabetes			0.048	0.826
yes	23 (48.94)	24 (51.06)		
no	19 (51.35)	18 (48.65)		
Operation mode			0.000	1.000
replacement of artificial femoral head	14 (50.00)	14 (50.00)		
proximal femoral anti rotation intramedullary nail	28 (50.00)	28 (50.00)		
Operation duration (min)	138.83±24.57	136.90±22.97	0.372	0.711
Intraoperative bleeding volume (mL)	282.98±46.19	273.64±47.20	0.917	0.362

Table 3. Comparison of anesthesia effects of different anesthesia schemes ($\bar{x}$±s)

Group	n	The onset time of anesthesia (min)	Postoperative awakening time (min)	Extubation time (min)
Control	42	17.08±1.24	14.33±2.97	21.50±3.79
Combine	42	14.97±1.07	11.94±2.71	15.06±3.01
t		8.349	3.852	8.623
P		<0.001	<0.001	<0.001

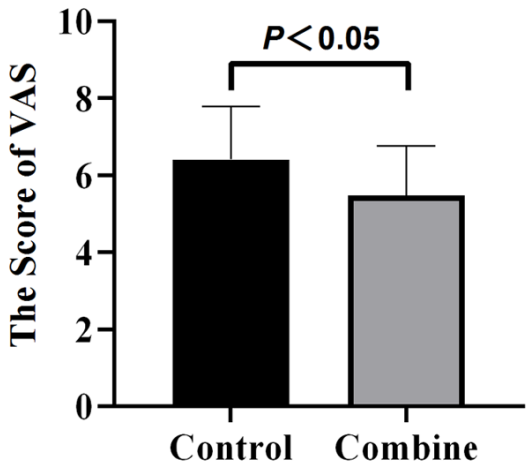

Figure 1. Postoperative pain of patients under different anesthesia schemes. Visual Pain Simulation Scale (VAS).

compared with the patients in the control group, the patients in the combined group had faster onset time of anesthesia, earlier postoperative recovery time, shorter extubation time, and lower postoperative pain (all *P*<0.05), as shown in **Table 3** and **Figure 1**.

Effects of different anesthesia schemes on short-term cognitive function

Table 4 shows that there was no significant difference in the cognitive status of the two groups 1 day before surgery (*P*>0.05). After the operation, the short-term cognitive function of patients in both groups decreased slightly, but the cognitive function of patients in the combined group had decreased less than those in the control group (*P*<0.05).

Hemodynamic changes of patients

With the passage of time, the systolic blood pressure of patients in both groups decreased (F_{time} = 51.230, *P*<0.05), and there was significant difference ($F_{interaction}$ = 20.150, *P*<0.05). The heart rate of patients in both groups showed a trend of change with time (F_{time} = 18.700, *P*<0.05). The change in the control

Table 4. Changes in short-term cognitive function of patients ($\bar{x}\pm s$)

Group	n	1 day before surgery	1 day after surgery	*t*	*P*
Control	42	27.16±1.05	25.83±0.97	6.030	<0.001
Combine	42	27.39±1.03	26.44±0.83	4.654	<0.001
t		1.013	3.097		
P		0.314	<0.001		

group was more significant (F_{group} = 10.060, P<0.05), but there was no significant difference ($F_{interaction}$ = 1.602, P = 0.189), as shown in **Table 5**. The results of Bonferroni comparison showed that there were significant differences in systolic blood pressure and heart rate between the control group and the combination group (P<0.05 after adjustment).

Postoperative complications

When comparing the safety of different anesthesia schemes, it was found that propofol combined with sufentanil did not increase the incidence of postoperative complications (P>0.05), as shown in **Table 6**.

Discussion

The hip is the section connecting the trunk and lower limbs. It is the center of a series of body movements. It is easy to cause a hip fracture once it is subjected to indirect rotation distortion because of the particularity of the hip bone structure. For the elderly, their physical functions are degraded. Most of them are accompanied with osteoporosis. Slight trauma may lead to a hip fracture [20, 21]. Surgery is the first choice for the treatment of hip fractures. but most elderly patients have medical diseases. Their tolerance to anesthesia and surgery is significantly reduced. During induction of general anesthesia intubation, patients will experience transient blood pressure rise and heart rate increase. This can cause an imbalance of myocardial oxygen supply, affecting a patients' postoperative recovery [22]. Senile patients have gradually developed degenerative diseases in various organs of the body. The ability of metabolism and clearance of narcotic drugs in the body is reduced, creating problems such as cognitive dysfunction after anesthesia [23]. For anesthesiologists, continuous improvement of the anesthesia program for elderly patients with intertrochanteric fracture of the femur can help reduce the risk of adverse reactions caused by anesthesia factors. This has positive clinical significance for promoting postoperative rehabilitation of patients.

Intravenous anesthesia is a method of general anesthesia. It controls the depth of anesthesia by adjusting the target plasma concentration of drugs and the target concentration of the target effect room [24]. General anesthesia is one of the main mode of anesthesia for hip fracture surgery. During the operation of hip fracture, patients need to receive endotracheal intubation, which will cause severe fluctuations in hemodynamics and easily lead to adverse reactions [25]. Anesthetics can effectively inhibit adverse hemodynamic changes [26]. To improve the anesthetic effect, the scheme of combined use of multiple anesthetic drugs was adopted in clinical practice. As an opioid receptor agonist, sufentanil has a stronger analgesic effect and longer duration than remifentanil and fentanyl [27, 28]. Sufentanil can be used for spinal and epidural anesthesia. Propofol is used in combination with neuromuscular blockers, inhalation anesthetics, and analgesics. Sufentanil is a N-4 thiophene derivative of fentanyl. Sufentanil is fat-soluble. It easily penetrates the blood-cerebrospinal fluid barrier μ_1 receptor and is highly selective [27]. Its analgesic effect is 10 times stronger than that of fentanyl, and its duration is twice as long as that of fentanyl. The pharmacokinetic characteristics of sufentanil conform to the three-compartment model. The time required for the drug concentration in the effect room to reach 50% of the maximum drug concentration in the effect room is four minutes [28]. Akarsu [29] found that the combination of propofol and sufentanil can effectively reduce the pain of patients undergoing colonoscopy without increasing the risk of respiratory depression.

This study was to observe the effect of propofol combined with sufentanil on elderly patients undergoing surgical treatment of intertrochanteric fracture of femur. The effect of hip fracture surgery is affected by anesthetic drugs. It is related to the patient's own characteristics and surgical methods. To enhance the accuracy of the evaluation of the effect of narcotic drugs, this study used propensity score matching to minimize the impact of confounding factors. Propensity score matching is a statistical method used to process data from observational

Table 5. Changes of blood pressure and heart rate of patients (n = 42, $\bar{x}\pm s$)

Index	Group	Before anesthesia induction	After anesthesia induction	Tracheal intubation	At the end of surgery
Systolic blood pressure (mmHg)	Control	131.47±6.33	114.25±5.91	119.28±5.46	115.33±4.61
	Combine	132.25±6.16	126.59±5.47	121.20±5.04	117.49±4.82
F_{time}	51.230	F_{group}	123.600	$F_{interaction}$	20.150
P_{time}	<0.001	P_{group}	<0.001	$P_{interaction}$	<0.001
Heart rate (Times/min)	Control	83.07±6.92	88.10±5.82	86.41±5.62	85.11±5.69
	Combine	82.15±7.08	85.91±6.13	83.02±5.16	80.33±5.07
F_{time}	18.700	F_{group}	10.060	$F_{interaction}$	1.602
P_{time}	<0.001	P_{group}	<0.001	$P_{interaction}$	0.189

Table 6. Occurrence of complications in patients

Group	n	Atelectasis	Hypoxemia	Nausea and vomiting	Dizzy	Total incidence
Control	42	2 (4.76)	2 (4.76)	3 (7.14)	2 (4.76)	9 (21.43)
Combine	42	1 (2.38)	1 (2.38)	2 (4.76)	2 (4.76)	5 (11.90)
χ^2						1.378
P						0.240

studies [30, 31]. In the observation study there are many data deviations and confounding variables. The method of propensity score matching is to reduce the influence of these deviations and confounding variables. This allows a reasonable comparison between the experimental group and the control group [32, 33]. In this study, 102 patients were initially included in the control group and 61 patients were in the combined group. Using propensity score matching, after matching the factors that may affect the evaluation results of anesthetic efficacy, such as the patient's gender, age, and surgical method, 42 patients in each group were matched.

The observation results of this study showed that compared with the patients in the control group, the patients in the combined group had faster onset time of anesthesia, earlier postoperative recovery time, shorter extubation time, and lower postoperative pain. Propofol combined with sufentanil can shorten the postoperative recovery time of patients and reduce postoperative pain. We found that propofol combined with sufentanil can reduce cognitive impairment and maintain hemodynamic stability in patients with intertrochanteric fractures of the femur. This was consistent with the research results of Tu [34]. Respiratory depression is the main side effect of sufentanil. Sufentanil produces dose-dependent respiratory depression by activating the μ_2 receptor in the brain stem respiratory center. When the dose of sufentanil is large, it may lead to the reduction of tidal volume, or respiratory arrest [35, 36]. With the continuous progress of the aging population in China, the number of elderly orthopedic surgery patients is increasing. Elderly patients are often complicated with hypertension, diabetes, and coronary heart disease. The use of anesthetic drugs during the perioperative period will lead to stress reactions such as a sharp increase in blood pressure, heart rate, and myocardial oxygen consumption. This can easily lead to arrhythmia, myocardial ischemia, and stroke complications, which have a serious impact on the quality of life of patients. After comparing the incidence of postoperative adverse reactions of the two groups of patients, we found that sufentanil did not increase the incidence of postoperative adverse reactions. This study showed that the anesthesia scheme of propofol combined with sufentanil is safe and feasible in elderly patients with intertrochanteric fractures of the femur.

Conclusion

For elderly patients with fractures, undergoing surgical treatment will increase with age. To

reduce the risk of surgery, it is necessary to carefully choose anesthesia methods. To sum up, the anesthesia scheme of propofol combined with sufentanil was applied to the elderly femoral intertrochanteric fracture surgery. It had a clear positive effect in shortening the postoperative recovery time, reducing postoperative pain, reducing cognitive dysfunction, and stabilizing hemodynamics. It did not increase the incidence of postoperative adverse reactions of patients.

Limitations and prospects

This study confirmed that the anesthesia scheme of propofol combined with sufentanil is safe and feasible in elderly patients with intertrochanteric fracture of femur. This study had some limitations, such as small sample size and single center study. It is hoped that more samples will be included in the multi center research in the future to enhance the reliability of the research results.

Disclosure of conflict of interest

None.

Address correspondence to: Xiaofeng Sun, Department of Anesthesiology, Central Hospital Affiliated to Shenyang Medical College, No. 5, Nanqi West Road, Tiexi District, Shenyang 110024, Liaoning, China. Tel: +86-024-85715709; E-mail: sunxiaofeng1118@126.com

References

[1] Yin B, He Y, Wang D and Zhou J. Classification of femur trochanteric fracture: evaluating the reliability of Tang classification. Injury 2021; 52: 1500-1505.

[2] Veronese N and Maggi S. Epidemiology and social costs of hip fracture. Injury 2018; 49: 1458-1460.

[3] Karakus O, Ozdemir G, Karaca S, Cetin M and Saygi B. The relationship between the type of unstable intertrochanteric femur fracture and mobility in the elderly. J Orthop Surg Res 2018; 13: 207.

[4] Xu BY, Yan S, Low LL, Vasanwala FF and Low SG. Predictors of poor functional outcomes and mortality in patients with hip fracture: a systematic review. BMC Musculoskelet Disord 2019; 20: 568.

[5] Chang SM, Hou ZY, Hu SJ and Du SC. Intertrochanteric femur fracture treatment in Asia: what we know and what the world can learn. Orthop Clin North Am 2020; 51: 189-205.

[6] Assefa MT, Chekol WB, Melesse DY, Nigatu YA and Bizuneh YB. Incidence and risk factors of emergence delirium in elderly patients after general or spinal anesthesia for both elective and emergency surgery. Ann Med Surg (Lond) 2022; 84: 104959.

[7] Li T, Li J, Yuan L, Wu J, Jiang C, Daniels J, Mehta RL, Wang M, Yeung J, Jackson T, Melody T, Jin S, Yao Y, Wu J, Chen J, Smith FG and Lian Q; RAGA Study Investigators. Effect of regional vs general anesthesia on incidence of postoperative delirium in older patients undergoing hip fracture surgery: the RAGA randomized trial. JAMA 2022; 327: 50-58.

[8] Bhushan S, Huang X, Duan Y and Xiao Z. The impact of regional versus general anesthesia on postoperative neurocognitive outcomes in elderly patients undergoing hip fracture surgery: a systematic review and meta-analysis. Int J Surg 2022; 105: 106854.

[9] O'Donnell CM, Black N, McCourt KC, McBrien ME, Clarke M, Patterson CC, Blackwood B, McAuley DF and Shields MO. Development of a core outcome set for studies evaluating the effects of anaesthesia on perioperative morbidity and mortality following hip fracture surgery. Br J Anaesth 2019; 122: 120-130.

[10] Liufu N, Liu L, Shen S, Jiang Z, Dong Y, Wang Y, Culley D, Crosby G, Cao M, Shen Y, Marcantonio E, Xie Z and Zhang Y. Anesthesia and surgery induce age-dependent changes in behaviors and microbiota. Aging (Albany NY) 2020; 12: 1965-1986.

[11] Song Y, Liu Y, Yuan Y, Jia X, Zhang W, Wang G, Jia Y, Wang X, Liu L, Li W, Li X, Cai N, Liu C, Li Y, Han Y, Zhou Y, Mi X, Shi C, Wang JQ, Vuylsteke A, Guo X and Li Z. Effects of general versus subarachnoid anaesthesia on circadian melatonin rhythm and postoperative delirium in elderly patients undergoing hip fracture surgery: a prospective cohort clinical trial. EBioMedicine 2021; 70: 103490.

[12] Chen X, Zhang J, Lin Y, Liu Z, Sun T and Wang X. Risk factors for postoperative mortality at 30 days in elderly Chinese patients with hip fractures. Osteoporos Int 2022; 33: 1109-1116.

[13] Li DN, Zhao GQ and Su ZB. Propofol target-controlled infusion in anesthesia induction during painless gastroscopy. J Coll Physicians Surg Pak 2019; 29: 604-607.

[14] Wu J, Han Y, Yang L and Liu Z. Analysis on the effect of intravenous anesthesia with dexmedetomidine and propofol combined with seaweed polysaccharides on hemodynamics and analgesia in pregnant females undergoing

painless induced abortion. Pak J Pharm Sci 2021; 34: 1249-1254.
[15] Dang SJ, Li RL, Wang J, Zeng WB, He Y, Yue HY, Li SY and Han LC. Oxycodone vs sufentanil in patient-controlled intravenous analgesia after gynecological tumor operation: a randomized double-blind clinical trial. J Pain Res 2020; 13: 937-946.
[16] Kowalski G, Zawadzki M, Leppert W, Szpot P, Siczek M, Slowinski K, Sobieszczanska M, Gawlowska A and Wieczorowska-Tobis K. Analgesic efficacy of sufentanil in dressings after surgical treatment of burn wounds. Burns 2021; 47: 880-887.
[17] Knuf KM, Maani CV and Cummings AK. Clinical agreement in the American Society of Anesthesiologists physical status classification. Perioper Med (Lond) 2018; 7: 14.
[18] Sung YT and Wu JS. The visual analogue scale for rating, ranking and paired-comparison (VAS-RRP): a new technique for psychological measurement. Behav Res Methods 2018; 50: 1694-1715.
[19] Cao SJ, Chen D, Yang L and Zhu T. Effects of an abnormal mini-mental state examination score on postoperative outcomes in geriatric surgical patients: a meta-analysis. BMC Anesthesiol 2019; 19: 74.
[20] Matsuo M, Yamagami T and Higuchi A. Impact of age on postoperative complication rates among elderly patients with hip fracture: a retrospective matched study. J Anesth 2018; 32: 452-456.
[21] Poeran J, Cozowicz C, Zubizarreta N, Weinstein SM, Deiner SG, Leipzig RM, Friedman JI, Liu J, Mazumdar M and Memtsoudis SG. Modifiable factors associated with postoperative delirium after hip fracture repair: an age-stratified retrospective cohort study. Eur J Anaesthesiol 2020; 37: 649-658.
[22] Liu Y, Su M, Li W, Yuan H and Yang C. Comparison of general anesthesia with endotracheal intubation, combined spinal-epidural anesthesia, and general anesthesia with laryngeal mask airway and nerve block for intertrochanteric fracture surgeries in elderly patients: a retrospective cohort study. BMC Anesthesiol 2019; 19: 230.
[23] Alexiou KI, Roushias A, Varitimidis SE and Malizos KN. Quality of life and psychological consequences in elderly patients after a hip fracture: a review. Clin Interv Aging 2018; 13: 143-150.
[24] Nimmo AF, Absalom AR, Bagshaw O, Biswas A, Cook TM, Costello A, Grimes S, Mulvey D, Shinde S, Whitehouse T and Wiles MD. Guidelines for the safe practice of total intravenous anaesthesia (TIVA): Joint Guidelines from the Association of Anaesthetists and the Society for Intravenous Anaesthesia. Anaesthesia 2019; 74: 211-224.
[25] Agerskov M, Sorensen H, Hojlund J, Secher NH and Foss NB. Pre-operative haemodynamic monitoring and resuscitation in hip fracture patients: protocol for a prospective observational study. Acta Anaesthesiol Scand 2018; 62: 1314-1320.
[26] Hazrati E, Vosoughi F, Chamanara M and Teymourian H. Effect of Dexmedetomidine infusion during hip fracture surgery on hemodynamic parameters and blood loss: a triple-blinded randomized clinical trial. Injury 2022; 53: 551-554.
[27] Sridharan K and Sivaramakrishnan G. Comparison of fentanyl, remifentanil, sufentanil and alfentanil in combination with propofol for general anesthesia: a systematic review and meta-analysis of randomized controlled trials. Curr Clin Pharmacol 2019; 14: 116-124.
[28] Xu Z, Tang Z, Yao J, Liang D, Jin F, Liu Y, Guo K and Yang X. Comparison of low-dose morphine intrathecal analgesia and sufentanil PCIA in elderly patients with hip fracture undergoing single spinal anesthesia - a randomized clinical trial. BMC Anesthesiol 2022; 22: 124.
[29] Akarsu Ayazoglu T and Uzman S. Combination of propofol and nasal sufentanil or intravenous midazolam for colonoscopy: a comparative study. Anaesthesiol Intensive Ther 2021; 53: 146-152.
[30] Kane LT, Fang T, Galetta MS, Goyal DKC, Nicholson KJ, Kepler CK, Vaccaro AR and Schroeder GD. Propensity score matching: a statistical method. Clin Spine Surg 2020; 33: 120-122.
[31] Liang J, Hu Z, Zhan C and Wang Q. Using propensity score matching to balance the baseline characteristics. J Thorac Oncol 2021; 16: e45-e46.
[32] Davis ML, Neelon B, Nietert PJ, Burgette LF, Hunt KJ, Lawson AB and Egede LE. Propensity score matching for multilevel spatial data: accounting for geographic confounding in health disparity studies. Int J Health Geogr 2021; 20: 10.
[33] Ferri-Guerra J, Aparicio-Ugarriza R, Mohammed YN, Ysea O, Florez H and Ruiz JG. Propensity score matching to determine the impact of metformin on all-cause mortality in older veterans with diabetes mellitus. South Med J 2022; 115: 208-213.
[34] Tu W, Yuan H, Zhang S, Lu F, Yin L, Chen C and Li J. Influence of anesthetic induction of propofol combined with esketamine on perioperative stress and inflammatory responses and postoperative cognition of elderly surgical patients. Am J Transl Res 2021; 13: 1701-1709.

[35] Tang C, Hu Y, Zhang Z, Wei Z, Wang H, Geng Q, Shi S, Wang S, Wang J and Chai X. Dexmedetomidine with sufentanil in intravenous patient-controlled analgesia for relief from postoperative pain, inflammation and delirium after esophageal cancer surgery. Biosci Rep 2020; 40: BSR20193410.

[36] Fonseca NM, Guimaraes GMN, Pontes JPJ, Azi LMTA and de Avila Oliveira R. Safety and effectiveness of adding fentanyl or sufentanil to spinal anesthesia: systematic review and meta-analysis of randomized controlled trials. Braz J Anesthesiol 2023; 73: 198-216.