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Retrospective Study

Dexmedetomidine-induced anesthesia in elderly patients undergoing hip replacement surgery

INTRODUCTION

Recent years have witnessed an increase in the aging population of China and hence in its population structure. Because the hip bone of the elderly bears a huge load and is subjected to a relatively greater extent of activity, it is more prone to fracture. Hip replacement is the main approach for the treatment of the hip fracture. Due to the decline in the dopaminergic, cholinergic, and other neuroregulatory system functions in elderly patients, the extent of postoperative inflammatory response is significantly increased, which can easily cause multiple organ dysfunction. This factor is detrimental to the postoperative healing of elderly patients. Recent studies have revealed that maintaining the function of important organs in elderly patients undergoing hip replacement surgery during anesthesia and reducing any potential bodily damage is conducive to postoperative recovery[1-4]. Midazolam and propofol are commonly applied anesthetics in elderly patients during surgery. The combination of these two agents has a good anesthetic outcome, but it cannot effectively protect organ functions[4,5]. Dexmedetomidine is a highly selective α2 receptor agonist, which has a good effect in reducing the body's stress response and in stabilizing the patient's intraoperative hemodynamics. Hence, it has a good application prospect in perioperative organ protection[6,7]. However, the applicability of dexmedetomidine as anesthesia in elderly patients with hip replacement surgery is not established yet. This

study intended to analyze the anesthetic outcome of dexmedetomidine in elderly patients with hip replacement.

MATERIALS AND METHODS

General information

A total of 98 elderly patients scheduled for hip replacement surgery who were admitted to our hospital during June 2020–2021, were randomly assigned to two groups: control (n = 49) and observation (n = 49). In the observation group: there were 23 women and 26 men with body mass index (BMI) of 20–26 kg/m^2 (average: 24.02 ± 0.41 kg/m^2) and average age 67.69 ± 2.79 years (age range: 62–74 years). The study included patients with injuries ranging from 18 to 65 years old, with 10 cases of injury resulting from crush injuries, 24 from traffic accidents, and 15 from falls. In the control group, there were 22 women and 27 men of BMI 20–27 kg/m^2 (average: 23.67 ± 0.37 kg/m^2). The average age of the control subjects is 68.55 ± 2.25 years (age range: 63–73 years). In these subjects, 25 cases of injury were caused by traffic accidents, 9 by squeezing, and 15 by falling. The general data of the two groups were comparable (P > 0.05).

Inclusion and exclusion criteria

Inclusion criteria: the diagnostic criteria of hip fracture met the "Expert consensus on the diagnosis and treatment of hip fracture in the elderly (2017)"[8], which was confirmed by preoperative X-ray examination: age ≥ 60 years; those who met the surgical indications of hip replacement; traumatic fracture admission; complete clinical data; informed consent of this study. Exclusion criteria: preoperative severe malnutrition; patients with severe infectious diseases; patients with severe organ dysfunction and malignant tumors.

Anesthesia method

The control group was administered the general anesthesia, as follows: anesthesia induction: midazolam (Jiangsu Enhua Pharmaceutical Co., Ltd., Sinopharm H19990027,

1 mL: 5 mg) 0.03–0.05 mg/kg, sufentanil (Yichang Renfu Pharmaceutical Co., Ltd., Sinopharm H20054171, 1 mL: 50 μg) 0.3–0.5 μg/kg, etomidate (Jiangsu Enhua Pharmaceutical Co., Ltd., Sinopharm H20020511, 10 mL: 20 mg) 0.2–0.3 mg/kg. Rocuronium bromide (N. V. Organon, import drug registration number H20140847, 5 mL: 50 mg) 0.6–1.0 mg/kg. A tracheal catheter or I-GEL laryngeal mask was inserted after 2–5 min of muscle relaxation. Anesthesia maintenance was performed as follows: sevoflurane (Albert Pharmaceutical Trading Co., Ltd., import drug registration number H20150020, 250 mL) inhalation concentration 1%–2%, propofol (Xi'an Libang Pharmaceutical Co., Ltd., Sinopharm approval number: H19990282, 20 mL: 0.2 g) 2–5 mg/(kg·h), remifentanil (Yichang Renfu Pharmaceutical Co., Ltd., Sinopharm approval number H20030197, 1 mg) 0.05–0.2 μg/(kg·min). Intermittent intravenous injection of cisatracurium (Zhejiang Xianju Pharmaceutical Co., Ltd., Sinopharm H20090202, 5 mg) 3–4 mg to maintain muscle relaxation. Sufentanil was added, with the total amount not exceeding 1 μg/kg, depending on the patient's response to anesthesia. The parameters of mechanical ventilation were set as follows: the recommended respiratory parameters were a tidal volume of 6–10 mL/kg, a respiratory rate of 8–12 breaths/min, and an inspiratory-to-expiratory ratio of 1:2. The mean arterial pressure (MAP) and heart rate (HR) were maintained within the basic value of ± 20%, and vasoactive drugs were administered based on the blood pressure of the patient during the surgery. Postoperative patient-controlled intravenous analgesia included sufentanil 200 μg, dezocine (Yangzijiang Pharmaceutical Group Co., Ltd., Sinopharm H20184150, 1 mL: 5 mg) 10 mg, tropisetron (Hainan Lingkang Pharmaceutical Co., Ltd., Sinopharm H20060287, 5 mg) 10 mg, normal saline 144 mL, total 150 mL; duration of 75 h, intravenous self-control 2 mL/h, load 0–2 mL, continuous volume 1.5–2 mL/h, and a lock time of 30 min.

Based on the anesthesia scheme of the control group, the observation group was treated with dexmedetomidine (Yangzijiang Pharmaceutical Group Co., Ltd., Chinese Pharmacopoeia: H20183219, 2 mL: 0.2 mg). Anesthesia induction and maintenance were performed consistently between the two groups. Before anesthesia induction, the

patients were intravenously administered 4 μg/mL dexmedetomidine for 10 min, which was then changed to 0.2 μg/(kg·h). Both groups were observed until the patient was discharged from the hospital.

Observation indicators

Vital signs Multifunctional ECG monitor [MX550, Philips (China) Investment Co., Ltd.] was used to measure the MAP, HR, and blood oxygen saturation (SpO_2) of the two groups before, during, and 6 h after the surgery.

The levels of serum inflammatory factors C-reactive protein (CRP), tumor necrosis factor-alpha (TNF-α), and interleukin-18 (IL-18) were determined by enzyme-linked immunosorbent assay (ELISA) before, during, and 6 h after the surgery for the two study groups (Shanghai Enzyme-linked Biotechnology Co., Ltd.).

To examine the renal functions, the levels of serum kidney injury molecule-1 (KIM-1), urea nitrogen (BUN), and creatinine (Cr) were detected by ELISA before, during, and 6 h after the surgery.

The following postoperative recovery factors were assessed and recorded: the first time getting out of bed, the recovery time of grade II muscle strength, the recovery time of grade III muscle strength, and the time of hospitalization.

The incidence of the following adverse events was recorded for the two groups of elderly patients, intraoperative hypotension, bradycardia, hypoxemia, and general body movement-related adverse events.

Statistical analysis

SPSS 21.0 statistical software was used for data analysis, with $P < 0.05$ considered to indicate a statistically significant difference. The measurement data included vital signs, serum inflammatory factor levels, renal function, and postoperative recovery. The mean ± SD represented the use of repeated measures analysis of variance for comparison. If the football symmetry test failed, the G–G correction method was applied. Under the interaction, the separation effect between the population and time was analyzed

further. The adverse events were counted as data, expressed as cases (percent) [n (%)], and passed through χ^2 tests for comparison.

RESULTS

Comparison of the vital signs between the two groups of patients

The vital signs of MAP, SpO_2, and HR data of the patients in the control and observation groups met the spherical symmetry test. The MAP, SpO_2 between the groups, time, and the interaction between the groups and time should be subjected to detailed analysis to understand the individual effect. The MAP of the two groups was lower than that before and after 6 h of the surgery; the MAP value was higher in the observation group than in the control group ($P < 0.05$). The SpO_2 standards in both groups were greater than that before and 6 h after the surgery. The HR in the observation group was higher than that in the control group ($P < 0.05$). In contrast with the HR of the two groups, the HR during and 6 h after the surgery was below that recorded before surgery, while the HR at 6 h after surgery was greater than that during surgery ($P < 0.05$). During and 6 h after surgery, the HR in the observation group was lower than that in the control group ($P < 0.01$) (Table 1).

Comparison of serum inflammatory factor levels between the two groups

The levels of serum CRP, TNF-α, and IL-18 between the two groups were not satisfied with the results of the football symmetry test and the G–G correction method. The interaction among the groups, time, and between the groups and time was found to be significant, after which the individual effects were analyzed. The serum levels of CRP and TNF-α were recorded at 6 h after surgery in both two groups. The levels of TNF-α and IL-18 were higher than those before and during surgery, but lower than those of the control group ($P < 0.05$) (Table 2).

Comparison of renal function indexes between the two groups

The renal function satisfied the spherical symmetry test. The group, time, and interaction between the group and time of KIM-1 and BUN have significant further analysis of the individual effect. As shown in Table 3, there was no interaction between the Cr index time and group ($P > 0.05$). Comparison of the serum KIM-1 Levels between the two groups showed that the levels during and 6 h after the surgery were higher than that before the surgery, those at 6 h after the surgery were higher than those during the surgery, during and 6 h after surgery, the observation group was lower than the control group ($P < 0.05$). The serum BUN levels after the surgery were elevated in both groups when compared to that before surgery. The observation group showed significantly lower levels than the control group ($P < 0.05$) for the measured parameter. The comparison of serum Cr levels between the two groups revealed that the levels during and 6 h after surgery were higher than those before surgery. It is lower during and 6 h after surgery. Table 3 depicts that the levels of the measured parameter in the observation group during and 6 h after surgery were significantly lower compared to those in the control group ($P < 0.05$).

Comparison of postoperative recovery between the two groups

The factors of the first time of getting out of bed, the recovery time of grade II muscle strength, grade III muscle strength, and hospitalization time were shorter in the observation group than in the control group ($P < 0.05$; Table 4).

Comparison of adverse events between the two groups of patients

During hospitalization, the rate of incidence of adverse events in the control group was higher than that in the observation group ($P < 0.05$; Table 5).

DISCUSSION

Hip fracture is the most common type of fracture occurring in the elderly. Hip fractures are commonly treated in clinics through total hip arthroplasty as one of the main preferred methods for the elderly. Due to the reduction of all aspects of the body in

elderly patients undergoing hip arthroplasty, the stress response and inflammatory response induced by surgery can aggravate the damage to important organs of the patients, which is not conducive to the recovery of the patients[9-11]. During the surgery, the use of certain anesthetic drugs can maintain the hemodynamic stability of the patient and reduce the damage to the patient's organs. Midazolam and propofol are common anesthetics applied in clinical practice, which have proven good sedative and analgesic effects, but they are not effective in protecting the functions of important organs of patients and need to be combined with other anesthetics for anesthesia[12,13]. In elderly patients undergoing hip replacement surgery, changes in hemodynamics, respiratory functions, and elevated levels of the inflammatory response can lead to short-term postoperative cognitive impairment[15,16]. Based on the current findings, the MAP of the observation group was higher than that of the control group during surgery. In addition, the HR of the observation group was lower than that of the control group during and after surgery. At 6 h after surgery, the MAP and SpO_2 levels as well as the serum CRP and TNF-α levels were higher for the patients in the observation group than for those in the control group. The levels of IL-18 and dexmedetomidine were significantly lower in the observation group than in the control group. This finding suggests that dexmedetomidine administration may be an effective intervention for improving vital signs and reducing inflammation in elderly patients with hip joint disorders. Dexmedetomidine can facilitate reaching the depth of anesthesia as soon as possible and thereby speed up the surgery process. Meanwhile, it can stabilize the hemodynamics of patients by inhibiting the secretion of norepinephrine and the activity of sympathetic nerves. In addition, it can maintain the patient's respiratory drive and improve the levels of MAP, HR, and SpO_2[17]. Dexmedetomidine can alleviate the synthesis of corticosteroids and glucocorticoids by enhancing parasympathetic activity and inhibiting sympathetic activity, which can effectively reduce the body's stress response and inflammatory response in elderly hip-replacement patients[18]. In elderly patients undergoing hip replacement surgery, increased levels of inflammatory response and hemodynamic changes may cause kidney damage. KIM-1 is a

transmembrane protein that is not expressed during normal renal functions, but appears after renal injury, thereby serving as a marker of early renal injury. BUN and Cr are the traditional indicators of renal functions, with elevated levels of renal functions. The present results revealed that the average serum levels of KIM-1, BUN, and Cr in the observation group were lower than those in the control group during and 6 h after the surgery, thereby indicating that dexmedetomidine can effectively alleviate renal injury in elderly hip-replacement patients and protect renal functions. Dexmetomidine can effectively reduce the inflammatory response and damage caused by them to the renal cells in elderly patients undergoing hip-replacement surgery. On the other hand, dexmedetomidine can effectively inhibit the release of norepinephrine, reduce sympathetic nerve excitability, and increase renal blood flow, which cumulatively protects renal functions. The present results also suggest that the postoperative recovery of the observation group was better than that of the control group. Moreover, the total frequency of adverse events was lesser than that of the control group, which signifies that dexmedetomidine can effectively enhance the recovery of articulatio coxae in the elderly. We thus found that dexmetomidine could reduce the body's inflammatory response and kidney damage and stabilize the patient's vital signs, thereby indicating a good safety profile. Meanwhile, its sedative effect is non-anesthetic, rapidly metabolized in the body, and shows a strong dose dependency. The low-dose dexmedetomidine infusion used in this study led to quick awakening and restoration of consciousness in elderly patients after anesthesia, implying its safety and efficacy.

CONCLUSION

In summary, dexmedetomidine could effectively improve the vital signs of elderly patients undergoing hip replacement surgery, reduce the body's inflammatory response and renal function damage, and promote postoperative recovery. Meanwhile, it demonstrated good safety and anesthetic outcomes. This finding has significant clinical implications and merits further investigations for optimized application. The relevant

indicators included in this study only compared the data of three different time points, before, during, and 6 h after the surgery, because of which the conclusion may be biased. In addition, as this study was conducted on a small sample size from a single center, the results may not apply to different populations. Subsequent research should include large sample size, a diverse subject population, and different age-group patients. We believe that a follow-up study on the changes of indicators at multiple time points and further analyses of the effect of dexmedetomidine in anesthesia during hip replacement surgery in the elderly are warranted to supplement the present findings.

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Table 1 Comparison of vital signs between the two groups (mean ± SD)

Group	*n*	MAP (mmHg)	SpO_2 (%)	HR (beat/min)
Preoperative				
Control group	49	90.02 ± 3.39	96.24 ± 3.07	88.12 ± 4.16
Observation group	49	91.12 ± 3.37	97.29 ± 2.45	87.14 ± 4.11
F value	-	2.136	1.871	1.389
P value	-	0.147	0.064	0.242
Intraoperative				
Control group	49	75.61 ± 4.49[a]	99.63 ± 0.49[a]	81.59 ± 3.21[a]
Observation group	49	79.61 ± 3.41[a]	99.80 ± 0.41[a]	79.12 ± 3.26[a]
F value	-	23.995	1.863	3.779
P value	-	< 0.001	0.066	< 0.001
6 h after operation				
Control group	49	82.78 ± 3.74[a,d]	98.49 ± 0.68[a,d]	86.73 ± 4.28[a,d]
Observation group	49	88.49 ± 4.67[a,d]	98.92 ± 0.28[a,d]	83.43 ± 3.45[a,d]
F value	-	46.040	10.001	4.202
P value	-	< 0.001	0.001	< 0.001

[a]$P < 0.05$ *vs* preoperative.

[d]$P < 0.05$ *vs* intraoperative.

MAP: mean arterial pressure; HR: Heart rate; SpO_2: Blood oxygen saturation.

Table 2 Comparison of serum inflammatory factor levels between the two groups (mean ± SD, ng/L)

Group	*n*	CRP	TNF-α	IL-18
Preoperative				
Control group	49	3.33 ± 1.21	15.11 ± 4.20	173.55 ± 23.52
Observation group	49	3.15 ± 1.20	15.50 ± 4.03	173.15 ± 22.50

F value	-	0.562	0.220	0.086
P value	-	0.455	0.640	0.932
Intraoperative				
Control group	49	15.53 ± 4.22[a]	53.23 ± 8.12[a]	199.25 ± 22.10[a]
Observation group	49	7.25 ± 3.20[a]	31.20 ± 5.21[a]	190.23 ± 21.33[a]
F value	-	119.785	255.597	4.222
P value	-	< 0.001	< 0.001	0.043
6 h after operation				
Control group	49	18.25 ± 4.13[a,d]	60.27 ± 9.23[a,d]	293.25 ± 11.50[a,d]
Observation group	49	11.73 ± 2.50[a,d]	38.25 ± 8.20[a,d]	203.19 ± 12.37[a,d]
F value	-	89.449	156.076	1393.312
P value	-	< 0.001	< 0.001	< 0.001

[a]$P < 0.05$ *vs* preoperative.

[d]$P < 0.05$ *vs* intraoperative.

CRP: C-reactive protein; TNF-α: Tumor necrosis factor-alpha; IL-18: Interleukin-18.

Table 3 Comparison of renal function between two groups (mean ± SD)

Group	*n*	KIM-1 (ng/L)	BUN (ng/L)	Cr (μmol/L)
Preoperative				
Control group	49	16.27 ± 5.11	5.20 ± 1.29	76.15 ± 11.09
Observation group	49	16.83 ± 4.07	5.29 ± 1.26	75.56 ± 12.59
t value	-	0.361	0.130	0.062
P value	-	0.549	0.720	0.804
Intraoperative				
Control group	49	28.22 ± 6.55[a]	6.98 ± 1.22[a]	95.52 ± 11.51[a]
Observation group	49	21.09 ± 5.55[a]	6.07 ± 1.13[a]	91.12 ± 13.30[a]
t value	-	33.745	14.779	3.976
P value	-	< 0.001	< 0.001	0.049
6 h after operation				
Control group	49	89.55 ± 8.55[a,d]	6.08 ± 1.23	86.05 ± 10.34[a,d]
Observation group	49	52.50 ± 6.76[a,d]	5.98 ± 1.13	81.25 ± 11.36[a,d]
F value	-	566.402	0.197	4.787
P value	-	< 0.001	0.658	0.031

[a]*P* < 0.05 *vs* preoperative.

[d]*P* < 0.05 *vs* intraoperative.

KIM-1: Serum kidney injury molecule-1; BUN: Urea nitrogen; Cr: Creatinine.

Table 4 Comparison of postoperative recovery between the two groups (mean ± SD)

Group	*n*	The first time to get out of bed (h)	II grade muscle strength recovery time (h)	III grade muscle strength recovery time (h)	hospitalization time (d)
Control group	49	26.84 ± 8.73	20.41 ± 7.72	36.41 ± 8.71	7.94 ± 3.72
Observation group	49	20.67 ± 8.78	12.82 ± 6.48	27.61 ± 7.85	5.92 ± 3.62
t value	-	3.485	5.274	5.253	2.725
P value	-	< 0.001	< 0.001	< 0.001	< 0.001

Table 5 Comparison of adverse reactions between the two groups, *n* (%)

Group	*n*	Hypotension	bradycardia	hypoxemia	general body movement	total incidence of adverse reactions
Control group	49	3 (6.12)	1 (2.04)	2 (4.08)	2 (4.08)	8 (16.33)
Observation group	49	1 (2.04)	1 (2.04)	0 (0.00)	0 (0.00)	2 (4.08)
χ^2 value	-	-	-	-	-	4.009
P value	-	-	-	-	-	0.045

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