Int J Clin Exp Med 2020;13(11):8447-8454
www.ijcem.com /ISSN:1940-5901/IJCEM0117857

Original Article

Effect of bispectral index values on hip arthroplasty in elderly patients under general anaesthesia combined with lumbar plexus nerve block

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Received July 8, 2020; Accepted August 30, 2020; Epub November 15, 2020; Published November 30, 2020

Abstract: Objective: This study aimed to analyze the influence of general anaesthesia (GA) combined with lumbar plexus block (LPB) on the treatment effect of hip arthroplasty (HA) in elderly patients under different bispectral index (BIS) values. Methods: A total of 81 elderly patients who underwent HA in our hospital were selected and randomly divided into the control group (CG, n=40) treated with GA combined with LPB under the BIS values of 40-49, and the observation group (OG, n=41) treated with GA combined with LPB under the BIS values of 50-59; so as to compare the hemodynamics, anaesthetic dose (AD) and cognitive function (CF). Results: (1) The heart rate of the CG was much lower than that of the OG during T4-T5 ($P<0.05$) and the mean arterial pressure of the CG was much lower than that of the OG during T3-T6 ($P<0.05$). (2) The dosage of propofol in the OG was lower than that in the CG ($P<0.05$) and there was no significant difference in dosage of sufentanil and times of using vasoactive agent between the two groups ($P>0.05$). (3) The postoperative breathing recovery time and postoperative tube drawing time of the OG were shorter than those of the CG ($P<0.05$). (4) The time to leave the recovery room (RR) of the OG was shorter than that of the CG after operation and the Aldrete scores of the OG were higher than those of the CG after half an hour in RR ($P<0.05$). (5) The CF scores of the OG were higher than those of the CG at 3 h after operation ($P<0.05$). (6) The incidence of postoperative cognitive dysfunction of the OG was lower than that of the CG ($P<0.05$). Conclusion: The anesthetic effect was better and the postoperative recovery was faster when BIS value was maintained between 50 and 59 during GA combined with LPB.

Keywords: Hip arthroplasty, bispectral index, general anaesthesia, lumbar plexus block

Introduction

Hip fracture is a type of multiple fracture that is typically found in the elderly. In recent years, with the incerase of population aging, the proportion of senile fracture is increasing gradually in all fractures, and the senile fracture is given more and more attention. Hip arthroplasty (HA) is the main clinical method in the treatment of geriatric hip fracture. With less bleeding during operation and less complications and faster recovery after operation, the hip joint function can be enhanced significantly through operation [1].

However, an operation causes severe stress to elderly patients because they are often complicated with a variety of chronic diseases, have poor liver and kidney functions, poor immunity, low tolerance to anaesthesia and hypofunction. In addition, anaesthesia has a relatively significant impact on patients' respiratory function and circulatory function, especially elderly patients who cannot tolerate the long-term general anaesthesia (GA) [2]. Therefore, reasonable operative and anaesthesia methods are very important for elderly patients treated by operations. As a derived EEG parameter, bispectral index (BIS) can be used to monitor the depth of anaesthesia [3]. The dose of GA can be controlled reasonably through BIS value so that the postoperative recovery will not be affected on the basis of enduring anesthetic effect. A study has found that the incidence of surgery-related complications in patients with surgery under the guidance of BIS is lower than that in patients undergoing surgery directly [4]. Another study has shown that the incidence of POCD is lower in patients undergoing surgery under the guidance of BIS [5].

In this study, 81 elderly patients treated with HA were selected as the subjects of study to compare the influence of GA combined with lumbar plexus block (LPB) on operative effect under two kinds of BIS values, with the aim to seek for safer and more effective anaesthesia methods for HA in elderly patients.

Materials and methods

General data

A total of 81 elderly patients who were admitted to our hospital and treated with HA from July 2018 to June 2019 were selected as the subjects of study and divided into two groups by a random number table method, including control group (OG, n=40) and observation group (OG, n=41). This study was conducted with the permission of The First Affiliated Hospital of Zhengzhou University Ethics Committee. (1) Inclusion criteria [6]: This study included patients aged 60 years old or above; those treated with selective HA; those with normal consciousness; those without anaesthesia contraindications; and those who were informed of the study contents and signed an Informed Consent Form. (2) Exclusion criteria: This study excluded patients complicated with severe cardiovascular and cerebrovascular diseases; those complicated with pulmonary infection; those complicated with mental disorders; those with a history of allergy to anesthetics; those with coagulation disorders; and those with low compatibility to anaesthesia.

Methods

The two groups were injected intramuscularly with 0.5 mg atropine half an hour before operation. After entering the operating room, the peripheral venous access was opened to monitor the oxyhemoglobin saturation, ECG and blood pressure. The electrode lead connected with the BIS instrument was respectively placed on the forehead, above the superciliary arch and on the temple. Before GA, all the patients were catheterized through the radial artery on the unaffected side to monitor the invasive arterial blood pressure, with the central vein opened.

LPB was performed on the affected side in both groups before the induction of GA. Patients were kept in lateral position and the upper side was the block side. The low back was exposed completely to facilitate operation and the sedation was achieved through 1 mg midazolam before puncture. Ultrasound was used to determine the L3 spinous process and L3 transverse process for accurate record of depth, which was followed by the determination of lumbar plexus through ultrasound. The local infiltration anesthesia was performed through 1% lidocaine after disinfecting the lumbar plexus with iodophor. With the technology of out-of-plane needle insertion, the needle tip was inserted into the part of lumbar plexus. The positive pole of the nerve stimulator was connected to the lower limb on the affected side through the ECG lead wire. The negative pole was connected to the lead wire at the end of puncture needle. After switching on, the electric current was controlled at 0.7 mA and then reduced gradually when the muscle group of quadriceps femoris beat regularly and violently. After the pump-back without blood and other fluids, 30 ml 0.4% ropivacaine was injected. Patients were kept in horizontal position upon the completion of block so as to monitor the sensory extinction of thigh and thus determine the effect of block. Then, the next step was induction of GA.

The induction of GA was performed through 0.2-0.3 mg/kg etomidate, 10 mg dexamethasone, 0.04-0.06 mg/kg midazolam, 5 mg dezocine and 0.2-0.25 mg/kg cisatracurium. Then, 0.2-0.3 ug/kg sufentanil was given 5 min before opening the skin. Masked oxygen inhalation and denitrogenation were performed for 3 min. The endotracheal tube connected with the anaesthesia machine was inserted when the BIS value reduced to about 50. Then, the endotracheal tube was fixed properly with tapes, with the tidal volume controlled at 8-10 ml/kg, the respiratory rate controlled at 10-12 breaths/min, the respiratory quotient controlled at 1:2 and the partial pressure of carbon dioxide in end expiratory gas controlled at 35-45 mmHg during operation.

Maintenance of intraoperative anaesthesia: 4.0-8.0 mg/(kg·h) propofol was pumped during operation and the concentration of sevoflurane

Table 1. Comparison of general data between the OG and CG (mean ± SD)/[n (%)]

General data		OG (n=41)	CG (n=40)	t/X^2	P
Gender	Male	23 (56.10)	21 (52.50)	0.106	0.745
	Female	18 (43.90)	19 (47.50)		
Age (years)		74.25±9.55	72.16±8.94	1.016	0.313
BMI (kg/m^2)		23.34±3.19	23.58±3.26	0.335	0.739
ASA grade	II	25 (60.98)	23 (57.50)	0.101	0.750
	III	16 (39.02)	17 (42.50)		
Operative duration (min)		105.24±12.16	108.75±15.75	1.124	0.264
Urine volume (ml)		305.24±115.42	316.93±124.87	0.438	0.663

was 1.2%. Patients were discontinuously injected with 0.05-0.10 mg/kg cisatracurium and 0.1 ug/kg sufentanil during operation and the dosage of propofol was adjusted according to the changes of BIS values. The BIS value was 50-59 in the OG and 40-49 in the CG. The depth of anaesthesia was regulated accordingly if BIS value exceeded the setting range.

Observation targets

(1) Hemodynamics: heart rate (HR) and mean arterial pressure (MAP) were compared between the two groups at 6 time points, including time of entering the operating room (T1), time of operation (T2), time of prosthesis implantation (T3), time of operative completion (T4), time of moving to the observation ward (OW) (T5) and half an hour after moving to the OW (T6). (2) Situation of medication: The two groups were compared in dosage of sufentanil, dosage of propofol and times of using vasoactive agent (VA). (3) Anesthetic recovery: The two groups were compared in postoperative breathing recovery time (PBRT) and postoperative tube drawing time (PTDT). (4) Postoperative situation: The Aldrete scoring [7] was conducted half an hour after moving to the OW, with the scoring items including activity, respiration, blood pressure, consciousness and oxyhemoglobin saturation. The scores of each item were determined as 2, 1 and 0 from the best to the worst, with a total score of 0-10 points. The time of leaving the OW was recorded in both groups. (5) Cognitive function (CF): The Mini-mental State Examination (MMSE) [8] was used to evaluate the CF of patients respectively before operation and at 3 h after operation, with the contents including time orientation, place orientation, immediate memory, attention and calculation, delayed memory, language and visual space. There were 30 questions in MMSE, with total scores of 0-30 points. Patients scored 1 point for correct answer and 0 points for wrong answer or no answer. The patients with a score of 26 or less had cognitive dysfunction (CD). The lower scores indicate severer CD.

Statistical analysis

SPSS 22.0 was used for statistical analysis. The measurement data were represented by mean ± standard deviation (mean ± SD) and the results between groups were compared through independent-samples *t* test. The enumeration data were represented by [n (%)] and the results between groups were compared through chi-squared test. The multi-point comparison in groups was performed through ANVOA and F test. $P<0.05$ indicated that the difference had statistical significance.

Results

Comparison of general data between the two groups

Patients were all in Grade II-III according to the grading system of American Society of Anesthesiologists (ASA). The CG included 40 patients aged 60-76 years, with an average age of (72.16±8.94) years. Their body mass index (BMI) was 17-28 kg/m^2, with an average value of (23.58±3.26) kg/m^2. The OG included 41 patients aged 61-78 years, with an average age of (74.25±9.55) years. Their BMI was 17-28 kg/m^2, with an average value of (23.34±3.19) kg/m^2. There was no significant difference in general data including gender ratio, average age, average BMI, proportion of each ASA grade, operative duration and urine volume between the OG and CG ($P>0.05$) (**Table 1**).

Comparison of hemodynamics between the two groups

In the OG, the HR and MAP at T2 were lower than those at T1 ($P<0.05$) and there was no significant change in HR and MAP during T3-T6

Table 2. Comparison of hemodynamics between the OG and CG at different time points (mean ± SD)

Group	Index	T1	T2	T3	T4	T5	T6
OG (n=41)	HR (beats/min)	80.23±8.38	76.72±6.05	79.75±6.38	79.58±6.92	79.61±4.58	77.53±5.15
	MAP (mmHg)	94.46±8.23	88.05±6.38	93.45±6.28	93.05±6.38	92.86±7.05	93.06±6.38
CG (n=40)	HR (beats/min)	82.56±8.94	78.05±4.46	77.51±3.38	76.28±4.49	76.02±4.37	76.61±4.58
	MAP (mmHg)	96.15±9.78	86.13±7.78	87.05±5.38	83.76±5.15	83.45±4.29	83.35±5.19
t1		1.211	1.124	1.967	2.539	3.608	0.849
P1		0.230	0.265	0.053	0.013	0.001	0.182
t2		0.842	1.216	4.920	7.200	7.235	7.503
P2		0.402	0.228	0.000	0.000	0.000	0.000

Notes: *t1* and *P1* refer to the comparison of HR between two groups and *t2* and *P2* refer to the comparison of MAP between two groups.

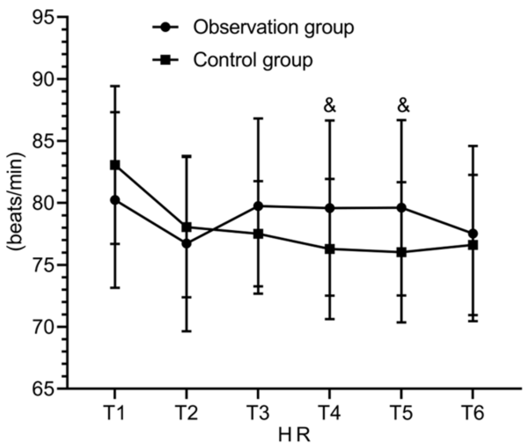

Figure 1. Comparison of HR between the OG and CG. There was little difference in HR between the OG and CG at T1, T2, T3 and T6 ($P>0.05$) and the HR of the OG was much higher than that of the CG at T4 and T5 ($P<0.05$). & means $P<0.05$ when the OG and CG were compared at the same time point.

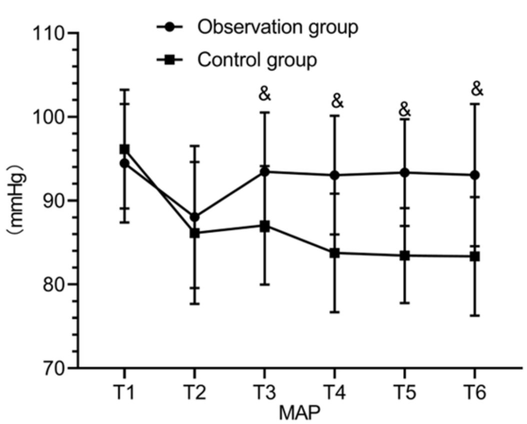

Figure 2. Comparison MAP between the OG and CG. There was little difference in MAP between the OG and CG at T1 and T2 ($P>0.05$), and the MAP of the OG was much higher than that of CG at T3, T4, T5 and T6 ($P<0.05$). & means $P<0.05$ when the OG and CG were compared at the same time point.

($P>0.05$). In the CG, the HR and MAP during T2-T6 were lower than those at T1 ($P<0.05$). The HR of the CG was much lower than that of the OG during T4-T5 ($P<0.05$) and was similar to that of the OG at other time points ($P>0.05$). The MAP of the CG was much lower than that of the OG during T3-T6 ($P<0.05$) and was similar to that of the OG at other time points ($P>0.05$) (**Table 2** and **Figures 1**, **2**).

Comparison of medication between the two groups

The dosage of propofol in the OG was lower than that in the CG ($P<0.05$), and there was no significant difference in dosage of sufentanil and times of using VA between the OG and CG ($P>0.05$) (**Table 3**).

Comparison of anesthetic recovery between the two groups

The PBRT and PTDT were respectively (8.75±1.16) min and (18.42±3.64) min in the OG and (10.62±1.52) min and (22.48±4.18) min in the CG. PBRT and PTDT of the OG were shorter than those of the CG ($P<0.05$) (**Figure 3**).

Comparison of postoperative situation between the two groups

The time of leaving RR of the OG was shorter than that of the CG after operation and the Aldrete scores of the OG were higher than those of the CG after half an hour in RR ($P<0.05$) (**Table 4**).

Comparison of CF between the two groups

The MMSE scores for CF were (23.35±2.16) in the OG and (23.75±2.42) in the CG before oper-

Table 3. Comparison of medication between the OG and CG (mean ± SD)

Group	Number of cases	Propofol (mg/h)	Sufentanil (ug/h)	VA (times)
OG	41	360.12±25.28	10.75±0.68	2.50±0.50
CG	40	412.35±31.62	11.05±0.70	2.68±0.57
t		8.221	1.957	1.512
P		0.000	0.054	0.135

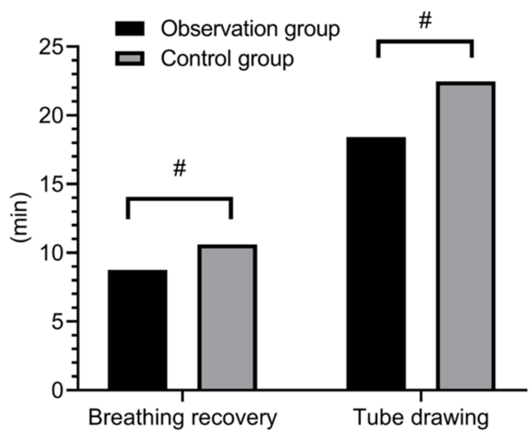

Figure 3. Comparison of anesthetic recovery between the OG and CG. The PBRT and PTDT of OG were much shorter than those of CG ($P<0.05$). # means $P<0.05$ when the OG and CG were compared in respect of the same index.

Table 4. Comparison of postoperative situation between the OG and CG (mean ± SD)

Group	Number of cases	Time of leaving RR (min)	Aldrete scores (scores)
OG	41	45.25±10.13	7.89±1.32
CG	40	56.92±12.17	6.12±1.13
t		4.695	6.476
P		0.000	0.000

ation. At 3 h after operation, the MMSE scores for CF were (27.86±1.13) in the OG and (25.37±1.21) in the CG. There was little difference in MMSE scores between the OG and CG before operation, while at 3 h after operation, the MMSE scores of the OG were much higher than those of the CG ($P<0.05$). There was 1 patient who suffered from postoperative cognitive dysfunction (POCD) in the OG, with the POCD incidence of 3.33%, and 6 patients who suffered from POCD in the CG, with the POCD incidence of 20.00% ($P<0.05$) (**Figures 4** and **5**, **Table 5**).

Discussion

In addition to low BMI, low body fluid volume, poor basic metabolism and slow drug metabolism, elderly patients also have renal and liver dysfunction to varying degrees and declined sterilization of liver [9]. Furthermore, due to the high incidence of atherosclerosis in cardio-cerebral-vascular system, elderly patients have violent hemodynamic fluctuations during operation, which may lead to arrhythmia and even sudden cardiac arrest in severe cases, threatening their life and safety [10]. In clinical practice, doctors often find it difficult to accurately control the dosage of GA used for elderly patients treated with operation, and the safety of operation cannot be guaranteed absolutely [11]. It can be seen that it is very crucial to monitor the depth of anaesthesia in elderly patients undergoing operation so that the anesthetic dosage can be determined and the amplitude of hemodynamic fluctuation can be controlled by monitoring the depth of anaesthesia.

Elderly patients treated with HA have varying degrees of cardiovascular functional disorders, and are often accompanied by acute pain caused by operative trauma, so they can hardly tolerate the implementation of GA [12]. Neuman et al. [13] found that compared with intraspinal anesthesia, GA increased the D-dimmer level of fracture patients more significantly and thus enhanced the risk of deep venous thrombosis. Based on the body conditions and physiological characteristics of elderly patients, LPB is selected as the operative method for elderly patients in many studies and LPB has been proved to be safer [14, 15]. Li et al. [16] indicated that LPB combined with mild sedation could enhance the stability of hemodynamics and this anaesthesia method could achieve a satisfactory safety and effectiveness in elderly patients undergoing hip fracture operation. Mei et al. [17] proposed that GA combined with LPB could significantly reduce the degree of pain in patients compared with the direct GA.

The safety of intraoperative anaesthesia is not only related to the proper choice of anesthetic, but also closely related to the control of the depth of anaesthesia. At present, there is still

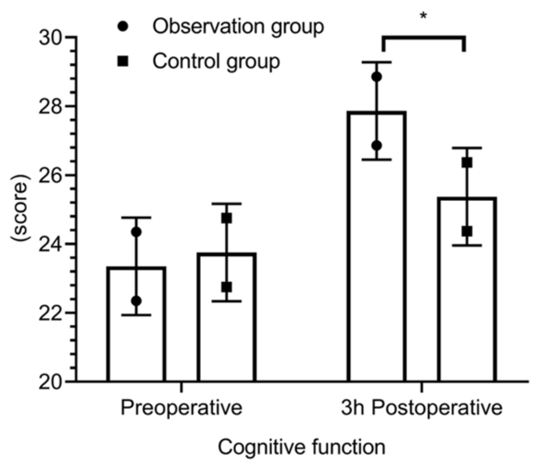

Figure 4. Comparison of CF scores between the OG and CG. There was little difference in CF scores between the OG and CG before operation ($P>0.05$). At 3 h after operation, the CF scores of the OG were much higher than those of CG ($P<0.05$). * means $P<0.05$ when the OG and CG were compared at the same time point.

no unified conclusion on the depth of anaesthesia that is most suitable for elderly patients in clinical intervention. An increasing number of studies have verified the feasibility and value of BIS when it is used to monitor the depth of anaesthesia during operation [18, 19]. As Louvet et al. [6] achieved an intraoperative wake-up of children through BIS monitoring and found that the BIS value could be used to judge the occurrence of intraoperative body movement. However, the pathogenesis of CD after GA has not been expounded comprehensively and there is still no unified conclusion about the range of BIS value that affects the occurrence of CD [20, 21]. In this study, the same anaesthesia method was used for the OG and CG, but the BIS value is different, and the results showed that the hemodynamic fluctuation of the OG was much smaller than that of the CG in perioperative period and the dosage of general anesthetic, propofol, in the OG was much lower than that in the CG ($P<0.05$). A similar study also showed that the usage amount of anesthetics for surgery guided by BIS was significantly lower than that of patients without BIS guidance [22]. This implied that the hemodynamic fluctuation could be reduced significantly in the perioperative period of HA when the BIS value was 50-59, which was conducive to reducing the dosage of general anesthetics, mitigating the impact of anesthetics on patients and guaranteeing rapid recovery after operation. The PBRT and PTDT of the OG were shorter than those of the CG and the time of leaving RR of the OG was shorter than that of the CG after operation. The Aldrete scores of the OG were higher than those of the CG after half an hour in the RR. Besides, the CD incidence of the OG was 3.33% at 3 h after operation, which was much lower than 20.00% in the CG ($P<0.05$). A study obtained similar results where the incidence of POCD in the BIS guided group was only 5.00%, significantly lower than 17.50% in the control group undergoing surgery directly [23]. This implied that the postoperative recovery was accelerated, the recovery time was shortened, and the recovery quality was improved without seriously affecting the CF of patients when BIS value was 50-59 during GA combined with LPB. This study showed that different BIS values did not affect the dosage of sufentanil and the times of using VA. Oh et al. [24] indicated that the dosage of opioid drugs could not inhibit the stress response of human body to operation, but with a synergistic effect, it could reduce the range ability of BIS caused by stimulation.

In conclusion, compared with the BIS value of 40-49 during GA combined with LPB, the value of 50-59 could not only control the hemodynamic fluctuation in a better way, but also reduce the AD and achieve a better effect of postoperative recovery, so the BIS value of 50-59 is worthy of application and promotion. However, this study is a retrospective study with relatively few subjects, and the analysis of the results is not comprehensive enough, with certain bias in the results. Intensive studies with larger samples in more aspects should be conducted in the future and the prospective studies should be emphasized to obtain more scientific and representative conclusions, so as to provide more references for anaesthesia methods used for elderly patients with hip fracture.

Acknowledgements

The authors received no financial support for the research, authorship, and/or publication of this article.

Disclosure of conflict of interest

None.

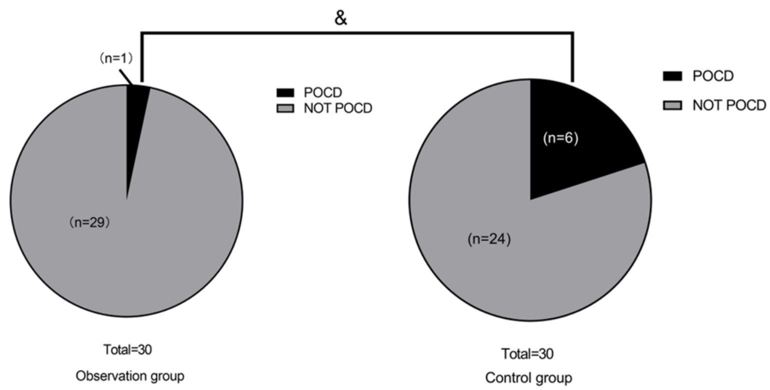

Figure 5. Comparison of POCD incidences between the OG and CG. Compared with the CG, there were less patients suffering from POCD in the OG ($P<0.05$) and more patients not suffering from POCD in the OG ($P<0.05$). & means $P<0.05$ when the OG and CG were compared in respect of CD incidence.

Table 5. Comparison of POCD incidences between the OG and CG [n (%)]

Group	Number of cases	POCD	Not POCD
OG	41	1 (3.33)	40 (96.67)
CG	40	6 (20.00)	34 (80.00)
X^2		4.046	
P		0.044	

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