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Original Article

Effects of different anesthesia methods on heart rate variability in senile cataract surgery patients with cardiovascular diseases

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Abstract: Objective: To explore effects of local anesthesia and retrobulbar anesthesia on heart rate variability (HRV) in elderly patients with cataract phacoemulsification complicated with cardiovascular disease. Methods: Patients were divided into topical anesthesia group (group T) and retrobulbar anesthesia group (group R) according to different anesthesia methods. Based on the risk level of cardiovascular diseases, group T and group R were divided into three subgroups. HRV frequency domain was detected by 24 h dynamic electrocardiogram (DCG). The changes of low frequency (LF), high frequency (HF) and low frequency/high frequency (LF/HF) between group T and group R under the same risk and at three different time points were compared. Results: Under the same risk, HRV indexes in group R were significantly lower than those in group T ($P<0.05$). LF and LF/HF in group T during operation were significantly lower than those 2 h before operation ($P<0.05$), while HF increased after operation. Each HRV index in group R 2 h during and after operation was significantly lower than those 2 h before operation ($P<0.05$). Conclusion: The risk level of cardiovascular disease was positively correlated with LF, HF and LF/HF values. The risk of cataract surgery for patients with cardiovascular diseases should be evaluated before operation and various indexes should be actively controlled.

Keywords: Anesthesia methods, senile cataract, cardiovascular disease, dynamic electrocardiogram, heart rate variability

Introduction

Cataract is one of the main causes of blindness. Cataract patients account for 46.7% of the world's blind population every year. Cataract is closely related to age. As the age increases, the transparency of the lens gradually decreases. When the age is over 85, almost 98% of the people suffer from cataract [1]. Therefore, patients undergoing cataract surgery are old, with an average age of about 70-75 years, and are often accompanied by certain cardiovascular diseases, such as hypertension, diabetes, heart disease, etc. When cataract surgery is performed on senile cataract patients with cardiovascular diseases, cardiovascular diseases may affect the success of the surgery and even become taboo for the patients. The main aim of this study was to determine whether different anesthesia methods of cataract surgery have influence on senile cataract surgery patients with cardiovascular diseases [2]. Cataract surgery is mainly under local anesthesia, and the purpose of which is to fix the eyeball and reduce intraoperative pain. At present, the most commonly used anesthesia methods are retrobulbar anesthesia and topical anesthesia [3]. Retrobulbar anesthesia is essentially a block anesthesia of posterior ciliary ganglion, which has become the most commonly used anesthesia method in ophthalmology. However, the complications of retrobulbar anesthesia often occur, such as retrobulbar hemorrhage, eyelid congestion, swelling, amaurosis fugax, eyeball injury and so on. The operation of topical anesthesia is simple and safe, with few complications, but the braking performance of the affected eye during operation is poor, requiring active cooperation of patients to successfully complete the operation. In this study, HRV was used as an index to analyze the two anesthesia methods. HRV can reflect the regulation of autonomic nerve on the heart. For cataract patients, various factors such as surgical

stress, anesthesia, oculocardiac reflex can lead to the imbalance of sympathetic and parasympathetic nerves, which can be reflected by changes in HRV. There is a certain relationship between AVS and cardiovascular diseases. HRV can judge the change of cardiovascular system by analyzing the change of the function of AVS [4]. In this paper, 24 h DCG was used to monitor HRV frequency domain and analyze which method between retrobulbar anesthesia and topical anesthesia is more beneficial for senile cataract patients with cardiovascular diseases.

Materials and methods

Research object

In this study, 120 cataract patients (120 eyes in all) who underwent cataract phacoemulsification and intraocular lens implantation in Jinan Jigang hospital from September 2019 to November 2019 were collected by prospective study. Inclusion criteria for patients were: (1) Patients with age-related cataract, mixed cataract, complicated cataract or metabolic cataract after diagnosis; (2) Patients with one or more cardiovascular diseases such as diabetes, hypertension and coronary heart disease clearly diagnosed by internal medicine; (3) Various indexes related to cardiovascular diseases were well controlled before operation and could tolerate operation. Exclusion criteria: (1) Unstable angina pectoris or acute myocardial infarction and other acute critical patients; (2) Thyroid disease or rheumatic heart disease and other systemic diseases that affect cardiovascular function; (3) Parkinson's disease (head shaking), cognitive impairment, dementia, allergy to anesthetics or patients who had recently taken painkillers; (4) Patients with contraindications to eye surgery, such as cataract patients complicated with fundus hemorrhage, retinal detachment, vitreous hemorrhage, neovascular glaucoma or diabetic retinopathy; (5) Patients with contraindications to drug use. The research plan was approved by the Ethics Committee of Jinan Jigang hospital, and the informed consent was signed after the patients were fully informed.

Preoperative evaluation and treatment

All cases were examined by detailed medical history, physical examination, electrocardiogram (ECG), echocardiogram, chest radiograph and cardiac function examination, and the diagnosis made by cardiovascular physician was consistent with the diagnosis of cardiovascular diseases. Patients with arrhythmia, hypertension, coronary heart disease, diabetes and other cardiovascular underlying diseases should consult a doctor in time. These patients should be given active symptomatic treatment before the operation to keep their heart rate, blood pressure and blood sugar within the normal range. Based on the risk level of cardiovascular diseases, group T patients were divided into Ta (low risk) group, Tb (medium risk) group and Tc (high risk) group while group R patients were divided into Ra (low risk) group, Rb (medium risk) group and Rc (high risk) group.

Evaluation reference of cardiovascular disease risk level is a Brazilian guideline on prevention of cardiovascular disease in patients with diabetes from the Brazilian Diabetes Society (SBD), the Brazilian Cardiology Society (SBC) and the Brazilian Endocrinology and Metabolism Society (SBEM) [5]. The cardiac function of all cases was controlled at level II before operation, and there were no frequent atrial premature beats or ventricular premature beats, chronic atrial fibrillation, high to third degree atrioventricular block or severe sick sinus syndrome. Electrocardiogram monitoring was carried out during operation to closely observe the occurrence of cardiovascular events.

Anesthesia methods

Retrobulbar anesthesia: Using the No.5 retrobulbar injection needle to pierce vertically backward from the skin surface parallel to the equator at the intersection of the outer 1/3 and the middle 1/3 of the orbital lower margin, then the needle was slightly turned to the inner upper part. After reaching the ball in the muscle cone, the needle tip was positioned between the ciliary ganglion and the ocular wall, and 2.5 mL of anesthetic (2% lidocaine: 0.75% bupivacaine =1:1) was injected after no blood was drawn back.

Topical anesthesia: After 2 drops (80 μL) of 0.4% oxybuprocaine hydrochloride eye drops were dropped into the conjunctival sac, blood pressure, heart rate and oxygen saturation were monitored. 6 minutes later, two drops (80 μL) of anesthetics were put into the eyes again.

All patients started surgery about 6 minutes after anesthesia.

Operation method: Before operation, the cloth was sterilized and the eyelids were opened with eyelid opener. A 3 mm lamellar incision was made behind the right upper limbus, and a 4-point corneal limbus puncture was used as an auxiliary incision. The upper incision was punctured into the anterior chamber, viscoelastic agent was injected, continuous curvilinear capsulorhexis was performed, coupled with sufficient water separation and water stratification, and ultrasonic etching or splitting method was used. The residual cortex was aspirated, and the capsular bag was injected with viscoelastic agent after polishing. The intraocular lens was implanted in the bag, and viscoelastic agent was replaced, then the incision was closed with water injection. After the operation, tobradex was smeared on the eyes and monocular dressing was applied.

HRV analysis method: Heart rate variability (HRV) is a measure of autonomic nervous system balance/imbalance. HRV measurement and analysis can be divided into time domain analysis and frequency domain analysis. In this paper, the methods and indexes recommended by HRV special committee jointly composed by European Cardiovascular Society and North American Pacing Electrophysiological Society were adopted, and the unified method stipulated by HRV countermeasure group of Chinese Journal of Cardiology was referred [6]. All cases were examined with the U.S. Century 3000 24 h DCG Detector from 5:00 p.m. one day before operation to 5:00 p.m. the next day after operation (6~8 hours after operation). Patients whose 24 h DCG examination recording time less than 22 h and those whose qualified rate of normal heart beat less than 85% were excluded. HRV analysis was automatically carried out on all detection data by computer, and 24 h sinus rhythm was detected to conduct HRV frequency domain index analysis. Frequency domain index mainly reflects the LF (0.04~0.15 Hz) of the interaction result of sympathetic nerve and vagus nerve. HF (0.15~0.45 Hz) mainly reflects the changes of vagal nerve tension. LF/HF reflects the activity balance of cardiac sympathetic nerve and vagal nerve. Electrocardiogram monitoring was carried out in all surgical cases during operation, and the perioperative cardiovascular disease emergencies were closely observed.

Index observation: 120 cases (120 eyes) of senile cardiovascular cataract elective surgery were divided into topical anesthesia group (group T) and retrobulbar anesthesia group (group R) according to different surgical anesthesia methods, with 60 cases in each group. The patients in group T and group R were assessed and divided into three subgroups: low-risk group (Ta and Ra), medium-risk group (Tb and Rb) and high-risk group (Tc and Rc). HRV frequency domain was detected by 24 h DCG, and the changes of HRV frequency domain indexes in the same risk group, between group T and group R, as well as three different time periods of 2 h before operation, 2 h during operation and 2 h after operation were analyzed and compared.

Statistic analysis: SPSS 19.0 software was used to complete the data processing. The measurement data were expressed by $\bar{x}\pm sd$. The comparison between groups was conducted by T test of independent samples, while the comparison within groups was conducted by variance analysis of single-factor repeated measurement data, and the comparison between two time points was conducted by SNK-q test. $P<0.05$ indicates that the difference is statistically significant.

Results

General data

This study included 120 cataract surgery patients with cardiovascular diseases, with an average age of 71.4±8.6 (65~81) years. Statistical tests were carried out on the general data of the two groups of patients. The results showed that there was no significant difference in age, gender, height, weight and body mass index (BMI) between the two groups ($P>0.05$), and the study was comparable. The general data of the two groups of patients are shown in **Table 1**, and the distribution of different risk levels of the two groups of patients are shown in **Table 2**.

Comparison of 24 h HRV mean between group T and group R

The 24 h HRV of patients in group T and group R were compared. The indexes of LF, HF and LF/HF in group R were significantly lower than those in group T ($P<0.05$), as shown in **Table 3**.

Table 1. General data of senile cataract surgery patients with cardiovascular diseases (n=120)

Group	Group T (n=60) Mean ± SD	Group R (n=60) Mean ± SD	P
Age	71.2±10.2	71.5±10.4	0.845
Gender (F/M)	40/20	33/27	
Height	160.3±8.1	162.1±7.7	0.221
Weight	58.3±10.4	62.2±11.2	0.266
BMI	21.9±2.5	23.2±3.1	0.496

Table 2. Distribution of different risk levels of the two groups of patients (P=0.05)

Level	Group T	Group R
a	30	28
b	18	22
c	12	10

Table 3. Comparison of HRV between Group T and Group R (n=60, $\bar{x}\pm s$)

Group	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF
T	853.85±322.25	213.09±40.47	4.37±1.64
R	677.44±292.54	183.43±57.28	3.45±1.17
t/P	-2.265/0.028	-2.306/0.024	-2.567/0.013

Table 4. Comparison of HRV in group T before, during and after operation (n=60, $\bar{x}\pm sd$)

Time	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF
2 h before operation	862.54±196.08	199.54±77.81	4.55±1.72
During operation	808.64±191.81	168.70±43.31	3.49±1.16
2 h after operation	830.04±223.59	176.21±54.10	3.70±1.18
F/P	1.86/0.172	2.25/0.119	4.14/0.028

Comparison of HRV at different times in group T

The HRV at different times in group T were compared, and the results showed that except for HF, the indexes of LF and LF/HF in group T decreased significantly 2 h before operation (P<0.05), but there was no significant difference between 2 h after operation and 2 h before operation (P>0.05), as shown in **Table 4**.

Comparison of HRV at different times in group R

The HRV at different times in group R were compared, and the results showed that the indexes of LF, HF and LF/HF in group R 2 h during operation and 2 h after operation were significantly lower than those 2 h before operation (P<0.05 or P<0.01), as shown in **Table 5**.

Comparison of 24 h HRV mean at different cardiovascular risk levels

The 24 h HRV mean of senile cataract patients with cardiovascular diseases at different cardiovascular risk levels were compared, and the results showed that the indexes of LF, HF and LF/HF in group R were significantly lower than those in group T (P< 0.05), as shown in **Table 6**.

Discussion

Heart rate variability (HRV), refers to the change of successive heartbeat cycle differences, and contains information about the regulation of neurohumoral factors on cardiovascular system, thus judging the disease condition and prevention of cardiovascular and other diseases. It may be a valuable index for predicting sudden cardiac death and arrhythmia events [7-10], and is widely used to evaluate autonomic nervous function. The decrease of HRV indicates the decrease of vagus nerve's control over the heart and the enhancement of sympathetic nerve's control over the heart, which leads to the instability of myocardial electricity and the premise of arrhythmia. Therefore, HRV evaluation of ANS changes in patients with cardiovascular diseases during cataract surgery is conducive to understanding the operation situation and the influence of anesthesia methods on cardiac ANS, so as to select a more reasonable and safe anesthesia method, which has important clinical significance for discovering or suggesting damages of autonomic nerve function in subclinical stage and improving prognosis.

Anesthesia, surgical trauma and postoperative pain have significant effects on the autonomic nervous function of patients [11]. Anesthesia can affect cardiovascular function by changing

Table 5. Comparison of HRV in group R before, during and after operation (n=60, $\bar{x} \pm s$)

Time	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF
2 h before operation	858.73±267.44	215.22±115.96	3.59±1.23
During operation	738.31±248.72	187.87±84.30	2.97±1.26
2 h after operation	791.12±266.56	234.06±100.14	3.19±1.73
F/P	7.59/0.005	2.56/0.085	2.13/0.14

Table 6. Effects of different levels of cardiovascular disease patients in group T and group R

Level	Group T			Group R		
	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF	LF (ms^2/Hz)	HF (ms^2/Hz)	LF/HF
a	883.2±310.17	230.54±36.48	4.20±1.52	678.74±292.54	216.26±69.78	3.36±1.23
b	830.65±214.27	218.01±35.46	3.38±1.68	658.44±292.54	182.46±64.93	2.95±1.63
c	752.41±242.16	193.08±41.33	2.51±1.44	618.44±292.54	155.26±43.28	2.06±1.13
F/P	2.36/0.230	2.50/0.053	4.06/0.16	8.42/0.005	3.39/0.077	2.06/0.25

autonomic nerve tension and balance. HRV can better reflect the changes of balance of sympathetic nerve and parasympathetic nerve caused by different anesthesia methods, providing basis for reasonable selection of anesthesia methods and anesthetics in clinical operations [12, 13]. Frequency domain index LF is the joint action of sympathetic nerve and vagus nerve, while HF is only controlled by vagus nerve. LF/HF reflects the balance between sympathetic nerve and vagus nerve, which is normally balanced. Once the balance is broken, arrhythmia, acute heart failure and even death will occur [14-16]. HRV can better reflect the changes of ANS in anesthesia monitoring. In this study, HRV frequency domain indexes (LF, HF and LF/HF) in retrobulbar anesthesia group were significantly lower than those in topical anesthesia group ($P<0.05$ or $P<0.01$), which shows that after the same operation, the topical anesthesia group is more prone to cardiovascular damage caused by autonomic nervous system dysfunction than the retrobulbar anesthesia group. The causes of HRV reduction under retrobulbar anesthesia in ophthalmic cataract surgery may be related to many factors that are prone to OCR, such as retrobulbar injection, eyeball compression, and extraocular muscle traction [17-20].

Although ophthalmic anesthesia is less traumatic to the whole body, the emotional tension, fear, pain stimulation and oculocardiac reflex can lead to the risk of cardiovascular disease during operation. ANS plays an essential role in the occurrence, development of cardiovascular disease and blood pressure regulation. In this study, for senile cataract surgery patients with cardiovascular diseases, whether topical anesthesia or retrobulbar anesthesia, the time points of greatest impact on cardiac ANS function are 2 h during and after operation, which are important time points for inducing adverse cardiovascular events. Correspondingly, HRV frequency domain indexes of senile cataract patients with different cardiovascular risks are also different. With the increase of cardiovascular risk level, HRV frequency domain indexes decrease greater. It can be seen that it is particularly necessary to consider the cardiovascular risk level of patients before cataract surgery, which is consistent with Ioanna Mylona's research [21]. The reasons for the impairment of cardiac ANS regulation function in senile cataract patients with cardiovascular diseases caused by surgical anesthesia were analyzed. The main points are as follows: (1) The neurohormone system is in an active state during operation, plasma catecholamine is released in large quantities, renin-angiotensin is activated, sympathetic nerve tension is increased, cardiac receptor function is reduced, and cardiac ANS loses its support and regulation function on cardiac function; (2) Cardiovascular disease itself and cardiovascular system aging, etc.; (3) Disorder of water electrolyte, imbalance of internal environment, instability of myocardial potential and oculocardiac reflex after operation; (4) The sensitivity of cardiac ANS function to anesthetic methods is different, and the high incidence of arrhythmia during and after operation may damage the

cardiac ANS regulatory function. Based on the above research, surgery should be avoided for patients with severe cardiovascular diseases.

To sum up, retrobulbar anesthesia is more suitable for senile cataract surgery patients with hypertension. The time points that have the greatest impact on cardiac ANS function are 2 h during and after operation, which may not be related to anesthesia method. The risk of cataract surgery for patients with cardiovascular diseases should be evaluated before operation, and various indexes of cardiovascular diseases should be actively controlled to be stable. For patients with serious cardiovascular diseases, surgical treatment can be abandoned if the surgical risk is greater than the benefit.

Disclosure of conflict of interest

None.

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