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Original Article

Effects of preoperative magnesium sulphate infusion on the hemodynamics in patients with off-pump coronary artery bypass grafting surgery

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Abstract: Background: Off-pump coronary artery bypass grafting (OPCABG) is an effective method for coronary artery revascularization, but it may lead to unstable hemodynamics. Purpose: To evaluate the effects of preoperative magnesium sulphate infusion on the hemodynamics in patients with OPCABG surgery. Methods: Sixty patients undergoing routine OPCABG surgery were randomly divided into control group (C) and magnesium sulfate group (M), 30 patients in each group. All patients were performed with routine operation preparation and induced anesthesia, followed by OPCABG surgery. Before surgery, M group was intravenously infused with magnesium sulfate (10 mg/kg), and C group was intravenously infused with 0.9% normal saline with the same volume. The preoperative and intraoperative hemodynamics indexes and intraoperative vasoactive drug use in two groups were recorded and compared. Results: There was no significant differences in gender, age, weight, preoperative hear rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse pressure or mean arterial pressure between two groups ($P > 0.05$), with no significant differences in surgery time, intraoperative blood loss or central venous pressure ($P > 0.05$). The intraoperative max SBP, max DBP, SBP fluctuation and DBP fluctuation in M group were significantly lower than C group, respectively ($P < 0.05$). The intraoperative min HR in M group was significantly higher than C group ($P < 0.05$), and the HR fluctuation in M group was significantly lower than C group ($P < 0.05$). The percentage of patients intraoperatively using vasoactive drugs in M group was significantly lower than C group ($P < 0.05$). Conclusion: Preoperative magnesium sulphate infusion can effectively reduce the hemodynamic fluctuation in patients with OPCABG.

Keywords: Magnesium sulfate, OPCABG, surgery, blood pressure, hear rate

Introduction

Coronary artery bypass grafting (CABG) is one of the most effective treatment methods for the coronary atherosclerosis, which has definite efficacy and has been worldwide applied [1]. The extracorporeal circulation and cardiac arrest are the basis of conventional CABG, which provides a bloodless field and coronary vascular area for the surgery [2]. However, the extracorporeal circulation has always been recognized as the important inducement of inflammatory response and multiple organ failure [3]. In order to reduce the occurrence of postoperative complications, off-pump coronary artery bypass grafting (OPCABG) is introduced in the coronary artery revascularization, which has achieved good short and long-term effects. OPCABG can avoid the physiological interference and reperfusion injuries caused by extracorporeal circulation, and reduce the complications [4]. However, OPCABG may lead to low heart rate (HR), low blood pressure, cardiac arrhythmia, and even circulatory failure due to movement of heart. Therefore, maintaining a stable hemodynamic is the basis of OPCABG [5].

Magnesium sulfate, a natural calcium antagonist, can prevent the overloading of calcium for ischemic cells, inhibit the late ventricular potential and eliminate the ventricular arrhythmias. It is often used in anti-convulsion, lowering blood pressure, and treating preeclampsia and eclampsia. In addition, it can be used for treating polymorphous ventricular tachycardia [6, 7]. It is reported that, the combined use of magnesium sulfate with amiodarone can reduce the occurrence of adverse cardiac events after CABG surgery and prevent the atrial arrhythmia [8]. The preoperative intravenous infusion of magnesium sulfate can effectively shorten the extubation time and alleviate the postoperative pain [9, 10]. In addition, it can reduce the postoperative blood loss and the dosage of allogeneic blood components [11], reduce the level of N-terminal pro-brain natriuretic peptide [12]. However, to the best of our knowledge, there is no report on the effects of magnesium sulfate on the hemodynamics in OPCABG surgery. This study investigated the effects of preoperative magnesium sulphate infusion on the hemodynamics in patients with OPCABG surgery to provide a reference for further application of magnesium sulfate in OPCABG surgery.

Materials and methods

Subjects

Sixty patients undergoing OPCABG surgery under general anesthesia in Honggang Hospital (Dongying, China) were enrolled in this study. There were 51 males and 9 females. Their ages were 37-79 years, with mean of 60.19 ± 9.33 years. The body weight was 50-102 kg, with mean of 73.56 ± 8.83 kg. The patients were with ASA grade II-III and NYHA heart function grade II-III. The patients had no cardiac surgery history, and no acute myocardial infarction occurred within 3 months. The left ventricular ejection fraction was more than 35%. The patients had no preoperative renal insufficiency, hepatic insufficiency, pulmonary insufficiency or blood coagulation dysfunction. The patients were randomly divided into magnesium sulfate group (M) and control group (C), 30 cases in each group. This study was approved by the ethics committee of Honggang Hospital. The informed consent was obtained from all the patients.

Preoperative preparation

All patients had conducted the preoperative examinations, and were forbidden to drink or eat for 8 h. At 30 min before the surgery, 10 mg morphine was intramuscularly injected. The first-aid medicines (norepinephrine, ephedrine, anisodamine, nitroglycerin, lidocaine, adrenaline, isopropyl of adrenaline and calcium gluconate) were prepared before the patients entering surgery room. Electrocardiogram, blood pressure, HR and blood oxygen saturation (SpO_2) were monitored after the patients entering surgery room. Under local anesthesia, the radial artery catheterization using 20-G needle was performed to monitor the direct arterial pressure, and the 18-G needle was punctured to open right upper limb venous pathway. The sodium lactate ringer's solution was intravenously injected. The oxygen was supplied with mask, with flow rate of 2-3 L/min.

Anesthesia methods and application of magnesium sulfate

The anesthesia induction was performed by intravenously injection of midazolam (0.1 mg/kg), etomidate (150-300 μg/kg), rocuronium (0.6-1.2 mg/kg) and fentanyl 10-20 (μg/kg). After giving oxygen to remove nitrogen for 3 min, the tracheal intubation was conducted, and the mechanical ventilation was perfomred, with gas volume of 8 ml/kg, breathing frequency of 12 times/min, and absorption ratio of 1: 2. The pressure of end tidal carbon-dioxide ($P_{ET}CO_2$) was monitored after general anesthesia, and was maintained at 30-35 mmHg. The internal jugular vein catheterization was performed to the central venous pressure monitor (CVP).

The anesthesia maintaining was conducted by intraoperative inhalation of 1%-2% sevoflurane and intermittent use of fentanyl and pipecuronium. Before the surgery, M group was intravenously infused with magnesium sulfate (10 mg/kg), and C group was intravenously infused with 0.9% normal saline with the same volume. The warming blanket was used to keep the temperature at 38.5°C, and the surgery room temperature was maintained at 24°C.

OPCABG surgery

The standard sternum midline incision was made. The left breast artery and saphenous vein were used fot transplantation. The myocardial movement was limited using medtronic holder. The spraying with CO_2 and normal saline was used to wash target blood vessels, ensuring the bloodless operative field. The distal vas-

Table 1. General data of patients in two groups

Index	C group	M group	P
Male [n (%)]	25 (83.33%)	26 (86.66%)	> 0.05
Female [n (%)]	5 (16.67%)	4 (13.34%)	> 0.05
Age (year)	62.53 ± 8.46	59.80 ± 9.87	> 0.05
Weight (kg)	72.93 ± 10.46	75.83 ± 7.97	> 0.05
HR at entry (time/min)	62.50 ± 8.98	67.00 ± 11.49	> 0.05
SBP at entry (mmHg)	134.33 ± 18.91	133.63 ± 16.49	P > 0.05
DBP at entry (mmHg)	71.87 ± 15.87	72.77 ± 11.48	P > 0.05
PP at entry (mmHg)	62.47 ± 17.84	60.87 ± 13.85	P > 0.05
MAP at entry (mmHg)	92.73 ± 14.79	93.07 ± 11.63	P > 0.05

HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MAP, mean arterial pressure.

cular anastomosis was performed using 8-0 or 7-0 polypropylene thread, and the proximal vascular anastomosis was performed using 7-0 or 6-0 polypropylene thread. Both the proximal and distal vascular anastomosis used pure continuous suture method. The ultrasonic flowmeter was used to measure the instantaneous blood vessel flow. The drainage tubes from pleura, pericardium and mediastinum were connected to the sterile glassware. The bleeding was stopped when closing the chest. During suergery the autologous blood transfusion was performed using BW-8100 autologous blood transfusion machine. For patients with intraoperative blood pressure fluctuation, the depth of anesthesia was adjusted, and the vasoactive drugs such as nitroglycerin and dopamine were intravenously infused during surgery if necessary.

Observation indexes

The gender, age, weight and HR, systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse pressure (PP) and mean arterial pressure (MAP) at entry were recored. In addion, the surgery duration, intraoperative blood loss, CVP, SBP, DBP, HR and vasoactive drug use were measured.

Statistical analysis

All statistical analysis was carried out using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). The enumeration data were presented as n (%), and were compared using χ^2 test. The measurement data were presented as mean ± SD, and were compared using t test. $P < 0.05$ was considered as statistically significant.

Results

General data of patients

The general data of patients in two groups were shown in **Table 1**. There was no significant difference of gender, age, weight, HR, SBP, DBP, PP or MAP between two groups ($P > 0.05$).

Comparison of surgery duration, intraoperative blood loss and CVP between two groups

The surgery durations in C group and M group were 4.08 ± 1.08 and 4.21 ± 0.73 h, respectively. The intraoperative blood losses in two groups were 392.00 ± 125.85 and 391.67 ± 155.41 ml, respectively. The max CVP, min CVP and CVP fluctuation in C group were 4.70 ± 2.23, 2.83 ± 1.89 and 1.87 ± 1.43 cmH_2O, respectively, and those in M group were 4.53 ± 1.85, 2.90 ± 1.24 and 1.63 ± 1.58 cmH_2O, respectively. There was no significant difference of each index between two groups ($P > 0.05$) (**Table 2**).

Comparison of intraoperative SBP and DBP between two groups

As shown in **Table 3**, the max intraoperative SBP, min intraoperative SBP and SBP fluctuation in C group were 132.97 ± 17.09, 92.33 ± 14.96 and 40.63 ± 15.45 mmHg, respectively, and those in M group were 110.83 ± 9.47, 94.93 ± 7.62 and 15.90 ± 6.83 mmHg, respectively. The max intraoperative DBP, min intraoperative DBP and DBP fluctuation in C group were 74.40 ± 13.60, 53.70 ± 13.39 and 20.70 ± 7.24 mmHg, respectively, and those in M group were 61.77 ± 6.08, 51.07 ± 5.15 and 10.70 ± 4.34 mmHg, respectively. The max intraoperative SBP, max intraoperative DBP, SBP fluctuation and DBP fluctuation in M group were significantly lower than those in C group, respectively ($P < 0.05$).

Comparison of intraoperative HR between two groups

The max intraoperative HR, min intraoperative HR and HR fluctuation in C group were 76.57 ± 11.14, 52.37 ± 7.175 and 24.20 ± 10.69 time/min, respectively, and those in M group were 72.10 ± 9.95, 60.23 ± 8.08 and 11.87 ± 4.88

Table 2. Comparison of surgery duration, intraoperative blood loss and CVP between two groups

Index	C group	M group	P
Surgery duration (h)	4.08 ± 1.08	4.21 ± 0.73	> 0.05
Intraoperative blood loss (ml)	392.00 ± 125.85	391.67 ± 155.41	> 0.05
Max intraoperative CVP (cmH_2O)	4.70 ± 2.23	4.53 ± 1.85	> 0.05
Min intraoperative CVP (cmH_2O)	2.83 ± 1.89	2.90 ± 1.24	> 0.05
CVP fluctuation (cmH_2O)	1.87 ± 1.43	1.63 ±1.58	> 0.05

CVP, central venous pressure.

Table 3. Comparison of intraoperative SBP and DBP between two groups

Index	C group	M group	P
Max intraoperative SBP (mmHg)	132.97 ± 17.09	110.83 ± 9.47	< 0.05
Min intraoperative SBP (mmHg)	92.33 ± 14.96	94.93 ± 7.62	> 0.05
SBP fluctuation (mmHg)	40.63 ± 15.45	15.90 ± 6.83	< 0.05
Max intraoperative DBP (mmHg)	74.40 ± 13.60	61.77 ± 6.08	< 0.05
Min intraoperative DBP (mmHg)	53.70 ± 13.39	51.07 ± 5.15	> 0.05
DBP fluctuation (mmHg)	20.70 ± 7.24	10.70 ± 4.34	< 0.05

SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 4. Comparison of intraoperative HR between two groups

Index	C group	M group	P
Max intraoperative HR (time/min)	76.57 ± 11.14	72.10 ± 9.95	> 0.05
Min intraoperative HR (time/min)	52.37 ± 7.17	60.23 ± 8.08	< 0.05
HR fluctuation (time/min)	24.20 ± 10.69	11.87 ± 4.88	< 0.05

HR, heart rate.

Table 5. Comparison of vasoactive drug use between two groups

Vasoactive drug	C group	M group	P
Dopamine [n (%)]	12 (40.00%)	6 (20.00%)	< 0.05
Nitroglycerin [n (%)]	29 (96.67%)	22 (73.33%)	< 0.05

time/min, respectively. The min intraoperative HR in M group was significantly higher than that in C group (P < 0.05), and the HR fluctuation in M group was significantly lower than that in C group (P < 0.05) (**Table 4**).

Comparison of vasoactive drug use between two groups

There were 12 cases (40.00%) and 6 cases (20.00%) using dopamine for intervention in C group and M group, respectively, with significant difference between two groups (P < 0.05). In addition, there were 29 cases (96.67%) and 22 cases (73.33%) using nitroglycerin for intervention in C group and M group, respectively, and the difference between two groups was also significant (P < 0.05) (**Table 5**).

Discussion

CABG technique has been widely applied in clinic, which can effectively improve the myocardial ischemia, achieve the vascularization, enhance the survival rate of patients, and reduce the incidence of heart attacks. However, it may cause a series of complications due to the use of extracorporeal circulation which disrupts the normal physiological condition and damages the body microcirculation. Especially, the myocardial ischemia-reperfusion injury can exacerbate the myocardial injury [13]. As a comparison, the OPCABG can shorten the surgery time, and bring fast recovered after surgery. It can avoid the influence of extracorporeal circulation on human body, and reduce the low cardiac output syndrome, malignant arrhythmia, perioperative myocardial infarction, lung and brain complications [14]. Therefore, OPCABG technique has been gradually recognized by many scholars.

As the extracorporeal circulation is avoid, the whole OPCABG surgery is conducted under the heart beating. Moving the heart can cause slow heart rate, lower blood pressure, cardiac arrhythmia, and even circulatory failure. Therefore, the patients should maintain stable heart rate and blood pressure in OPCABG [15]. The parameters including HR, arterial blood pressure, pulmonary artery pressure, pulmonary artery wedge pressure, cardiac output, and others must be continuously monitored in the surgery. If necessary the vasoactive drugs such as nitroglycerin and dopamine are used to maintain the blood pressure. In addition, controlling a slower heart rate is significant to the balance of myocardial oxygen supply and demand, which is helpful for strengthening the tolerance of ischemia for heart [16]. In OPCABG, the main purpose of the anesthesiologist is to deal with coronary artery blockage and hemodynamics disorder caused by the cardiac surgery, and to prevent the myocardial ischemia, maintaining the stability of intraoperative blood pressure and the balance of myocardial oxygen supply.

Mg^{2+} is one of the most important ions for human body and its pharmacological effects are complex. It is a natural blocker for Ca^{2+} channel, and can interfere in the neurotransmitter release of synaptic connection, playing a role in inhibiting the central and peripheral nervous system and causing the loss of sense and consciousness. It can also inhibit the heat block, expand the peripheral vessel and thus effectively reduce the blood pressure [17]. In addition, it can reduce the release of acetylcholine and calcium ions for presynaptic membrane and the sensitivity of acetylcholine for postsynaptic membrane thus interfere in the normal depolarization of nerve muscle joints and muscle relaxation [18].

Results of this study showed that, the max intraoperative SBP, max intraoperative DBP, SBP fluctuation and DBP fluctuation in M group were significantly lower than those in C group, respectively ($P < 0.05$); the min intraoperative HR in M group was significantly higher than that in C group ($P < 0.05$), and the HR fluctuation in M group was significantly lower than that in C group ($P < 0.05$); the percentage of patients intraoperatively using vasoactive drugs in M group was significantly lower than C group ($P < 0.05$). This indicated that, magnesium sulfate could reduce the intraoperative fluctuation of blood pressure and HR, maintain them at a stable state. The mechanism may be that, Mg^{2+} ions inhibit the inflow of Ca^{2+} ions, and increase the coronary blood flow, thus protects the vascular endothelial function, and reduces the myocardial infarction area after ischemia-reperfusion [19]. In addition, Mg^{2+} can inhibit the catecholamine release for adrenal and adrenergic nerve endings, and inhibit the excitability of central nervous [20]. In this study, there was no significant difference in surgery duration, intraoperative blood loss and CVP between two groups. This indicated that, the Mg^{2+} ions had no adverse effect on the surgery.

The adverse effects of magnesium sulfate include burning sensation at the point of venipuncture, systemic thermal feeling, heart palpitation, etc.. However, these adverse effects need not be dealt with. There is no report on the serious complications after the application of magnesium sulfate. In conclusion, the preoperative magnesium sulphate infusion can effectively reduce the hemodynamic fluctuation in patients with OPCABG. This study has some shortcomings. For example, the sample size is relatively small. In addition, we have not investigated and verified the mechanism of magnesium sulfate in reducing the blood pressure and HR fluctuation during OPCABG. In next studies, the sample size should be further increased for obtaining more satisfactory outcomes, and the mechanism of magnesium sulfate action should be further investigated.

Disclosure of conflict of interest

None.

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References

[1] Ascione R, Reeves BC, Rees K, Angelini GD. Effectiveness of coronary artery bypass grafting with or without cardiopulmonary bypass in overweight patients. Circulation 2002; 106: 1764-1770.

[2] Anastasiadis K, Fragoulakis V, Antonitsis P, Maniadakis N. Coronary artery bypass grafting with minimal versus conventional extracorporeal circulation; an economic analysis. Int J Cardiol 2013; 168: 5336-5343.

[3] Vohra HA, Whistance R, Modi A, Ohri SK. The inflammatory response to miniaturised extracorporeal circulation: a review of the literature. Mediators Inflamm 2009; 2009: 707042.

[4] Abu-Omar Y, Taggart DP. Off-pump coronary artery bypass grafting. Missouri Med 2012; 109: 327-330.

[5] Arom KV, Flavin TF, Emery RW, Kshettry VR, Janey PA, Petersen RJ. Safety and efficacy of off-pump coronary artery bypass grafting. Ann Thorac Surg 2000; 69: 704-710.

[6] Kinlay S, Buckley NA. Magnesium sulfate in the treatment of ventricular arrhythmias due to digoxin toxicity. J Toxicol Clin Toxicol 1995; 33: 55-59.

[7] Witlin AG, Sibai BM. Magnesium sulfate therapy in preeclampsia and eclampsia. Obstet Gynecol 1998; 92: 883-889.

[8] Tiryakioglu O, Demirtas S, Ari H, Tiryakioglu SK, Huysal K, Selimoglu O, Ozyazicioglu A. Magnesium sulphate and amiodarone prophylaxis for prevention of postoperative arrhythmia in coronary by-pass operations. J Cardiothorac Surg 2009; 4: 8.
[9] Ferasatkish R, Dabbagh A, Alavi M, Mollasadeghi G, Hydarpur E, Moghadam AA, Faritus ZS, Totonchi MZ. Effect of magnesium sulfate on extubation time and acute pain in coronary artery bypass surgery. Acta Anaesthesiol Scand 2008; 52: 1348-1352.
[10] Wilder-Smith CH, Knöpfli R, Wilder-Smith OH. Perioperative magnesium infusion and postoperative pain. Acta Anaesthesiol Scand 1997; 41: 1023-1027.
[11] Dabbagh A, Rajaei S, Shamsolahrar MH. The effect of intravenous magnesium sulfate on acute postoperative bleeding in elective coronary artery bypass surgery. J Perianesth Nurs 2010; 25: 290-295.
[12] Dabbagh A, Bastanifar E, Foroughi M, Rajaei S, Keramatinia AA. The effect of intravenous magnesium sulfate on serum levels of N-terminal pro-brain natriuretic peptide (NT pro-BNP) in elective CABG with cardiopulmonary bypass. J Anesth 2013; 27: 693-698.
[13] Eugene JR, Barnes T, Tagoe A, Miglietta M, Edwards J, Schwartz K, Nwiloh JO, Asche-Crowe P. CABG complication: subclavian artery steal syndrome increases risk of ischemia, death. Geriatrics 2001; 56: 49-52, 55.
[14] Houlind K, Kjeldsen BJ, Madsen SN, Rasmussen BS, Holme SJ, Nielsen PH, Mortensen PE; DOORS Study Group. On-pump versus off-pump coronary artery bypass surgery in elderly patients: results from the danish on-pump versus off pump randomization study. Circulation 2012; 125: 2431-2439.
[15] Khan NE, De Souza A, Mister R, Flather M, Clague J, Davies S, Collins P, Wang D, Sigwart U, Pepper J. A randomized comparison of off-pump and on-pump multivessel coronary-artery bypass surgery. N Engl J Med 2004; 350: 21-28.
[16] Barišin S, Šakić K, Goranović T, Barišin A, Sonicki Z. Perioperative blood pressure control in hypertensive and normotensive patients undergoing off-pump coronary artery bypass grafting: prospective study of current anesthesia practice. Croat Med J 2007; 48: 341-347.
[17] Soltani N, Keshavarz M, Dehpour AR. Effect of oral magnesium sulfate administration on blood pressure and lipid profile in streptozocin diabetic rat. Eur J Pharmacol 200; 560: 201-205.
[18] Tolsa JF, Gao Y, Raj JU. Developmental change in magnesium sulfate-induced relaxation of rabbit pulmonary arteries. J Appl Physiol 1999; 87: 1589-1594.
[19] Kao MC, Jan WC, Tsai PS, Wang TY, Huang CJ. Magnesium sulfate mitigates lung injury induced by bilateral lower limb ischemia-reperfusion in rats. J Surg Res 2011; 171: e97-106.
[20] Wojtowicz JM, Marshall KC, Hendelman WJ. Depression by magnesium ion of neuronal excitability in tissue cultures of central nervous system. Can J Physiol Pharmacol 1977; 55: 367-372.