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Post-operative change in colloid osmotic pressure and its clinical significance after heart surgery in adults.

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Abstract

Objectives: This study aimed to investigate the post-operative change in Colloid Osmotic Pressure (COP) and its significance in clinical prognosis in adults receiving heart surgery.

Methods: A total of 21 adults receiving heart surgery were recruited and divided into CPB group (valve replacement under cardiopulmonary bypass) and OP group (minimally invasive coronary artery bypass surgery). The COP was recorded at 5 min after anesthesia (T0), 5 min after initiation of CPB (T1), 5 min after the end of CPB (T2), post-operative return to ICU (T3), 2 h (T4), 4 h (T5), 8 h (T6), 24 h (T7) and 3 days after surgery, and the duration of mechanical ventilation and ICU stay were also recorded for comparisons between them.

Results: The baseline characteristics were comparable between two groups before surgery. The peri-operative COP reduced to different extents in both groups, but there was no significant difference between them (P>0.05). The change in intra-operative COP was the most obvious (P<0.05). The incidence of complications, post-operative ICU stay and duration of mechanical ventilation were comparable between two groups (P>0.05).

Conclusions: CPB surgery may reduce COP, but it restores rapidly after management, and the change in COP has no influence on the clinical prognosis.

Keywords: Cardiopulmonary bypass, Colloid osmotic pressure.

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Introduction

Colloid Osmotic Pressure (COP) is containment force that restraints the leakage of water from the blood vessels to interstitial space and play an important role in the stabilization of blood volume and prevention of tissue edema [1-3]. Heart surgery is often conducted under cardiopulmonary bypass (CPB). In CPB, the blood dilution, activation of inflammation and ischemia/reperfusion injury may cause the reduction in COP, which may increase the post-operative complications and affect the patient's health [4,5]. The post-operative complications reduce gradually with the improvement of CPB technique. In this study, we monitored the COP at different time points in the peri-operative period in adults who received heart surgery, and the post-operative complication, duration of mechanical ventilation and ICU stay were recorded, aiming to evaluate the influence of CPB on the peri-operative COP and its clinical significance for prognosis.

Materials and Methods

General characteristics

Adult patients who received heart surgery between January 2016 and March 2016 in our department were recruited and divided into two groups according to the surgical methods: CPB group (valve replacement under CPB) and OP group (minimally invasive coronary artery bypass surgery).

Exclusion criteria: Patients had severe liver, kidney or heart dysfunction; patients were older than 75 years; patients had other diseases affecting post-operative recovery (such as chronic obstructive pulmonary disease, obesity and severe pulmonary hypertension). A total of 21 patients were included in this study. There were 11 patients in CPB group and 10 patients in OP group. There were no significant differences in the age, gender, body mass index (BMI), left ventricular ejection fraction (LVEF), pre-operative haemoglobin, albumin and creatinine between two groups (P>0.05) (Table 1).

Anesthesia

After being transferred into operation room, intravenous access was established, and radial artery puncture was performed under local anesthesia for continuous monitoring of blood pressure. Vecuronium at 0.15 mg/kg, sufentanil at 0.6 μg/kg and dexmedetomidine at 1 μg/kg were used for anesthesia induction. Anesthesia was maintained with dexmedetomidine, sufentanil, vecuronium and sevoflurane. Sevoflurane was discontinued during CPB. Mechanical ventilation was performed at fixed volume, tidal volume of 8-10 ml/kg and respiratory rate of 12 breaths/m.

CPB

After anesthesia, blood was collected from the radial artery. HCT was detected with i-stat. The total prime volume was calculated with targeted HCT at 20%. When the HCT was >0.45, 300-500 ml of blood was exsanguinated (blood was infused back to the patient after surgery or CPB), and 4% succinylated gelatin of equal volume was infused. The prime fluid includes 5% sodium bicarbonate (1.5 ml/kg), 20% mannitol (5 ml/kg), magnesium sulfate (0.25 mmol/kg), potassium chloride (0.5 mmol/kg), methylprednisolone, 20% human serum albumin (100 ml), and sodium lactate Ringer's injection.

Measurement of COP

The plasma colloid osmotic pressure detector (ONKOMETER BMT932) was used to measure the COP. After adjustment, blood was added to the detector. 0.5 ml of blood was collected from the radial artery and then added to the detector, followed by being balanced for 15 s. Additional blood was added, and the COP was measured.

Detections

At 5 min after anesthesia (T0), 5 min after initiation of CPB (T1), 5 min after the end of CPB (T2), being transferred into ICU (T3), and 2 h (T4), 4 h (T5), 8 h (T6) and 24 h (T7) after surgery, the COP was measured.

Statistical analysis

All the data are expressed as mean ± standard deviation (SD), and statistical analysis was performed with SAS. Comparisons between two groups were done with t test. A value of P<0.05 was considered statistically significant.

Table 1. *General characteristics of patient's in two groups.*

Variables	CPB group (n=11)	OP group (n=10)	Statistics	P value
Age (y)	53.33 ± 10.93	55.90 ± 10.86	t=0.54	0.5956
Gender (F/M)	42891	42890	-	0.575
BMI	22.79 ± 1.39	23.69 ± 1.90	t=1.25	0.2274
LVEF	63.00 ± 2.37	62.80 ± 4.26	Z=0.1705	0.8646
HB	127.33 ± 25.41	134.70 ± 15.47	t=0.79	0.4379
ALB	42.33 ± 3.01	40.10 ± 3.48	t=1.30	0.2136
Scr	72.05 ± 18.94	79.63 ± 21.19	t=-0.72	0.484

BMI: Body Mass Index; LVEF: Left Ventricular Ejection Fraction; HB: Haemoglobin; ALB: Albumin; Scr: Serum Creatinine.

Results

General characteristics of patients included in this study are shown in Table 1. There were no significant differences in these characteristics between the two groups (P>0.05).

Peri-operative COP in CPB group and OP group

COP at different time points in CPB group was only slightly higher than in OP group, and there was no marked difference between them (P>0.05) (Table 2). After initiation of the surgery, the absolute reduction in COP (ΔT1) was significantly different between two groups (-5.48 ± 2.40 *vs* -1.91 ± 0.97, P<0.05) (Table 3). After the end of surgery and 1 day after the surgery, the blood red cell count, albumin, creatinine and oxygenation index were comparable between two groups (P>0.05). In addition, there were no significant differences in the duration of post-operative mechanical ventilation (12.50 ± 5.72 *vs* 27.20 ± 22.36, P>0.05) and ICU stay (58.67 ± 11.94 *vs* 61.10 ± 25.86, P>0.05). Acute lung injury, acute kidney injury and low cardiac output syndrome were not observed in both groups (Table 4).

Table 2. *Peri-operative COP in CPB group and OP group.*

Group	T0	T1	T2	T3	T4	T5	T6	T7
CPB	23.15 ± 3.83	17.67 ± 2.60	22.12 ± 4.64	20.93 ± 3.90	21.60 ± 3.02	21.77 ± 3.24	21.73 ± 3.05	19.28 ± 2.12
OP	19.52 ± 1.67	17.61 ± 1.93	18.34 ± 2.21	18.44 ± 2.32	19.40 ± 1.68	19.51 ± 1.87	19.85 ± 1.74	18.08 ± 2.34
t	2.2	0.05	1.87	1.62	1.89	1.78	1.71	1.03
P	0.0687	0.9608	0.1078	0.1275	0.0793	0.096	0.1035	0.3203

Table 3. *Absolute change in peri-operative COP in CPB group and OP group.*

Group	ΔT1	ΔT2	ΔT3	ΔT4	ΔT5	ΔT6	ΔT7
CPB	-5.48 ± 2.40	-1.03 ± 1.28	-2.22 ± 2.43	-1.55 ± 3.44	-1.38 ± 2.59	-1.42 ± 3.63	-3.87 ± 3.64
OP	-1.91 ± 0.97	-1.18 ± 1.21	-1.08 ± 1.30	-0.12 ± 1.29	-0.01 ± 2.23	-0.67 ± 1.54	-1.44 ± 2.25
Statistics	Z=-2.6672	t=0.23	Z=-1.2483	-0.98	-1.13	-0.48	-1.66

P	0.0076	0.821	0.2119	0.3671	0.2791	0.6488	0.1185

Table 4. Incidence of peri-operative complications.

Group	Mechanical ventilation	ICU stay	Acute lung injury	Acute kidney injury	Low cardiac output syndrome
CPB	12.50 ± 5.72	58.67 ± 11.94	0	0	0
OP	27.20 ± 22.36	61.10 ± 25.86	0	0	0
Statistics	-1.7039	0.1628			
P	0.0884	0.8707			

Discussion

70% of COP in human plasma is ascribed to the albumin, and the remaining COP is related to the macromolecular non-ionic substances such as fibrinogen and globulin [6,7]. The normal COP is an important force that restrains the leakage of water from blood vessels into interstitial space and plays an important role in the stabilization of blood volume and prevention of tissue edema [8]. In a healthy adult, the normal COP is 25 mmHg [9]. COP lower than 16 mmHg displays a compromised capability to restrain the water in the blood vessel, leading to the leakage of a large amount of fluid into interstitial space. Under this condition, fluid may accumulate in the lung, myocardium, intestinal wall and peripheral tissues, which affect the post-operative respiratory function, cardiac function, intestinal movement and wound healing [10]. In CPB, the hypothermia, inflammation, blood dilution, protein denaturation and extravascular exudation of proteins may reduce the plasma albumin, leading to the reduction in COP [4,11-13]. In the present study, results were consistent with previously reported. Our findings indicated that COP reduced significantly after the initiation of CPB, which continued to the end of surgery. However, there was no significant difference in COP between CPB group and OP group.

Some clinical trials and animal experiments have shown that elevation of COP during CPB is able to prevent the fluid accumulation and the body weight gain [14-16], which may protect the respiratory function and cardiac function. Hanna et al. found [17] maintenance of a high COP was able to reduce the post-operative concentration of blood lactate and shorten the duration of mechanical ventilation, leading to a better prognosis. In our study, prime fluid containing albumin and post-operative ultrafiltration were used to increase the post-operative COP after CPB, and there was no marked difference in COP between CPB group and OP group when the patients were transferred back to ICU (P>0.05). In addition, none of these patients developed low cardiac output syndrome and acute lung injury, and there was no significant difference in the incidence of acute kidney injury (P>0.05). The duration of mechanical ventilation and ICU stay were also comparable between two groups (P>0.05). Taken together, heart surgery under CPB is becoming mature. The improvement of components in the prime fluid and the ultrafiltration significantly reduces the adverse effects of CPB, which decreases the post-operative complications and reduces the duration of mechanical ventilation and ICU stay. Moreover, the clinical prognosis after CPB is similar to that after minimally invasive surgery. This suggests that heart surgery under CPB is safe. However, the sample size in this study was small, which might be reason for the insignificant differences in this study. Thus, more clinical studies are required to confirm our findings.

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