Original Article

A COMPARISON OF OFF-PUMP AND ON-PUMP CORONARY ARTERY BYPASS GRAFTING FOR PATIENTS WITH RESPIRATORY DYSFUNCTION

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ABSTRACT

Objective: *To compare the clinical outcomes of off-pump coronary artery bypass grafting (OPCABG) and on-pump coronary artery bypass grafting or conventional coronary artery bypass grafting (CCABG) with Cardiopulmonary bypass (CPB) in patients with respiratory dysfunction.*

Methods: *Data of 28 patients who had two specific respiratory diseases and had received off-pump coronary bypass operation in our hospital were summarized and compared with that of 19 patients who also had the same respiratory diseases but had received on-pump coronary artery bypass at our hospital from Jan 1998 to May 2002.*

Results: *There was no operation-related death. One patient died of respiratory failure in hospital 14 days after the operation. There were more respiratory complications in the conventional coronary artery bypass grafting group (CCABG) than in the OPCABG group. The PaO_2 / FiO_2 in CCABG was higher than that in OPCABG during the operation because of CPB, but was lower than that in OPCABG 6-12 hours after the operation. The concentration of plasma intercellular adhesion molecule-1 showed an obvious difference between the two groups from 2 hours to 24 hours post-operatively.*

Conclusion: *OPCABG seems more suitable than CCABG for coronary artery disease patients having chronic obstructive pulmonary disease since it causes less damage to the oxygen-exchange capability and produces less respiratory complications due to less inflammatory reaction.*

Key words: *Chronic obstructive pulmonary disease; Coronary artery disease; Off-pump bypass; On-pump bypass; Respiratory function.*

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INTRODUCTION

Conventional coronary artery bypass grafting (CCABG) with Cardiopulmonary bypass(CPB) has been accepted as an effective and safe intervention in order to treat multi-vessel coronary artery disease .CPB may still contribute to the operation field as relatively lesser technical expertise is needed. However, it also causes a serious systemic inflammatory reaction, which can lead to dysfunction of some important organs. Off-pump coronary artery bypass grafting (OPCABG) has recently emerged as an alternative method allowing coronary revascularization without the use of CPB, and has more advantages in reducing postoperative cardiac complications and morbidity compared with on-pump or conventional coronary artery bypass grafting. In this paper we have studied the clinical outcome of patients with chronic obstructive pulmonary disease in patients receiving off-pump coronary artery bypass grafting or on-pump coronary artery bypass grafting.

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MATERIALS AND METHODS

1.General clinical material

All of the 47 patients had a history of myocardial infarction or angina pectoris, and had at least 3 vessel lesions, a fact certified by cardiac catheterization. According to the criteria of diagnosis and classification of COPD, the patients were classified in a specific subgroup defined by the Chinese Medical Association[1]. Six cases were included in stage I, 19 in stage IIA, 13 in stage IIB and 9 in stage III, depending on the results of pulmonary function tests, blood gas analysis, auscultatory findings and roentgenograms. The male /female ratio was 18/29 and the mean age was 61.9years.They were randomly divided into two groups, and under went either CCABG or OPCABG from January 1998 till September 2002. Any patient with a high risk factor or combined problem such as valvular heart disease, great artery disease, ejection fraction <30% or requiring emergency or urgent operation was excluded. Some of the patients suffered from other diseases along with COPD; 5 of them had dysfunction of liver and kidneys, 7 patients had hyperten-

sion while 10 had diabetes. The clinical data are shown in detail in table 1.

DATA	OPCABG (n=28)	CCABG (n=19)
Age	62.4±2.7	61.3±1.9
Female/Male	16/12	12/7
History of smoking	20	15
COPDI-II	23	15
COPD III	5	4
No. of diseased vessels	3.4±0.2	3.1±0.4
Left main stem disease	7	5
LVEF (%)	49.1±2.9	51.4±3.4
H/O Hypertension	3	2
Renal impairment	5	2
Diabetes	6	4
Parsonnet score	7.1±1.2	8.3±1.4

Table 1. Patients' clinical characteristics

All operations were performed by the same surgical team through a median sternotomy incision and left internal mammary artery was usually anastomosed to the left anterior descending artery (LAD). Mostly the great saphenous vein was used as a conduit, but the radial artery, whose long -term patency is superior to that of saphenous vein grafts, was also harvested as a conduit in some cases. CCABG used both antegrade and retrograde blood cardioplegia for myocardial protection during the period of cardiac arrest. OPCABG needed deep pericardial traction sutures in some patients. The right pleural space was opened in some patients to facilitate the exposure of the circumflex artery. Stabilization system used for the coronary arteries was Medtronic Stabilizer. After the surgical procedure, both groups of patients were admitted to the intensive care unit (ICU) where they received ventilatory assistance in a controlled mandatory ventilation mode, and were extubated as soon as clinically possible

2. Blood sample test

Blood samples were taken for blood gas analysis before the operation without oxygen supply, during anesthesia with oxygen supply, before CPB and at 2 hours, 6 hours, 12 hours and 24 hours post-operatively to observe the change in PaO_2/FiO_2. At the same time, the plasma soluble Intercellular adhesion molecule-1 was tested by ELISA and neutrophils in bronchoalveolar lavage were counted by a Flow CytoMeter (FCM).

3.Statistical analysis

The data is expressed as a mean ±standard deviation. Unpaired Student t test and chi square (X^2) were used to analyze variables between the two groups. A p value less than 0.05 was considered as statistically significant (SPSS 9.0).

RESULTS

There was no difference with regard to age, gender, diseased vessels, smoking history, previous myocardial infarction, renal insufficiency, and Parsonnet score. This did not include pulmonary test in the two groups. Among them, 4 patients who were supposed to be revascularized without CPB, required conversion to CCABG due to instability of blood pressure and ventricular arrhythmia during the operation. Postoperative outcomes are shown in table 2.

Table 2. Postoperative outcomes

Variables	OPCABG (n=28)	CCABG (n=19)	p value
Chest drainage (ml)	450±190	680±210	<0.01
Time to extubation (hrs)	13±10	18.7±12	<0.05
Delayed extubation	6	11	<0.05
COPD	4	3	>0.05
Re opening for bleeding	3	1	>0.05
Pneumothorax	2	1	>0.05
Pleural effusion	4	2	>0.05
Reintubation	2	2	>0.05
ICU time (hrs)	21.2± 2.5	16.8±4.5	<0.05
ARDS	1	5	<0.05
Trachesotomy	1	2	>0.05
In-hospital mortality	1	0	>0.05
In-hospital stay (Days)	15.4±4.5	21.8±3.4	<0.05
IABP*	3	1	>0.05
LOS*	1	1	>0.05
Postoperative MI	1	0	>0.05
PVA*	2	7	>0.05
No. of grafts	3.3±0.5	3.5±0.4	>0.05

PVA: postoperative ventricular arrhythmia; IABP: intraaortic balloon pump ; LOS: low output syndrome

OPCABG patients underwent fewer bypass grafts per patient as compared to CCABG patients while more saphenous vein grafts were used in OPCABG patients. Furthermore there were also obvious differences with regard to chest drainage, time till extubation, reintubation times, intensive care unit time, stay time in hospital and ARDS occurrence. Some of them however had no statistical value. No difference was found in total in-hospital deaths or re-exploration for bleeding, pleural effusion, bronchospasm , pneumothorax, postoperative ventricular arrhythmia, intraaortic balloon pump and low output syndrome .

PaO_2/FiO_2 is a very important marker to evaluate the function of gas exchange of the lung during and

after the operation. Patients with CCABG had higher PaO_2/FiO_2 than those with OPCABG because of CPB during operation. There was no difference between the two groups at first 2 hours post-operatively, but during 6-12 hours after the operation, the CCABG group had an obviously lower PaO_2/FiO_2 than the OPCABG group. (See table 3.)

The concentration of plasma soluble intercellular adhesion molecule-1 at different times is shown in table 4. The increase in ICAM-1 was related with the degree of inflammatory reaction, and there was obvious difference between the two groups. Consistent with the change in ICAM-1, there was also an obvious increase in neutrophils in the bronchoalveolar lavage from 2 to 24 hours post-operatively. (Figure 1)

Fig 1. The number of neutrophils in bronchoalveolar lavage at different times.

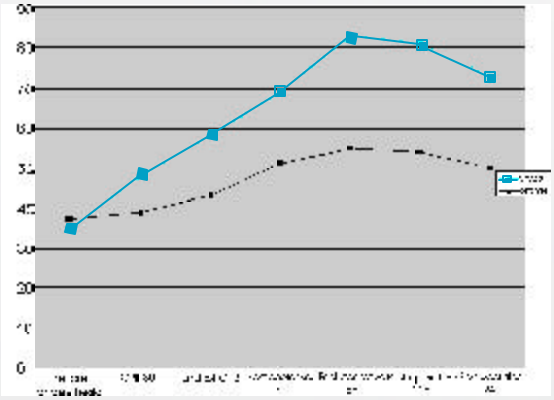

Table 3. The changes of PaO_2/FiO_2 in two groups at different times(mmHg)

	In operation		Post-operation			
	Before anaesthesia	CPB	2h	6h	12h	24h
OPCABG (n=28)	342±24 (SHSO)	310±23	281±36	273±14	278±19	311±11
CCABG (n=19)	340±20	352±21	278±23	244±18	238±12	301±23
P value	>0.05	<0.05	>0.05	<0.05	<0.05	>0.05

SHSO: Starting heart surface operation ;
CPB: Cardiopulmonary bypass

Table 4. The change of ICAM-1 in two groups (Mean±SDng/ml)

	In operation			Post-operation			
	Beforeanaesthesia	CPB30'	end of CPB	2h	6h	12h	24h
OPCABG (n=14)	70±22.5 (SHSO)	56±3.5	60±4.5	69±3.0	85±4.0	101±4.5	70±1.1
CCABG (n=9)	65±3.0	77±2.5	89±2.6	110±4.5	148±6.5	189±3.5	177±5.4
P?	>0.05	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01

DISCUSSION

Chronic obstructive pulmonary disease (COPD) is characterized by a progressive development of airflow limitation that is not fully reversible. It encompasses chronic obstructive bronchitis, with the obstruction of small airways and emphysema and enlargement of air space or destruction of lung parenchyma with the loss of lung elasticity and closure of small airways[2]. 14.3% of all patients with coronary heart disease in our hospital suffered from COPD.

It is well-known that CPB not only leads to pathologic effects including volume retention, coagulopathy, release of systemic inflammatory mediators, reperfusion injury of heart and neurocognitive changes, but also interferes with pulmonary functions in patients undergoing CABG[3,4]. Before the coronary artery bypass on the beating heart without CPB was reintroduced into cardiac surgical practice, a lot of measures, such as aprotinin use or heparinized circuit, were being taken to reduce these detrimental side effects of extracorporal circulation. These effects seem more serious and dangerous for the patients with COPD, because Cardiopulmonary bypass has adverse effects on the alveolar stability due to activation of the complement cascade, adherence and sequestration of the neutrophil in the pulmonary microvascular bed, release of the oxygen-derived free radicals and change in the composition of alveolar surfactant. Due to a wide vascular bed and endothelium,the lung becomes the main target of inflammatory factors. Some studies showed a waterfall-like release after CPB inflammatory mediators such as interleukin 2, 6 or 8, whose peak times are between postoperative 4-12 hours[6, 8,9]. This correlates with the change in PaO_2/FiO_2, which we had observed in our study. Patients with OPCABG showed mild change only. This means that patients with the same severity of COPD should rather receive OPCABG than CCABG.

Parsonnet score, which was widely recommended in many European heart centers, was used to evaluate the preoperative condition in our hospital, but the OPCABG high risk factor profiles were different from the CCABG. Even though the Parsonnet scores of the two groups in our hospital were alike, the respiratory complication of the two groups had an obvious difference. Our results also echo the previous report about the hospital mortality and morbidity of COPD patients who underwent CABG[5,6]. Rational Parsonnet score evaluation needs further modification due to the changing of method of operation for CABG.

Nearly all COPD patients needed delayed mechani-

cal ventilation after the operation. Positive end-expriratory pressure is still controversial because COPD patients have increased functional residual volume and PEEP will enhance the volume of the lung. Thus some surgeons are worried that post-operative PEEP will increase internal mammary artery tension and cause its spasm, which will lead to post-operative myocardial infarction. Our experience showed that 4-8 cm H_2O PEEP reduced extravascular water in the lung and was suitable for patients with congestive heart failure before the operation. Reintubation was often needed because of continuous continuous hypoxemia. Pharmacological intervention played a very important role in improving the respiratory dysfunction. Inhaled long-acting $ß_2$ –agonists and corticosteroids are now the mainstay of therapy. The use of non invasive positive-pressure ventilation with a simple nasal mask, which eliminates the necessity for endotracheal intubation, reduces the need for mechanical ventilation in acute exacerbation of COPD in the hospital[2,7].

ICAM-1 plays a very important role in many inflammatory reactions associated with the immigration and rolling of neutrophils. Some studies have shown that the increase of ICAM-1 during the cardiac operation was caused by myocardial ischemic reperfusion injury[11]. We have reported previously that ICAM-1 also takes part in acute traumatic lung injury[10]. It too was an important marker for lung ischemic reperfusion injury. In this study we found that ICAM-1 paralleled the change in the number of neutrophils in bronchoalveolar lavage during 2–24 hours after operation.

To conclude, with less adverse effects of CPB such as systemic inflammatory reactions, postoperative organ dysfunction and significant coagulatory disorders, OPCABG has less respiratory complications and is safer than CCABG for patients with COPD.

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