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European Journal of Cardio-thoracic Surgery 39 (2011) 689–692

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

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Comparison of inflow occlusion on the beating heart with cardiopulmonary bypass in the extraction of a mass lesion or a foreign body from the right heart

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Received 20 May 2010; received in revised form 26 August 2010; accepted 31 August 2010; Available online 8 October 2010

Abstract

Objective: Two basic surgical techniques exist in the extraction of a mass lesion or a foreign body from the right atrium and/or the right ventricle. These are inflow occlusion of the right heart and with assistance of the cardiopulmonary bypass (CPB). In this study, these two methods were compared. **Methods:** Between May 2001 and April 2010, 15 patients were operated upon for the extraction of a mass lesion or a foreign body from the right heart. Seven patients were operated upon using venous inflow occlusion technique, whereas eight patients were operated upon using CPB. These two groups were evaluated and compared in terms of clinical parameters. **Results:** Intracardiac masses or foreign bodies were completely removed by using both methods. Patients who were operated upon using inflow occlusion on beating heart (IOBH) developed no postoperative complication, whereas two patients who were operated upon with CPB developed complications, postoperatively. Moreover, duration of hospital stay, duration of intensive care unit (ICU) stay, and intubation time were significantly lower in the IOBH group when compared with the CPB group. In the CPB group, the amount of blood transfused was significantly higher. **Conclusions:** In suitable patient groups, the IOBH technique could be safely performed by experienced centers.
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Keywords: Inflow occlusion; Cardiopulmonary bypass; Intracardiac material

1. Introduction

Inflow occlusion on beating heart (IOBH) was a technique that was used more commonly in cardiac surgery prior to the cardiopulmonary bypass (CPB) era. Nowadays, this technique is seldom preferred in cases such as pulmonary valvotomy, aortic valvotomy, atrial septectomy, cardiac injury, and extraction of intracardiac thrombus or foreign body [1–6]. These aforementioned operations could also be performed by using CPB. Both, complications due to technical issues (tissue injury during cannulation or embolic events) and perioperative problems secondary to the inflammatory process triggered by extracorporeal circulation make us think that CPB is not a more innocent and less-complicated technique than IOBH. In this study, we investigated the results of IOBH and CPB techniques used in similar disease groups and compared them on the basis that the IOBH technique might be superior to CPB in some parameters.

2. Materials and methods

A total of 15 patients with no associated operable abnormality, who were operated upon between May 2001 and April 2010 for the extraction of a foreign body or a mass lesion from the right heart, were evaluated retrospectively. Seven of these patients were operated upon using the IOBH technique, whereas the remaining eight patients were operated upon under CPB. In the IOBH group, three patients were male and four patients were female with a mean age of 51.5 ± 8.2 (39–62) years. In the CPB group, five patients were male and three patients were female with a mean age of 47.7 ± 8.7 (38–61) years.

Inclusion criteria of the study were the absence of cardiac pathology other than foreign body or mass and the absence of any other concomitant cardiac intervention. Two patients intended to undergo IOBH but converted to CPB due to hemodynamic instability and two patients due to extensive invasion of the mass lesion were excluded from the study.

Although there were no exact criteria to decide which patient would be operated upon with which technique, we had tendency toward CPB when the material to be extracted was large, diffuse, or infected. Likewise, when a patient had

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doi:10.1016/j.ejcts.2010.08.048

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Table 1. Data of the patients in IOBH group.

Patient nr.	Age	Gender	Extracted material	Operation time (min)	Hospital stay (day)	ICU stay (day)	Intubation time (h)	Packed red blood cells used (unit)	Inflow occlusion time (s)
1	62	M	RA THROMBUS	90	6	2	2	2	120
2	60	M	RV LEAD	100	5	3	3	0	90
3	45	F	RV LEAD	105	7	1	1	0	135
4	56	F	RA THROMBUS	80	6	3	3	1	60
5	49	F	SWAN GANZ	75	8	2	2	2	150
6	50	M	RA LEAD	90	8	3	3	3	60
7	39	F	RV LEAD	90	7	3	3	2	90

RA: right atrium; RV: right ventricle; and SWAN GANZ: Swan-Ganz catheter.

many comorbid factors that made us unwilling to establish CPB, we preferred the IOBH technique more readily. All the surgical procedures were carried out by the same experienced surgical team. A similar anesthetic protocol was used in all patients of both groups. Standardized anesthesia was induced with midazolam (0.05–0.1 mg kg^{-1}), fentanyl (5 μg kg^{-1}), etomidate (0.2 mg kg^{-1}), and pancuronium (0.1 mg kg^{-1}). Isoflurane (0.6–1 volume percentage end tidal) and continuous fentanyl were given to maintain anesthesia. In the IOBH group, a standard dose of 100 IU kg^{-1} 1 heparin was administered before inflow occlusion, whereas a standard dose of 300 IU kg^{-1} heparin was administered before cannulation in the CPB group. In the IOBH group, the administered heparin was not neutralized by protamin sulfate, whereas it was neutralized before decannulation with a dose identical to heparin.

In general, when the hematocrit level dropped below 30%, these patients were transfused with packed red blood cells.

The age of the included patients, gender, length of hospital stay, length of intensive care unit (ICU) stay, postoperative mechanical ventilation time, amount of packed red blood cells used, duration of inflow occlusion, development of complications, and results of histopathological examinations of the mass lesions were recorded (Tables 1 and 2).

2.1. Surgical technique of IOBH

In the operating room, a CPB pump and a cell-saver aspirator (Fresenius CATS (Continuous Autotransfusion System)) were available. Patients were operated upon under intratracheal general anesthesia. After median sternotomy, the superior and inferior vena cavae were snared with nylon tapes. Two purse-string sutures were placed on the right atrium. At this stage, the patients were ventilated at an oxygen concentration of 100% for 5 min. After the occlusion of the venae cavae by snares, a right atriotomy was made between the purse-string sutures. Right atrial contents were aspirated with the cell saver and the material was extracted from inside the right atrium. In cases where the prolongation of the procedure by more than 45 s was necessary, the atriotomy was closed by suspending the sutures and placing a side-biting clamp and loosening the snares, thus permitting normal flow. After a period of 3 min of normal inflow, the procedure was repeated. In this way, a continuous inflow occlusion of more than 45 s was not permitted. If the material to be extracted was located within the right ventricle, the procedure was repeated with right atriotomy by the transvalvular route. After extraction of the material, the right atriotomy was clamped and the snares were loosened. The right atriotomy was closed using 4/0 polypropylene sutures. The blood aspirated into the cell saver was then administered back to the patient.

2.2. Surgical technique of CPB

Patients were operated upon under intratracheal general anesthesia. After median sternotomy, standard aortobicaval cannulation was made. Both venae cave were snared with nylon tapes. Intermittent antegrade isothermic hyperkalemic blood cardioplegia was used. After the establishment of CPB and the placement of an aortic cross-clamp, the snares were squeezed, occluding the venae cavae. After right atriotomy, the intracardiac foreign body or the mass lesion was extracted. In cases where the material to be extracted was located within the right ventricle, the procedure was repeated with right atriotomy by the transvalvular route. After extraction of the material, the right atriotomy was closed using 4/0 polypropylene sutures and the cross-clamp was removed followed by weaning from CPB.

Table 2. Data of the patients in CPB group.

Patient nr.	Age	Gender	Extracted material	Operation time (min)	Hospital stay (day)	ICU stay (day)	Intubation time (h)	Packed red blood cells used (unit)
1	58	M	RV THROMBUS	150	11	4	12	3
2	48	F	RV LEAD	120	9	5	9	3
3	39	F	RA THROMBUS	110	8	5	12	2
4	49	F	RA THROMBUS	140	9	3	10	2
5	50	F	RA THROMBUS	120	10	3	9	4
6	61	M	RV THROMBUS	120	9	6	14	3
7	39	F	RA THROMBUS	120	9	4	13	2
8	38	M	RV LEAD	150	11	5	10	3

RA: right atrium; and RV: right ventricle.

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The extracted materials were sent to the pathology laboratory perioperatively.

The patients were fully monitored with mechanical ventilatory support in the ICU after both procedures. All the patients were weaned from mechanical ventilation when arterial blood gas analyses, ventilatory parameters ($PaO_2/FIO_2 > 150–200$; requiring positive end-expiratory pressure (PEEP) $\leq 5–8$ cm H_2O; $FIO_2 \leq 0.4–0.5$; and $pH \geq 7.25$) and their general conditions were suitable. Transthoracic echocardiographic examination was done after the operation confirming the total extraction of the intracardiac material. The patients were then discharged.

2.3. Statistical analysis

The Statistical Package for Social Sciences (SPSS) 15.0 for Windows was used in statistical evaluation of the data. These data were summarized in tables. All the variables were compared with the Mann–Whitney *U* test between the groups. A p value <0.05 was considered statistically significant.

3. Results

No perioperative mortality was observed in both groups. No postoperative complication was recorded in the IOBH group. In the CPB group, a transient vision loss developed in one patient immediately after the extubation on the 1st postoperative day after extraction of the right atrial thrombus. Another patient who underwent extraction of the right atrial thrombus developed acute deterioration of renal functions (serum creatinine level reached 2.5 mg dl^{-1}) on the 2nd postoperative day; the patient recovered without necessitating hemodialysis.

Echocardiographic examinations of the included patients were held on the 1st postoperative day, and after the first month, showing no intracardiac foreign material. The mean inflow occlusion time was 100 ± 32 (60–150) s.

No statistically significant difference was detected between both groups in terms of mean age and operation time ($p > 0.05$).

Table 3. Statistical comparison of the patients' data.

	Group	*N*	Median	*z*	*p*
Age	IOBH	7	50 (39-62)	−0.931	0.352
	CPB	8	48 (38–61)		
Hospital stay (day)	IOBH	7	7 (5–8)	−3.173	0.002
	CPB	8	9 (8–11)		
ICU stay (day)	IOBH	7	3 (1–3)	−2.885	0.004
	CPB	8	5 (3–6)		
Intubation time (h)	IOBH	7	3 (1–3)	−3.258	0.001
	CPB	8	11 (9–14)		
Packed red blood cells used (unit)	IOBH	7	2 (0–3)	−2.257	0.024
	CPB	8	3 (2–4)		
Operation time (min)	IOBH	7	90 (75–105)	−1.185	0.236
	CPB	8	120 (110–150)		

CPB: cardiopulmonary bypass; and IOBH: inflow occlusion on beating heart.

The mean duration of hospital stay and ICU stay, mean intubation time, mean unit(s) of packed red blood cells used were significantly lower in the IOBH group when compared with the CPB group ($p < 0.05$) (Table 3).

4. Discussion

IOBH used to be a frequent technique before the CPB era, although it has lost its popularity with the use of CPB in daily practice. Recently, IOBH is used in the removal of some materials as intracardiac thrombus, catheter, and pace leads; in cardiac wounds, in pulmonary embolectomy, and in congenital cardiac defects such as pulmonary stenosis [1–7].

In our study, consistent with the literature, the IOBH technique was used in such procedures as removal of the right atrial thrombus and catheter and right atrial or ventricular pace leads.

To our knowledge, there are not many studies comparing both IOBH and CPB techniques. These studies mostly deal with congenital cardiac surgery [8,9]. Nevertheless, there are many case reports published regarding the use of the inflow occlusion technique. In one of these studies, Gürbüz et al. reported that they successfully removed a pacemaker lead from a patient with endocarditis using the IOBH technique [5]. Tokmakoglu et al. reported the extraction of a right atrial thrombus using IOBH in a patient with gastric carcinoma [4]. In another case report, successful right atrial thrombectomy with IOBH was reported in a patient with heparin-induced thrombocytopenia with thrombosis [10]. There are also numerous studies reporting the use of IOBH technique in cardiac wounds [11,12]. In our study, with the use of the IOBH technique, a right atrial thrombus was removed in two cases, whereas a right atrial pacemaker lead was removed in one case, right ventricular pacemaker leads were removed in three cases, and one Swan-Ganz catheter was removed from the right atrium.

CPB may become necessary particularly in cases with complicated right atrial material. This necessity is due to comorbidities of the patient, extension of the material, and its potential for pulmonary embolism. Studies demonstrated that use of CPB is particularly common in cases with coexistence of extracardiac tumors and large, invasive, right atrial thrombus [13–15]. The IOBH technique as well as CPB may be used in the extraction of intracardiac pacemaker leads [16,17]. In our study, with the use of the CPB technique, a right atrial thrombus was removed in four cases, whereas a right ventricular thrombus was removed in two cases, and right ventricular pacemaker leads were removed in two cases.

There are also some disadvantages to the use of the IOBH technique. Cardiac and neurological complications may be seen due to systemic and cerebral malperfusion, particularly in occlusions of more than 3 min [1]. In our study, we paid particular attention to not exceeding 3 min. Inflow occlusion was performed in periods of 45 s. An interval of 3 min was permitted for normal flow after each occlusion period. The mean inflow occlusion time was 100 ± 32 (60–150) s. With the application of such precautions, no complication was observed in a patient.

Another unwanted situation is that with the use of IOBH, more blood transfusion was needed when compared with

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CPB. Eventually, aspirated blood could not be readministered to the patient in contrast to CPB. However, with advances in medical technology, autotransfusion devices could partially overcome this problem. Therefore, we used cell-saver aspirators while performing this technique. As a result, we noticed that, in the IOBH group, a mean of 1.43 ± 1.13 units of blood was used, whereas, in the CPB group, a mean of 2.75 ± 0.71 units of blood was used. This means that, in the IOBP group, the amount of blood transfused was significantly lower.

Another advantage of IOBH is that the inflammatory response would be less pronounced that in the case of CPB. As a result of this, although there was no significant difference between two groups regarding the operation time, duration of hospital stay, duration of ICU stay, and intubation time were significantly lower in the IOBH group.

Consequently, CPB is definitely the method of choice in complicated cases where the intracardiac mass is very large or invading the surrounding tissues and the foreign body is diffusely infected. However, in some circumstances where the preoperative management was held optimally in cases with comorbidity that could complicate CPB, the IOBH technique could be preferred successfully by experienced surgical teams using some tools as autotransfusion equipments.

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