

Totally Minimized Extracorporeal Circulation: An Important Benefit for Coronary Artery Bypass Grafting in Jehovah's Witnesses

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Claude Vaislic, MD, Olivier Bical, MD, Claude Farge, MD, Didier Gaillard, MD, Olivier Ponzio, MD, Yves Ollivier, MD, Youcef Abdelmoumen, MD, Bruno Robine, MD, Gérard Souffrant, MD, Touami Bouharaoua, MD

Centre Médico Chirurgical Parly 2, Le Chesnay, France

ABSTRACT

Background: Jehovah's Witnesses who require cardiac surgery represent a challenge to the physician because of their refusal to accept blood transfusions. Because coronary artery bypass grafting (CABG) is performed by most surgeons under cardiopulmonary bypass (CPB), which has potentially deleterious effects on hemostasis, we used a new concept called minimal extracorporeal circulation (MECC). MECC includes heparin-coated tubing, a centrifugal pump, and an oxygenator. There is no venous reservoir or vent, and suction is used through the cell saver. We assessed the hypothesis that MECC in combination with low-volume blood cardioplegia preserves more hemoglobin than conventional CPB in standard CABG.

Methods: In 40 patients of the Jehovah's Witnesses faith undergoing CABG with the use of MECC and intermittent warm blood cardioplegia, clinical and biological data as well as values for parameters of hemolysis (plasma hemoglobin) and myocardial damage (troponin T) were determined. The results were compared with those of a control group of 40 patients who underwent operations with standard CPB.

Results: Demographics, hemodynamics, the number of anastomoses, and CPB and cross-clamp times were comparable between the groups. MECC patients demonstrated significantly lower peak levels of plasma hemoglobin (21.8 ± 114 mg/dL versus 35.4 ± 15 mg/dL) and troponin T (0.12 ± 0.4 ng/mL versus 0.65 ± 0.7 ng/mL), a higher minimum hematocrit level during CPB ($30\% \pm 7\%$ versus $23\% \pm 6\%$), and a higher hemoglobin level 2 days after surgery (13 ± 3 g/100 mL versus 9.4 ± 0.98 g/100 mL). Preoperative values were not significantly different.

Conclusion: The use of MECC instead of conventional CPB reduces hemolysis, hemodilution, blood loss, and myocardial damage.

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Address correspondence and reprint requests to: Claude Vaislic, MD, FETCS, CMC Parly 2, 21 rue Moxouris, 78150 Le Chesnay, France; 33-663294841 (Claudevaislic@hotmail.com).

INTRODUCTION

Jehovah's Witnesses requiring cardiac surgery represent a challenge to the physician because of these patients' refusal to receive blood transfusions. In this context and in the face of progressively increasing risk for cardiac surgery patients, an improvement is needed. It has been demonstrated that avoiding patient transfusions after cardiac surgery is possible only with a variety of different but complementary means [Forest 2002]. Although no single means is able to resolve the problem on its own, an ensemble approach can provide a solution.

Whereas most surgeons perform coronary artery bypass grafting (CABG) with cardiopulmonary bypass (CPB), which has potentially deleterious effects on hemostasis, we have used a new concept called minimal extracorporeal circulation (MECC), which is designed to compensate for the potential hazards of CPB by reducing the contact of blood with air and foreign bodies. An additional benefit of this method is a significant decrease in postoperative bleeding.

METHODS

The MECC system is a closed cardiopulmonary bypass that excludes the blood-gas interface but includes heparin-coated tubing that is as short as possible, an active venous drainage, a centrifugal pump, and a membrane oxygenator. There is no venous reservoir or aortic vent, the cell saver being the only means of suction in the operative field. The total priming volume of only 500 mL can be totally eliminated whenever possible with the retropriming method. The patient's core temperature is allowed to drift to 34°C , and ventilation is stopped. The aorta is cross-clamped, and the heart is arrested by intermittent warm blood cardioplegia. Coronary anastomoses are realized on an arrested heart with a dry, still operative field. The proximal anastomoses are also realized under MECC with single lateral aortic cross-clamping.

Between January 2001 and June 2003, 40 patients of the Jehovah's Witnesses faith underwent CABG with this technique. Outcome data were collected for clinical parameters as well as for markers of inflammation (interleukin 6), hemolysis (plasma hemoglobin), and myocardial damage (troponin T). Results were compared with a control group of 40 patients who underwent operations with standard CPB during the same period. We assessed the hypothesis that MECC in combination with retropriming and low volume blood cardioplegia

Table 1. Patient Characteristics*

Clinical Data	MECC JW (n = 40)	Standard CPB (n = 40)
Female sex, n	12	14
Age, y	69 ± 5	71 ± 8
Body mass index	24 ± 6	22 ± 9
LVEF, %	63 ± 14	65 ± 11
Diabetes mellitus	20%	25%
Renal insufficiency	10%	10%
Stroke	5%	10%
Hypertension	80%	60%
Hyperlipidemia	50%	55%
EuroSCORE	3.9	4.1

*MECC JW indicates minimized extracorporeal circulation with Jehovah's Witnesses patients; CPB, cardiopulmonary bypass; LVEF, left ventricular ejection fraction.

preserves more hemoglobin and blood mass than conventional CPB with standard CABG procedures.

The primary end point was therefore to compare postoperative bleeding between the groups. The secondary end point was to confirm the clinical evaluation with biological, hematologic, inflammatory, and tissue parameter measures. To study only these objectives, we selected only patients at low risk, based on the EuroSCORE model and the Parsonnet score. Fifteen patients were consequently withdrawn from this cohort because of an ejection fraction lower than 25%, a cardiac surgery history, a nonelective intervention, or an associated renal insufficiency (creatininemia greater than 15 mg/dL).

RESULTS

Demographics, hemodynamics, number of anastomoses, and CPB and cross-clamp times were comparable for the two groups (Tables 1 and 2). No differences were found in

Table 2. Clinical Data*

	MECC JW	Standard CPB	p
Bypasses, n	3.4 ± 1	3.1 ± 1	
ECC, min	59 ± 21	62 ± 24	
Cross-clamping, min	51 ± 15	53 ± 16	
CP volume, mL	500 ± 7	1500 ± 488	<.05
ACT maximum, s	870 ± 97	850 ± 147	
Blood loss, mL	312 ± 141	721 ± 619	<.05
Patients transfused, %			
Intraoperative	0	2	<.05
Total	0	2	<.05
Ventilation (range), h	2 (0-5)	2 (0-6)	
ICU stay (range), d	2 (0-4)	2 (0-5)	
Hospital stay (range), d	9 (8-11)	11 (8-14)	

*MECC JW indicates minimized extracorporeal circulation with Jehovah's Witnesses patients; CPB, cardiopulmonary bypass; ECC, extracorporeal circulation; CP, cardiopulmonary priming; ACT, activated coagulation time; ICU, intensive care unit.

Table 3. Patient Complications*

Complication	MECC JW, n	Standard CPB, n
Mortality	0	0
Infarction	0	2
Low output	0	0
Atrial fibrillation	5	7
Reoperation for bleeding	1	1
Mediastinitis	0	0
Stroke	0	0

*MECC JW indicates minimized extracorporeal circulation with Jehovah's Witnesses patients; CPB, cardiopulmonary bypass.

intensive care unit duration and length of hospital stay. Ultrafast-track surgery with extubation on the operative table was performed in all but 2 patients in each group. The clinical evolution was uneventful in all cases in this low-risk cohort (Table 3). No patient received transfusion in the MECC group, and 2 patients in the control group received transfusions (Table 2).

The MECC patient group demonstrated a significant decrease in postoperative blood loss through the thoracic drainage compared with the control group (312 ± 141 mL versus 721 ± 619 mL). The minimal hematocrit level during CPB and the hemoglobin level 2 days after surgery were also increased (30% ± 7% versus 23% ± 5% and 13 ± 3 g/100 mL versus 9.4 ± 0.98 g/100 mL, respectively) relative to preoperative values, which were not significantly different between the two groups (Figures 1 and 2). Peaks of plasma hemoglobin and troponin T were also decreased in the MECC patient group (21.8 ± 114 mg/dL versus 35.4 ± 15 mg/dL and 0.12 ± 0.4 ng/mL versus 0.65 ± 0.7 ng/mL, respectively) (Figures 3 and 4).

DISCUSSION

Interest of MECC

Standard extracorporeal circulation (ECC) is altered by complications such as inflammatory process activation,

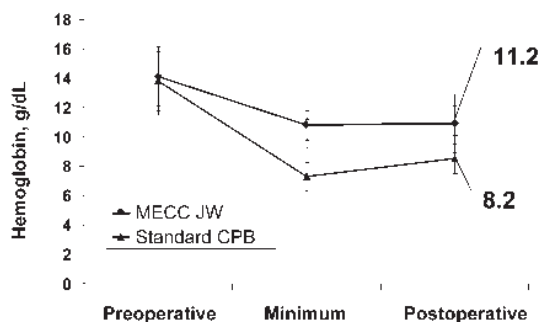


Figure 1. Hemoglobin levels before, during, and after surgery in Jehovah's Witnesses patients undergoing operations with minimized extracorporeal circulation (MECC JW) and in patients undergoing operations with standard cardiopulmonary bypass (CPB).

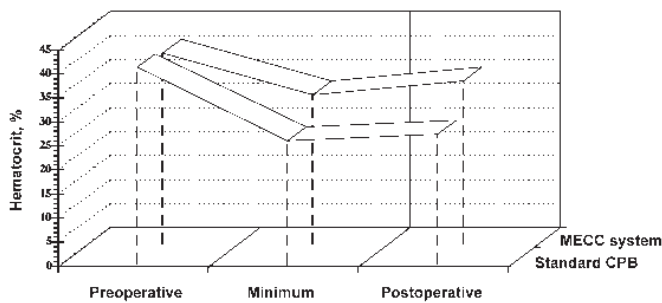


Figure 2. Hematocrit levels before, during, and after surgery in Jehovah's Witnesses patients undergoing operations with minimized extracorporeal circulation (MECC JW) and in patients undergoing operations with standard cardiopulmonary bypass (CPB).

coagulopathies, and nonunivocal pathogeny embolism induction. These mechanisms lead to neurologic, cardiac, and hematologic problems that in turn may cause an increase in postoperative bleeding. Given these disorders, a first answer was to definitely suppress ECC in coronary revascularization surgery via the technical development known as beating heart surgery.

In the last decade, CABG patients have generally been older and more seriously ill with multiple organ dysfunctions. If these comorbidities were the only parameter to take into account, beating heart surgery would indeed be a logical solution [Folliguet 2003]. However, the principal characteristic of these patients is a diffuse, evolved coronary effect on spindly arteries often previously dilated or stented. Grafting these kinds of vessels is technically more difficult than what was proposed to surgeons only 10 years ago. Recent prospective studies on these kinds of patients have demonstrated a better anastomosis quality and a higher bypass patency on the arrested heart (particularly in the marginal area) than on the beating heart [Davit 2002]. This situation is all the more true because meager internal mammary arteries or sequential anastomoses with a 9×0 wire in the case of a totally arterial revascularization are used. For these reasons, we favor the gold standard of the arrested

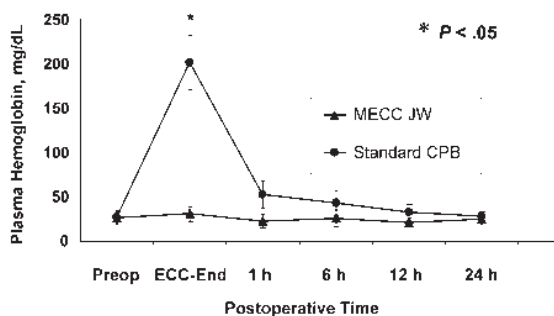


Figure 3. Hemolysis levels before, during, and after surgery in Jehovah's Witnesses patients undergoing operations with minimized extracorporeal circulation (MECC JW) and in patients undergoing operations with standard cardiopulmonary bypass (CPB). Preop indicates preoperative; ECC, extracorporeal circulation.

heart bypass. MECC represents an attractive solution to reduce classic ECC iatrogenicity.

MECC avoids blood-air contact with the elimination of all suction, the left vent, and the reservoir. It uses less tubing, therefore reducing blood-foreign surface contact, creates better flow conditions with less resistance to overcome, and causes less hemodilution by reducing the priming solution [Fromes 2002, Liebold 2002].

These several points favor blood loss reduction. This study concerns only patients with low operative risk to avoid the addition of adverse parameters (redux operation, log care ECC on altered ventricular functions, and renal insufficiency, which could make result interpretation difficult). In our daily practice, MECC is applied with all of our coronary patients, regardless of the operative risk. Our results are as favorable as those prolifically reported in the literature.

Postoperative Transfusion

Recently, current technical advances have suggested that bloodless cardiac surgery is possible, and the question remains whether avoiding transfusions is an important goal in itself, besides the reduction in the risk of infection and cost containment. In fact, more than 3000 papers have been published delineating the risk of transfusion.

An article [Engoren 2002] and an editorial [Spieß 2002] published in the *Annals of Thoracic Surgery* in October 2002 reported for the first time the effects of blood transfusion on long-term survival after cardiac operation. That the transfusion trigger is not defined by clear physiological parameters with important differences in resuscitator decisions between various centers and different resuscitators of a same center was established beyond reasonable doubt. The authors of the study reported ". . . that patients transfused during elective CABG surgery were twice as likely to die as those not transfused. Transfusion in CABG surgery is associated with an increased mortality and is a significant and independent predictor of death" [Engoren 2002]. If these results challenge the current medicolegal context, then efforts should be made to avoid blood transfusions to all patients and not just to Jehovah's Witnesses.

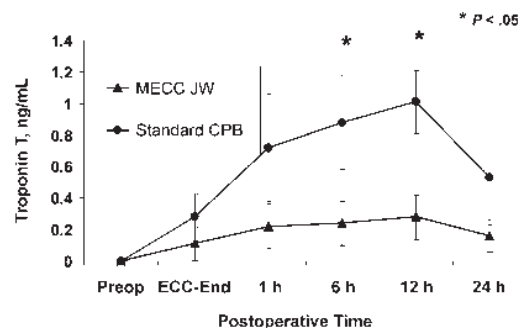


Figure 4. Myocardial damage as measured by troponin T levels before, during, and after surgery in Jehovah's Witnesses patients undergoing operations with minimized extracorporeal circulation (MECC JW) and in patients undergoing operations with standard cardiopulmonary bypass (CPB). Preop indicates preoperative; ECC, extracorporeal circulation.

Care of Jehovah's Witnesses Patients

Taking care of patients who are Jehovah's Witnesses imposes a multifactor approach to treatment because of the contractual impossibility of giving them transfusions. Treatment, therefore, cannot be limited to the use of MECC but has to be integrated into a protocol incorporating a "multi-modality blood conservation strategy," which is inspired by numerous previous works and has been formalized by the Cornell University team [Helm 1998].

The 40 patients in the present study have been integrated via the application of a strategy of constant improvement into a series of 207 patients who underwent operations over a 14-year period. Before surgery and after eliminating unrealistic indications of high risks for transfusions, reducing biological samples, and avoiding hematoma, we require a minimum hemoglobin level of 14 g/dL. If the patient does not reach this minimum level, we use erythropoietin and high doses of iron. This therapeutic strategy is continued in the postoperative period until the patient achieves a hematocrit value of 28%. During surgery, MECC and normothermia with blood cardioplegia avoids hemodilution and the activation of the inflammatory mechanism. The use of aprotinin, a cell saver, and fibrin glue, when accepted by the patient, are added to achieve an acute hemostasis. After surgery, we apply the same methods as before, and hemostatic redo decision choices are multiple.

For three decades, the approach to the care of Jehovah's Witnesses in all areas of cardiac surgery has been validated by numerous and prestigious surgical teams in thousands of cases and is now well codified [Ott 1977, Jovanovic 2000, McMullan 2000, Brest van Kempen 2002]. Such care has allowed, among other benefits, transplantations and pediatric surgeries [Burnett 1990, Forest 2002], but it clearly remains an additional risk and a challenge that is sometimes dangerous. It has also permitted the generalization of blood-saving methods to all patients to avoid transfusional risks, the importance of which has now clearly been demonstrated.

CONCLUSION

MECC is a simple and safe alternative to conventional ECC in isolated CABG and leads to excellent patient outcomes. No adverse event has been related to the system. It is well accepted by surgeons, anesthesiologists, and perfusionists that MECC has advantages over standard ECC, ie, less hemodilution, hemolysis, inflammation, and myocardial damage, and has a

positive clinical impact by reducing transfusion needs and resulting in a lower incidence of organ complications.

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