Clinics in Surgery

Research Article
Published: 01 Dec, 2017

Percutaneous Retrograde Cardioplegia in Minimal Access Aortic Valve Replacement Reduces Aortic Cross-Clamping Time Significantly

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Abstract

Introduction: One of the main obstacles of minimally invasive surgery for Aortic Valve Replacement (M-AVR) is the increased Cardiopulmonary Bypass (CPB) and aortic cross-clamping time. We Hypothesize that the use of a percutaneous coronary sinus catheterto deliver retrograde cardioplegia may facilitate surgery and reduce CPB- and aortic cross-clamping time.

Methods: Data were collected prospectively at the Amphia Hospital, Breda, and the Netherlands from May 2014 to May 2016 and were analysed retrospectively. A total of 40 M-AVR patients were included. In all cases warm blood cardioplegia was used. The initial dose of cardioplegia was administered antegradely through the aortic root in all 40 patients. In all patients cardioplegia was repeated each 20 min. Patients with a percutaneous coronary sinus catheter received their following doses of cardioplegia retrogradely, whereas patients without a coronary sinus catheter received cardioplegia selectively through the coronary ostia.

Results: 23 patients received retrograde cardioplegia through a percutaneous coronary sinus catheter versus 17 patients that received their cardioplegia solely antegradely. Mean aortic cross-clamp time was significantly shorter in the percutaneous coronary sinus catheter group (63 ± 11 *vs.* 55 ± 12, p=0.045).The mean CPB time was 8 minutes shorter in the percutaneous coronary sinus catheter group, although this was not significant (82 min ± 14 *vs.* 74 min ± 14, p=0.075). Maximum Troponin T did not differ significantly between the two groups (0.12 [0.08] *vs.* 0.13 [0.11], p=0.227).

Conclusion: Percutaneous retrograde cardioplegia administered through a coronary sinus catheterin minimal invasive AVR reduces aortic cross-clamping time significantly.

Keywords: Retrograde cardioplegia; Minimally invasive surgery aortic valve replacement; Percutaneous coronary sinus catheter

Introduction

Minimally invasive surgery for Aortic Valve Replacement (M-AVR) was introduced in 1996 and is now an acknowledged and established method of surgery. Compared to conventional sternotomy for aortic valve replacement (AVR), M-AVR diminishes postoperative ventilation time, reduces pain, hospital length of stay, time until return to full activity, and decreases use of blood products [1-10]. Although M-AVR has a mortality rate comparable to conventional AVR [1-8], one of the main obstacles of M-AVR is the increased Cardiopulmonary Bypass (CPB) and aortic cross-clamping time [9,10]. At the Amphia Hospital Breda, The Netherlands, intermittent 20:1 diluted warm blood cardioplegia solution, administered at a 20-minutes interval, is used since many years. Unfortunatelyrepeated ante grade warm blood cardioplegia delivery selectively through both coronary ostia can be time consuming. Labriola, et al. [11] published in 2016 that the use of necklines may facilitate surgery by reducing the number of lines to be inserted and removed by surgeons, and provide an unobstructed view of the surgical field [11]. Labriola et al. also showed that retrograde cardioplegia can be delivered through a percutaneous Coronary Sinus Catheter (CSC), guided by Transoesophageal Echography (TEE), via the right internal jugular vein (PR9 Catheter, Edwards Scientific, Salt Lake City, Utah USA), positioned in the coronary sinus [11]. To show possible benefits of this retrograde canula we analysed our M-AVR data retrospectively, focussing on CPB time and aortic cross-clamping time.

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Received Date: *27 Sep 2017*
Accepted Date: *22 Nov 2017*
Published Date: *01 Dec 2017*

Citation:
Scohy TV, van Kerckhoven G, Bentala M, Bramer S, Laboutv JAM, Gerritse BM. Percutaneous Retrograde Cardioplegia in Minimal Access Aortic Valve Replacement Reduces Aortic Cross-Clamping Time Significantly. Clin Surg. 2017; 2: 1796.

Table 1: Baseline characteristics.

	Percutaneous M-AVR	Antegrade M-AVR	P-value
TOTAL	**N=23**	**N=17**	
Sex (Male)	15 (65.2)	11 (64.7)	0.973
Age	69.00 ± 11	66.39 ± 12	0.2
BMI	27.1 ± 4.8	26.2 ± 4.6	0.347
NYHA Classification			0.726
None	12 (52.2)	10 (58.8)	
I	1 (4.3)	1 (5.9)	
II	6 (26.1)	2 (11.8)	
III	4 (17.4)	4 (23.5)	
EuroSCORE I	5 [3-7]	4 [0-8]	0.621
Pre-operative Hb (mmol/L)	8.6 ± 1.5	8.2 ± 1.6	0.634
Pre-operative creatinine (umol/L)	85 ± 18	80 ± 23	0.242
Co-morbidity			
Left ventricular function			0.455
<30%	-	-	
30-50%	3 (13)	1 (5.9)	
>50%	20 (87)	16 (94.1)	
COPD	1 (4.3)	3 (17.6)	0.166
Peripheral arterial disease	-	3 (17.6)	0.036
CVA	1 (4.3)	-	0.384
TIA	-	3 (17.6)	0.036
Diabetes Mellitus type II	2 (8.7)	3 (17.6)	0.397
Hypertension	10 (43.5)	5 (29.4)	0.364
Hypercholesterolemia	9 (39.1)	4 (23.5)	0.298
Pulmonary hypertension	-	1 (5.9)	0.239
A trial fibrillation	2 (8.7)	-	0.212
Aortic valve regurgitation	1 (4.3)	2 (11.8)	0.379
Left ventricular hypertrophy	20 (87.0)	17 (100)	0.122

BMI: Body Mass Index; NYHA: New York Heart Association classification of dyspnoea; EuroSCORE: additive European System for Cardiac Operative Risk Evaluation; COPD: Chronic Obstructive Pulmonary Disease; CVA: Cerebrovascular Accident; TIA: Transient Ischemic Attack
Qualitative data are given as absolute number (percentage); quantitative data are given as median value & IQR or mean & st. dev when normally distributed

Materials and Methods

Study design, setting and patients

Data were prospectively collected at the Amphia Hospital, Breda, and the Netherlands from May 2014 to May 2016 and analysed retrospectively. A total of 40 M-AVR patients, diagnosed with severe aortic stenos is, were included. Patients were 18 years or older and were operated by either one of two experienced cardiothoracic surgeons in M-AVR (MB and SB). In our institution, warm blood cardioplegia is intermittently delivered, every 20 min, with the purpose of inducing and maintaining cardioplegic arrest. The cardioplegic solution is produced by mixing oxygenated blood with a hyperkalemic solution in a 20:1 ratio.The initial dose of cardioplegia was administered antegrade through the aortic root in all 40 patients. In all patients cardioplegia was repeated after 20 min. Patients, with a percutaneous coronary sinus catheter, received their following doses of cardioplegia retrogradely. Patients without a percutaneous coronary sinus catheter received their following doses antegradely by selective canulation of the coronary ostia. Patients received either a bio prosthetic or mechanical valve. The percutane coronary sinus catheter (retrograde cardioplegia) was solely employed when one of the two cardiothoracic anaesthesiologists, who are experienced in the use of this device, were available (BG and TS). The standard cardiac-anaesthesia protocol was used in all patients. After induction with midazolam, sufentanil and rocuronium, anaesthesia was maintained with sevoflurane and remifentanil. As patients were not subjected to investigational actions the medical ethics commission was notified, but further approval of a medical ethics commission was not necessary. Patient confidentiality was guaranteed according to the Dutch law on personal data protection.

Operative technique

The operative technique of M-AVR has been extensively described [12-14]. A vertical small 5 cm skin incision is made on the region of the manubrium sterni joint. A partial J-sternotomy is performed with a Hall® Saw. The J parts of the bone incision is performed with the

Table 2: Operative characteristics.

	Percutaneous M-AVR	Antegrade M-AVR	P-value
TOTAL	N=23	N=17	
CPB time (min)	74.09± 13.54	82.06 ± 13.709	0.075
ACC time (min)	54.78 ± 12.354	62.59 ± 10.995	0.045

CPB: Cardiopulmonary Bypass; ACC: Aortic Cross-Clamping
Qualitative data are given as absolute number (percentage); quantitative data are given as median value & IQR or mean & st. dev. when normally distributed

Table 3: Postoperative outcomes.

	Percutaneous M-AVR	Antegrade M-AVR	P-value
TOTAL	N=23	N=17	
Maximum Troponin T (umol/L)	0.12 [0.08]	0.13 [0.11]	0.227
Postoperative myocardial infarction#	0	2 (11.8)	0.091
Postoperative potassium (mmol/L)	4.822 ±0.4295	4.941 ±0.3743	0.365
Maximum creatinine (umol/L)	87 [32]	79 [17]	0.124
Other adverse events	0	1 (5.9)	0.239

#Postoperative MI, defined as: a changing ECG with signs of ischemia and elevated Troponin T (see Data collection)
Qualitative data are given as absolute number (percentage); quantitative data are given as median value & IQR or mean & st. dev. when normally distributed

unprotected blade of the Hall® Saw, from lateral to medial and from the second or the third inter costal space, depending on the body habitus of the patient. The pericardium is opened and the pericardium edges are pulled out through the incision, and fixed to the skin. The right femoral vein is used for vein cannulation. A Sorin double staged vein cannula is placed through the femoral vein using the Seldinger technique, positioned under TEE guidance. The arterial cannulation is done centrally in the ascending aorta. An aortic root needle is placed. Venting takes place through the aortic valve. The retrograde cardioplegia coronary sinus catheter is placed percutaneously through the right internal jugular vein guided by TEE guidance. All intended percutane coronary sinus catheters are adequately positioned without any negative side effects. The aorta is cross-clamped using a Cosgrove flexible aortic cross-clamp. Cardioplegia delivery was considered successful when dark blood appeared from both coronary ostia administration.

Data collection

Data were retrospectively collected; baseline characteristics, such as patient age and sex, pre-operative Hb and creatinine. Pre-operative comorbidity, such as left ventricular function, aortic valve regurgitation and left ventricular hypertrophy. Collected operative characteristics were CPB time and aortic cross-clamping time. Postoperative outcome measures were maximum Troponin T, postoperative myocardial infarction, postoperative potassium, maximum creatinine and postoperative adverse events. Primary we compared CPB time and aortic cross clamping time between the PR9 retrograde- and the anterograde cardioplegia group. Secondly, we investigated whether the difference in clamping time led to difference in myocardial damage, measured by maximum Troponin T and the occurrence of myocardial infarction postoperatively.

Definition of adverse events

Death in relation to surgery was defined as any death occurring during the same hospital admission as for the surgery. Renal disorders were defined as an elevated creatinine, decreased urine output and the necessity for Continuous Veno-Venous Hemofiltration (CVVH). Postoperative myocardial infarction was defined as a changing ECG with signs of ischemia and elevated troponin T. The category other adverse events was used as a collection category.

Statistics

All data were analysed using SPSS Statistics Version 22 (IBM, Armonk, NY, USA). Categorical variables are described as numbers (percentages). Continuous variables were described as mean (± standard deviation) if normally distributed, or median [inter quartile range] if not normally distributed. Statistical analyses between the two groups were made using the unpaired T test for numerical variables and the Pearson Chi Square for categorical data. Statistical significance was accepted as $p<0.05$.

Results

A total of 40 patients had elective M-AVR during the study period. Twenty-three patients received retrograde cardioplegia through a percutane coronary sinus catheter (Retrograde M-AVR group). The patient's demographic characteristics are listed in Table 1. Operative characteristics are presented in Table 2. Mean aortic cross-clamping time was significantly shorter in the retrograde M-AVR group (63 min ± 11 *vs*. 55 min ± 12, p=0.045). The mean CPB time was slightly longer in the solely antegrade cardioplegia M-AVR group, but did not differ significantly (82 min ± 14 *vs*. 74 min ± 14, p=0.075). The main clinical outcomes of the groups are presented in Table 3. Maximum Troponin T did not differ between the two groups (0.12umol/L [0.08] *vs*. 0.13umol/L [0.11], p=0.227). There were two postoperative myocardial infarctions in the antegrade M-AVR group as opposed to zero in the retrograde M-AVR group. However, this difference was not statistically significant (p=0.091). One patient in the antegrade M-AVR group required a re-exploration due to excessive drain production, caused by leakage from the aortic seam.

Discussion

The present study shows that retrograde cardioplegia through a percutane coronary sinus catheter does reduce aortic cross-clamping time significantly during M-AVR. We also see a tendency of shorter CPB times of mainly 8 min in the retrograde cardioplegia M-AVR group. This can be explained by the fact that administering retrograde cardioplegia through a percutane coronary sinus catheter, in a setting of M-AVR, facilitates delivery of cardioplegia, as the surgical procedure does not have to be stopped for administration of selective cardioplegia in both coronary ostia, which sometimes can be time-consuming and challenging in M-AVR. Adequate cardioplegia delivery must only be checked, by the appearance of dark fluid from both coronary ostia. As published by Labriola, et al. [11] the percutane coronary sinus catheter ensure effective retrograde cardioplegia of the heart and allow surgeon stop rate in an unobstructed surgical field [11]. On the other hand the anaesthesiologist will need some extra time to deploy the percutane coronary sinus catheter successfully [11]. Shehada et al. [10] published comparable aortic cross-clamp times (M-AVR 65.6 ± 18.4 min *vs.* conventional AVR 64.3 ± 19.8 min, P=0.25) in his propensity score analysis between M-AVR and conventional AVR (n=585 in both groups) [10], those aortic cross-clamp times are comparable with our solely antegrade cardioplegia M-AVR (63 ± 11 min). On the other hand, Shehada, et al. [10] published much longer operation time compared to a full sternotomy because of limited exposure of the heart and much longer CPB times for M-AVR compared with conventional AVR (93.5 ± 25 *vs.* 88 ± 28 min, P<0.001) [10]. Our CPB times (82 ± 14 min *vs.* 74 ± 15 min) are much shorter, which can partially be explained by a gain of experience over time. The main principle of myocardial protection in cardiac surgery is to preserve myocardial function by preventing ischemia with the use of cardioplegia. Therefore, in our institution, warm blood cardioplegia is intermittently delivered in the coronary arteries. We are well aware of the fact that myocardial protection is still a major issue in cardiac surgery, since inadequate protection increases the risk of postoperative cardiac dysfunction. We only saw a significant reduction of aortic cross-clamp time in this study. The sample size of this pilot study was generally not large enough to detect a significant difference of maximum Troponin T (0.12 umol/L [0.08] *vs.* 0.13 umol/L [0.11], p=0.227) between the groups, therefore 948 patients are needed. Minimal invasive AVR has several advantages such as shorter length of stay [1-3,5,6,8] shorter duration of ventilation [1,2,6,8], decreased time until return to full activity [2], improved cosmetics [4,8,10], decreased rate of postoperative renal failure [5] and less postoperative pain [8] compared with conventional AVR. A recent meta-analysis found no significant difference between AVR and MAVR for postoperative a trial fibrillation, myocardial infarctions, pneumonia, pneumothorax, sternal/wound infections or mortality rate [3]. Since our study shows a significant reduced aortic cross-clamp time with the use of a percutane coronary sinus catheter for retrograde cardioplegia, additional studies are required to determine whether the use of percutane coronary sinus catheter is associated with better outcomes in M-AVR.

Study Limitations

The present study is based on a retrospective analysis of our prospectively collected database, and thus it reflects a single centre experience only, and carrying all the limits that a retrospective analysis design implies.

Conclusion

Retrograde cardioplegia administered through a percutane coronary sinus catheter in minimal invasive AVR reduces aortic cross-clamping time significantly.

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