The Heart Surgery Forum #1998-75226
1 (2):142–145, 1998 Online address: www.hsforum.com/vol1/issue2/1998-75226.html

Continuous Warm Blood Cardioplegia Pitfalls and Solutions

(#1998-75226 ... October 30, 1998)

Giuseppe Rescigno, MD, Patrick Nataf, MD, Richard Raffoul, MD, Ramzi Ramadan, MD, Marcio Scorsin, MD, Arrigo Lessana, MD

Department of Cardiac Surgery, Centre Cardiologique du Nord (CCN), Saint Denis, France

ABSTRACT

Background: Continuous warm blood cardioplegia offers superior preservation in both routine and complicated cardiac cases. Management of continuous perfusion is an important task during each case.

Methods: The authors have developed several specific techniques to ensure stable catheter insertion and placement for continuous coronary sinus or antegrade ostial perfusion.

Results: Over 3,800 patients have been operated on with continuous warm blood cardioplegia using catheter techniques as described in this article. The overall 30-day mortality was 3.9%.

Conclusions: Safe application of continuous warm blood cardioplegia has many advantages over prior cold techniques, but surgeons must know certain technical modifications to be able to universally apply continuous techniques safely.

INTRODUCTION

Since the introduction of normothermic blood cardioplegia by Lichtenstein and Salerno in 1991, [Lichtenstein 1991A], many studies have shown its superior effects on myocardial protection compared with those of conventional cold blood cardioplegia. [Lichtenstein 1991B, Anonymous 1994, Lessana 1992]. In fact, continuous normothermic coronary perfusion might avoid myocardial ischemia during the aortic cross-clamping [Le Houerou 1992, Menasche 1992]. However, this technique requires an effective, uninterrupted myocardial perfusion of either antegrade or retrograde. Retrograde delivery is safe and reliable, provided that the retroplegia cannula remains in a perfectly stable position. The tip of the cannula should ideally be just one or two centimeters inside the coronary sinus. This provides good perfusion of the whole cardiac venous system. In most cases, this can be easily accomplished using a commercially available coronary sinus catheter inserted through an atrial pursestring. Nevertheless, in some patients, cannulation of the coronary sinus (CS) is difficult or impossible. For these patients we have developed a few techniques to achieve stable cannula position and continuous perfusion.

Address correspondence and reprint requests to: Giuseppe Rescigno, MD, 24 Rue Briant, 92260 Fontenay aux Roses, France, e-mail: grescigno@aol.com

MATERIALS AND METHODS

Transatrial Insertion

Before starting the cardiopulmonary bypass (CPB), we attempt to cannulate the coronary sinus by means of a retroplegia cannula with a self-inflated textured 18 mm balloon (RMI Midvale, Utah). This is introduced through a small incision in the right atrial wall. The cannula placement is verified by palpating the posterior wall of the heart. The cannula is positioned fairly distally into the vessel in order to avoid its displacement during the surgical maneuvers. The pressure side port is connected to a transducer and the waveform is displayed with the other hemodynamic monitors. After aortic cross-clamping, the retrograde cardioplegia injection pressure is checked. If this pressure exceeds 50 mmHg, then the cannula can be gently pulled back.

Assessment of an Effective Retrograde Perfusion

Several signs may indicate good perfusion of the myocardium: (i) a significant back-flow of deoxygenated blood from the opened coronary artery (or from both coronary ostia during an aortic valve replacement procedure); (ii) distension of the epicardial coronary veins, which should be vivid red or pink in color to indicate oxygenated perfusate from the pump (see Figure 1, ◎); (iii) a pathognomonic cyclic pressure waveform in the pressure tracing during the coronary sinus perfusion.

Techniques for Unstable Coronary Sinus Positions

If the position of the cannula seems unstable, the simplest option is to place a folded laparotomy pad around the inferior vena cava and the inferior face of the heart (see Figure 2, ◎). This maneuver wedges the catheter into the ostium of the sinus and reduces slippage. Another option is to secure the cannula by passing a transatrial 5/O Prolene suture (Ethicon, Sommerville, NJ) around the catheter, almost at the level of the coronary sinus origin. This suture is then snared after aortic cross-clamping.

Impossible Coronary Sinus Cannulation

If coronary sinus cannulation is impossible by the standard closed transatrial technique, then we switch to a "direct vision" cannulation. When a double-stage cannula has been used for venous return, the inferior vena cava is taped, the cavoatrial cannula pushed far into the cava and the tape snugged over. The superior vena cava is clamped and the right atrium opened. The coronary sinus is then cannulated under direct vision using the same RMI retroplegia cannula. A 4/O Prolene pursestring suture is placed around the cannula, biting the right atrium wall. If the introduction of a standard RMI cannula appears impossible because of an extremely small coronary sinus, we have used a large (8 mm) coronary perfusion cannula with a balloon tip (Polystan, Vaerlose, Denmark).

For aortic valve replacement, in case of primary coronary sinus cannula dislodgement, we prefer a direct ostium cannulation. This is also used in rare cases in which the coronary sinus cannot be catheterized, even under direct vision, for anomalous or multiple coronary sinuses. Two small-diameter silicone coronary cannulas with a balloon tip (Ref: 215810; Polystan, Vaerlose, Denmark) are placed into the right and left coronary ostia (see Figures 3 and 4, ◎). These cannulas are available in different sizes ranging from 4 to 8 mm. We have found that a 6 mm cannula for the left coronary artery and 5 mm cannula for the right coronary artery are often the optimal sizes. A U-shaped 5/O Prolene suture (22 mm needle) is passed from the inside to the outside of the aorta and snared around the cannula in order to avoid any displacement. Care is taken to avoid positioning the left coronary ostium cannula too far, especially in short left common trunks. Once the cannulas are in place, a continuous antegrade injection of warm cardioplegia is started, without any derangement to the surgical maneuvers.

DISCUSSION

Continuous warm cardioplegia provides superior myocardial protection by relaxing the ventricle, reducing oxygen demands, and providing continuous perfusion to the asystolic, resting heart. Studies have shown a 90% decrease in myocardial oxygen consumption without the need for hemodilution and hypothermia. Return of sinus rhythm and normal contractility are typical outcomes of the continuous warm technique.

However, stable and consistent catheter placement is a critical component that must be mastered to safely utilize continuous warm cardioplegia in a variety of surgical settings. Dislodgement or malposition of retrograde cannulas during continuous warm cardioplegia is a potentially fatal complication. Detection of dislodgment is an important surveillance point for the surgical team using continuous perfusion. Loss in coronary sinus perfusion waveform or pressure, sudden loss in venous distension or color, failure for deoxygenated blood to appear in the coronary arteries are all signs of cannulation dislodgment. It is important that pressure monitoring and transducers are correctly calibrated and displayed in full view of perfusion and support personnel responsible for following the coronary sinus pressure waveform. When a waveform is demonstrated, sudden stoppage of the infusion causes a dramatic fall in pressure which immediately reverses when restarted.

About 1% of the population has a persistant left superior vena cava (PLSVC) which drains into the distal coronary sinus behind the left atrium. This anomaly can be potentially lethal during retrograde cardioplegia if unrecognized. Retrograde cardioplegia will reflux into the PLSVC reducing perfusion of the myocardium. A large PLSCV is recognized by the absense (or atresia) of the innominate vein associated with an abnormally dilated coronary sinus. Small PLSCVs can be present with a normal innominate vein and without any change in the size or shape of the coronary sinus.

For large PLSVCs with absence of the innominate vein, the PLSVC should be cannulated with a small angled venous cannula or vent line, and then occluded with an encircling snare. For small PLSVC, a temporary snare or ligature will prevent occult reflux of coronary sinus perfusate and permit adequate CS pressures during continuous retrograde cardioplegia.

We have consistently utilized continuous warm cardioplegia for the past seven years with excellent results. The mortality rate of 3.9% could seem high when compared to the STS standard. However, this should be compared to the operative risk of the patient population. Since 1997 we have been using the Parsonnet score (Parsonnet 1989) to preoperatively evaluate the patient operative risk. Last year we operated on 552 patients. 21 patients died (3.8%). This percentage includes the patients who died during their hospital stay (even after post-op day 30) and those who died after discharge (but during the first post-op month). The overall mean Parsonnet score was 7,8 ± 4. The mean Parsonnet score for the mortality subgroup was 19 ± 6. Thirteen patients presented a risk score superior to 15. Twenty percent of the patients who died were operated on an emergency basis (external cardiac massage, etc.). If we analyse the low Parsonnet score subgroup (lower or equal to 9), our mortality rate was 1.9%.

In order to cannulate or maintain catheter position, several surgical techniques have evolved to handle the various causes of catheter problems. Most of these ideas are very simple and easy to employ. Widespread use of continuous warm cardioplegia requires the surgical team to be vigilent about monitoring perfusion and to be able to deal with catheter malpositions of different types when they arise. Using an open insertion technique as described above, nearly every case can be converted to retrograde perfusion.

If not, stable coronary ostial perfusion as described herein perserves the advantages of the continuous technique.

These few techniques may allow the use of continuous warm heart cardioplegia even in those rare cases where standard retrograde delivery of cardioplegia is difficult or impossible.

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REVIEW AND COMMENTARY

1. Editorial Board member EK34 writes:

The authors need to give in-hospital mortality + 30 day. This is consistent with the STS in defining OP Mort. Since the average OP Mortality is 3.9%, how can the authors say this is excellent since the STS database lists an average mortality of around 3.4%. If the authors' state their patients are sicker, they need proof.

2. Editorial Board member TL41 writes:

This is a good, clear, practical "how-I-do-it" paper, by authors who appear to have an extensive experience of this technique. The overall mortality of 3.9% at 30 days is, on the face of it, high, but might be explained on a basis of case profile, etc.

Author(s)' Response by Giuseppe Rescigno, MD:

Reviewer EK34 and reviewer TL41 found that our in-hospital mortality is higher than the STS standard. Unfortunately we have started to use an operative risk score (the Parsonnet score) at the beginning of 1997. Therefore my analysis will concern 1997 results only. Last year we operated on 552 patients. 21 patients died (3.8%). This percentage includes the patients who died during their hospital stay (even after post-op day 30) and those who died after discharge (but during the first post-op month). The overall mean Parsonnet score was 7,8 ± 4. The mean Parsonnet score for the mortality subgroup was 19 ± 6. Thirteen patients who died had a risk score superior to 15. Twenty percent of the patients who died were operated on an emergency basis (ECM, etc.). If we analyse the low Parsonnet score subgroup (lower or equal to 9), our mortality rate was 1.9% which, I believe, is a good result. Finally, you may also consider that indication for valve diseases are more frequent in Europe than in the USA and this kind of patient is often sicker than the elective CABG patients. We have added these data to the paper.

3. Editorial Board member TL41 writes:

I would find it helpful to know how frequently each modification was used, and results in those subsets. Also some discussion of when and why, if ever, it is better to abandon the warm cardioplegia strategy.

Author(s)' Response by Giuseppe Rescigno, MD:

Reviewer TL41 would like to know how frequently each modification was used. I have no precise statistics about this point. I should say that direct vision coronary sinus cannulation is rarely performed (perhaps 0.5% of the cases). On the contrary, coronary ostia cannulation is more frequently used (about 2% of the aortic valve replacements). I have noted that, especially for aortic valve stenosis, coronary sinus diameter is frequently small, probably because of the LV hypertrophy. Preventive retroplegia cannula snaring is frequently performed by one of us (Ri.R.). I believe that it is never wise to abandon the warm cardioplegia; one option is to switch to intermittent antegrade cardioplegia.

4. Editorial Board member TD9Z writes:

Could the authors briefly compare this technique to the now-popular intermittent antegrade warm blood cardioplegia. A list of references will be helpful.

Author(s)' Response by Giuseppe Rescigno, MD:

Reviewer TD9Z would appreciate a brief comparison between continuous and intermittent warm cardioplegia. In fact these few techniques may be also used for intermittent antegrade or retrograde warm blood cardioplegia. We believe that the comparison between these different ways of delivering cardioplegia was not the aim of our paper.

5. Editorial Board member SC389 writes:

A statement is made in the discussion that studies have shown a 90% decrease in myocardial oxygen consumption etc. without specific references. It is a how-I-do-it paper and I did not clearly understand the perfusion temperature seperate to the cardioplegia temperature. He mentions 3.9% mortality without specifics of cohorts of patients. Needs above explanations as well as complication rate and length of stay.

Author(s)' Response by Giuseppe Rescigno, MD:

In response to reviewer SC389: Cardiac arrest alone allows a 90% decrease of oxygen consumption. This has been clearly demonstrated by Buckberg GD et al. (Studies of the effects of hypothermia on regional blood flow and metabolism during cardiopulmonary bypass). J Thorac Cardiovasc Surg 1977; 73: 87-94. CPB perfusate and cardioplegia temperatures are the same. We have already discussed our mortality rate and analysis in response to a prior question.