

Technique Articles

Custodiol[®] HTK Cardioplegia Use in Robotic Mitral Valve

Nirav Patel, MD; Ed DeLaney, MS, CCP; Gerard Turi, CCP; Thomas Stapleton, MS, CCP

Lenox Hill Hospital, North Shore/Long Island Jewish, New York, New York

Abstract: Robotic surgery is a growing subspecialty in cardiac surgery. Custodiol[®] HTK cardioplegia offers long-term myocardial protection, decreased metabolism, and eliminates multiple cardioplegia dosing. This article reviews the technique, strategy,

and considerations for use of Custodiol[®] HTK for myocardial protection in robotic mitral valve surgery. **Keywords:** robotic surgery, Custodiol[®] HTK, cardioplegia, mitral valve. *JECT. 2013;45:139–142*

OVERVIEW

By applying modified traditional perfusion methods and new robotic techniques and technology, surgeons have been able to speed the development of less invasive mitral operations with shorter surgical duration. Recent successes with direct-vision, videoscopic, and robotic minimally invasive surgery all have reaffirmed that this evolution can be extremely fast (1). Andersen et al. (2) cited in 1992 that artificial aortic valves can be implanted in closed-chest animals by means of a transluminal catheter technique. Wong and colleagues (3) reviewed mitral valve repair past, current, and future and concluded that minimally invasive techniques of mitral valve repair further reduce access trauma and could potentially benefit patients previously excluded from conventional surgery. Grossi and associates at New York University compared 100 minimally invasive mitral valve operations. They reported a perioperative mortality rate of 1.0%. In these patients, 80% had a posterior leaflet repair and 30% had an anterior leaflet reconstruction. Their results suggested that minimally invasive mitral operations can be done safely using port-access methods with similar results as conventional operations and with no added mortality or morbidity. At the same time, they had

fewer transfusions, shorter lengths of stay, and fewer septic complications despite longer cardiopulmonary bypass times (4). In a 759-patient study, Mihaljevic et al. concluded that robotic repair of posterior mitral valve leaflet prolapsed is as safe and effective as conventional approaches. Technical complexity and longer operative times for robotic repair are compensated for by lesser invasiveness and shorter hospital stay (5). In a 745-patient study, Suri et al. reported that robotic mitral valve repair allows complete anatomic correction of all categories of leaflet prolapsed using techniques identical to open approaches. Robotic repair effectively corrects mitral regurgitation, offers excellent freedom from adverse events, and facilitates rapid weaning from ventilation, translating into earlier hospital dismissal. Safety and efficacy after open and robotic mitral valve repair are higher than recently reported in the endovascular valve edge-to-edge repair (EVEREST) II trial and establish a benchmark against which nonsurgical therapies should be evaluated (6). In a 202-patient study, Suri et al. concluded that functional quality-of-life (QOL) outcomes within the first 2 years after early mitral valve repair are excellent using open and robotic platforms. A robotic approach may be associated with slightly improved early QOL and return to employment-based activities. These results may have implications regarding future evolution of clinical guidelines and economic health care policy (7).

Our approach combines the surgical advances with Custodiol[®] HTK for myocardial protection. Custodiol[®] HTK solution is a low-potassium, low-sodium concentration solution that minimizes risks for safe organ inactivation (Table 1). Histidine extends the buffer capacity and tryptophan supports membrane activity, whereas

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Address correspondence to: Ed DeLaney, MS, CCP, Perfusion Clinical Coordinator, Cardiovascular Services, Lenox Hill Hospital Northshore/Long Island Jewish, 100 East 77th Street, New York, NY 10021. E-mail: e26delaney@yahoo.com

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Table 1. Composition of Custodiol[®] HTK perfusion solution (1000 mL).

	Grams	mmol/L
Sodium chloride	.8766	15.0
Potassium chloride	.6710	9.0
Potassium hydrogen 2-ketoglutarate	.1842	1.0
Magnesium chloride 6 H ₂ O	.8132	4.0
Histidine HCL H ₂ O	3.7733	18.0
Histidine	27.9289	180.0
Tryptophan	.4085	2.0
Mannitol	5.4651	30.0
Calcium chloride 2H ₂ O	.0022	.015

Osmolality: 310 mOsm/kg.

Essential Pharmaceuticals, LLC product package.

alpha-ketoglutarate serves as a substrate for aerobic energy production during the induction of cardioplegia and when restarting the heart. Custodiol[®] HTK is perfused as a cold solution so that its hypothermic effect contributes to a decreased metabolic rate (8). Braathan et al. (9) cited cardioplegia with histidine–tryptophan–ketoglutarate (HTK–Custodiol[®]; Koehler Chemi, Alsbach-Haenlien, Germany) or Bretschneider solution for cardiac arrest during cardiac operations has been widely used clinically and reported in more than 700,000 cases of open cardiac surgery. Braathan et al. (9) concluded that one single dose of antegrade cold HTK cardioplegic solution in elective mitral valve surgery protects the myocardium equally as well as repetitive antegrade cold blood cardioplegia. Sakata et al. conducted a study comparing the effect of HTK with that of cold blood cardioplegic solution in mitral valve surgery. Their results suggest that HTK provided more adequate myocardial protection in mitral valve surgery (10). Scarscia et al. concluded that Custodiol[®] HTK and cold blood cardioplegic solutions assure similar myocardial protection in patients undergoing thoracic aorta operations. In long cross-clamp times, the lower postoperative cardiac troponin release detected using HTK may be indicative of better myocardial protection in these extreme conditions (11). The growing interest in Custodiol[®] cardioplegia for robotic and minimally invasive surgery and our success at Lenox Hill Hospital prompted the writing of this timely technique article.

DESCRIPTION

After the patient has been fully anesthetized, 5000 IU of heparin is given. The anesthesiologist then places a 17-French Medtronic, Inc. (Minneapolis, MN) femoral cannula into the right internal jugular vein. The patient is prepared and draped and cannulas are placed in the femoral artery and femoral vein (18–22 Fr Fem-Flex; Edwards Lifesciences LLC, Irvine, CA; and either 22 Fr or 23/25 Fr

Estech; Sorin, Milan, Italy, respectively). The internal jugular and femoral venous cannulas are connected using tubing extensions and a Y connector to the cardiopulmonary bypass circuit. A 7-Fr Medtronic, Inc. aortic route cannula with a flow guard introducer for antegrade protection is used. The patient is vented using the antegrade cannula and a cardioplegia Y connection. A 20-Fr Medtronic, Inc. cardiac sump is used. Sorin tubing packs and a Sorin S5 heart lung machine are used (Sorin, Milan, Italy). Heparin is given at 300 IU/kg to achieve an activated clotting time greater than 480 seconds. After placement of the ports for robotic access (Figure 1), bypass is started and the robot is docked (connected and positioned) (Figure 2). The patient is cooled down to 32°C and a Chitwood clamp is placed through a second incision to the left of the right anterior thoracotomy incision. Custodiol[®] HTK cardioplegia is kept refrigerated before administration. One-liter bags are administered and three per case are ordered from the pharmacy. It is given between 2 and 6°C during bypass. The initial arresting dose of 2 L is given over 6–8 minutes with a flow between 250 mL and 300 mL depending on the arterial antegrade cardioplegic line pressure. The first dose is an antegrade dose unless the surgeon suspects aortic insufficiency or antegrade

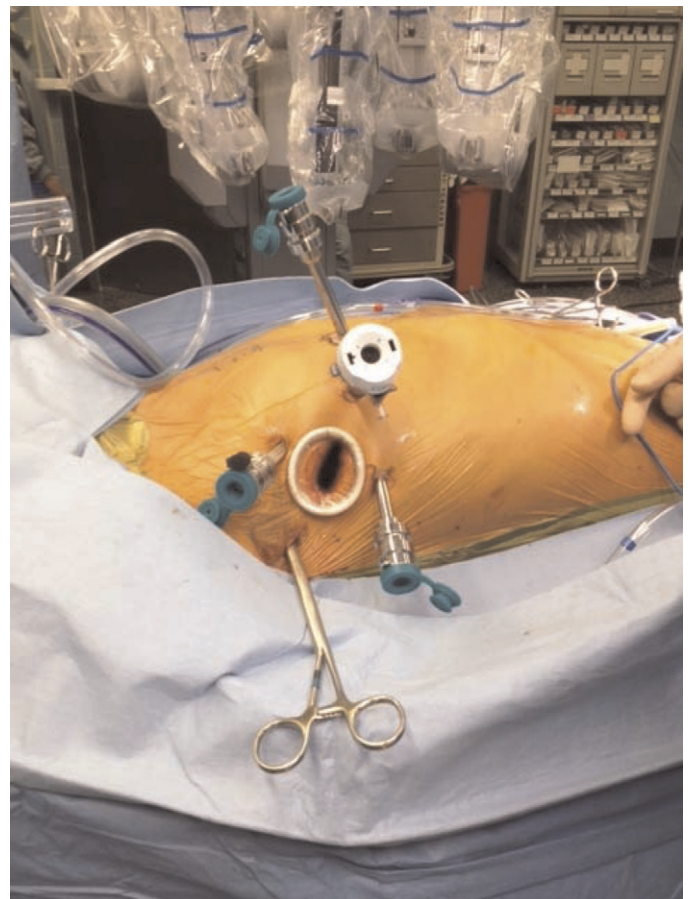


Figure 1. Port access.

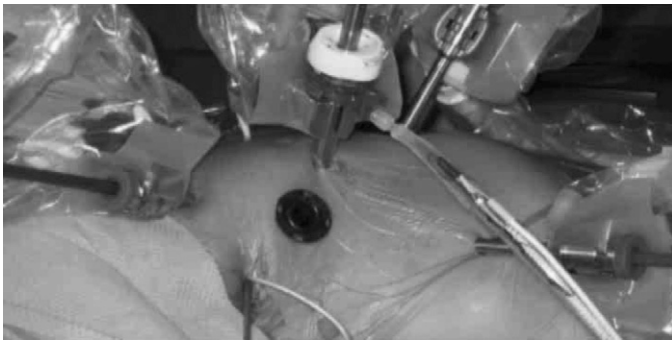


Figure 2. Robot docked.

administration problems. At 120 minutes, the surgeon will be notified and a decision will be made for a 500- to 1000-mL maintenance dose per surgeon instructions. If the surgeon is close to finishing, the additional dose will not be given. To reduce the dilutional effects of the 2 L of Custodiol[®] HTK cardioplegia, the perfusionist hemoconcentrates at the start of cardioplegia administration. Arterial blood gases and electrolytes are monitored and treated until normal values are obtained. Additional sodium bicarbonate (50 mEq) is routinely given to correct the arterial blood gas values. The initial prime solution is Isolyte (Braun Medical Inc., Irvine, CA) but additional volume given on bypass is .9% NaCl (Braun Medical Inc.) until the sodium is in a normal range. Custodiol[®] HTK is stored at 8–15°C and the solution can be stored for up to 1 year. Before removal of the cross-clamp, 2 g magnesium and 200 mg lidocaine are administered.

DISCUSSION

The surgeon requested that the perfusion team research an alternative way to protect the heart during robotic-assisted mitral valve surgery. Previous experience at this hospital with percutaneous coronary sinus cannulation yielded various results and extended operative times. Plotkin et al. showed various placement times ranging from 2.5 minutes to 42 minutes in 10 patients (mean, 10.5 minutes) and one failed attempt. Their experience yielded three minor complication of atrial fibrillation and one dislodgement (12). D'Alonzo and colleagues stated that even with two-dimensional echocardiography and fluoroscopy, the technique remains challenging, and placement of the coronary sinus catheter carries complication risks, which, although rare, include the potential to cause cardiac injury (13). Custodiol[®] HTK solution offers rapid homogenous cooling, ischemic tolerance, a high buffering capacity, excellent visibility, and excellent recovery of heart function. The cardiac team has observed a decrease in our total operating room time associated with elimination of the percutaneous coronary sinus catheter place-

ment. Also, a reduction has been seen in cross-clamp and bypass times associated with a reduction in intraoperative myocardial protection issues. For 2010, average times for robotic mitral valve repairs were 272 minutes operative time, 182 minutes bypass time, and 116 minutes for the cross-clamp time. For 2011, using Custodiol[®] HTK for myocardial protection, operative times for robotic mitral valve repairs were 259 minutes, 153 minutes for bypass time, and 88 minutes for cross-clamp time. There has been an \$1100.00 reduction in cost per case with the elimination of the percutaneous coronary sinus catheter. Additional Custodiol[®] HTK cardioplegia had to be given on induction for cross-clamp repositioning. In nonrobotic cases with aortic insufficiency, cardioplegia is given down the coronary ostia or retrograde or a combination. For robotic mitral valve patients with trace to moderate aortic insufficiency, the arresting dose is increased to 2500 mL of Custodiol[®] HTK. To ensure effectiveness of Custodiol[®] HTK, our team avoids actively or passively filling the heart until the cross-clamp has been removed. An additional 500-mL dose is given for any electrocardiographic (EKG) activity. Our team does not monitor myocardial temperature, but this strategy could provide additional myocardial protection information. Visual arrest of the heart is monitored through direct vision of a robotic camera and the EKG. Another consideration is venous cannulation safety. The anesthesia team places the internal jugular cannula using a Seldinger technique with echocardiograph confirmation of guidewire position and placement. The internal jugular cannula is double-clamped by anesthesia after placement. Perfusion in conjunction with anesthesia directs removal of the clamps during initiation of bypass and clamp placement at the termination of bypass. In addition, the venous line going to the perfusion circuit is clamped and monitored by perfusion. The U.S. Food and Drug Administration 510k summary states Custodiol[®] HTK solution is indicated for perfusion and flushing donor kidneys, livers, and hearts before removal from the donor or immediately after removal from the donor. The success of this technique and cited research prove Custodiol[®] HTK to be valid myocardial protection strategy.

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