Alternative Method for Cardioplegia Delivery During Totally Endoscopic Robotic Intracardiac Surgery

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The optimal technique for antegrade cardioplegia delivery during totally endoscopic robotic surgery is still evolving. Cardioplegia delivery with endovascular balloon clamping of the aorta is commonly used but this method has several disadvantages and may lead to serious complications. We describe a novel cardioplegia delivery procedure for totally endoscopic intracardiac surgeries such as atrial septal defect closure and mitral valve repair. The method uses a transthoracic aortic clamp and an antegrade cardioplegia cannula without the need for thoracotomy. The technique is safe and reliable, permits simple cardioplegic arrest, and prevents complications related to endovascular balloon clamping during robot-assisted intracardiac surgery.

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Recently, robotic surgery has enabled surgeons to perform totally endoscopic atrial septal defect (ASD) closure and mitral valve repair [1–4]. However, cardioplegia delivery is still technically demanding for robotic-assisted, totally endoscopic cardiac procedures. Generally, 2 methods are used to deliver cardioplegia in robotic cardiac surgeries. One method is remote access perfusion using the endovascular balloon clamping technique [1–4]. The other method is transthoracic aortic clamping and antegrade cardioplegia delivery as used in conventional cardiac surgery [5]. With the remote access perfusion and endoclamping technique, some endoscopic procedures including ASD closure, mitral valve repair, and coronary artery bypass graft (CABG) can be performed without thoracotomy. With the transthoracic aortic clamping (such as Chitwood clamp) and antegrade cardioplegia delivery technique, however, a right minithoracotomy is still needed to prepare the aortic root, and closure of the cardioplegic catheter insertion site with manually (hand) sewn purse-string sutures is required after removal of the cardioplegic needle. In this article, we describe a novel cardioplegia delivery method for robotic-assisted totally endoscopic cardiac surgery, which uses standard transthoracic aortic clamping and an antegrade cardioplegia cannula without the need for small thoracotomy or hand assist.

Technique

Patients were anesthetized and positioned in a right decubitus position. A 14- or 16-French jugular vein cannula was introduced to facilitate venous drainage during cardiopulmonary bypass. The camera port was introduced directly into the fourth intercostal space (ICS) at the anterior axillary line. The left robotic arm was introduced through the second ICS at the anterior axillary line, and the right arm through the fifth or sixth ICS at the midaxillary line. A 2-cm incision was made in the fourth ICS 2-cm posterior to the camera port, and a 20-mm trocar (Flexible Port, Hakko Co. Ltd, Japan) was introduced, which served as a service port. The CPB was established at 32°C using the femoral artery, femoral vein, and jugular vein. The pericardium was opened and exposed.

With the help of robotic instruments (da Vinci; Intuitive Surgical, Sunnyvale, CA), double purse-string elastic sutures orienting at 180° to each other were placed on the aorta around the planned site of cardioplegia cannula insertion (Fig 1A). The 2 ends of 1 elastic suture were clipped together using da Vinci clips, and both sutures were clipped in the same manner. Aortic clamp and cardioplegia line were introduced. An antegrade cardioplegia needle was passed through the chest wall directly. Inside the thoracic cavity, with the help of robotic instruments, an antegrade cardioplegia cannula was inserted through the middle of the purse-string sutures into the ascending aorta (Fig 1B). The position of the cardioplegia cannula was not fixed. The depth of the cannula was adjusted using the marking on the cannula as index. A transthoracic flexible aortic clamp was inserted through the service port into the transverse sinus to occlude the ascending aorta proximal to the innominate artery. The transthoracic aortic cross-clamp together with blood cardioplegia delivered intermittently through the antegrade cardioplegia cannula maintained cardiac arrest and provided myocardial protection. After ASD closure or mitral valve repair was completed, removal of air was performed through the antegrade cardioplegia cannula. After removal of air and

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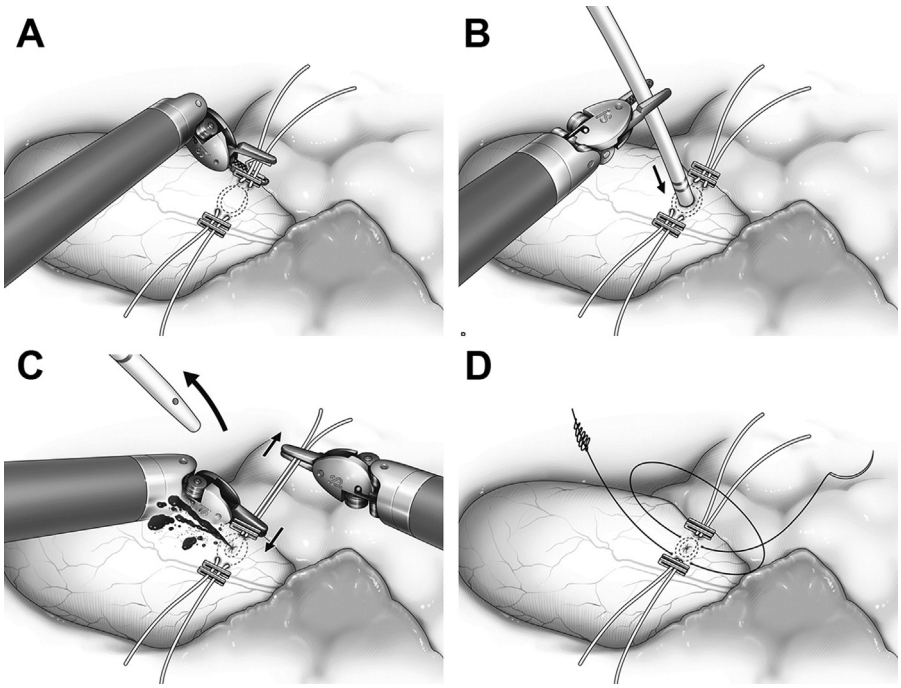

Fig 1. Diagrammatic representation of the novel method for cardioplegia delivery during totally endoscopic robotic surgery. (A) Double purse-string sutures are placed on the aorta. (B) A cardioplegia cannula is inserted through the middle of the purse-string sutures into the aorta. (C) Cardioplegia cannula is removed and purse-string sutures are drawn together by sliding the clips. (D) Proline suture is tied.

a hot shot dose of cardioplegia, the cross-clamp was removed. Before weaning from cardiopulmonary bypass, the antegrade cardioplegia cannula was removed and the elastic purse-string sutures were drawn together by sliding the clips that were placed beforehand (Fig 1C). Closure by the purse-string sutures temporarily stopped bleeding from the cannula hole. An additional 4-0 proline suture was placed to ensure hemostasis. Finally the proline suture was tied (Fig 1D). There was no bleeding from the cardioplegia site.

This technique was used in 137 consecutive cases during robotic-assisted, totally endoscopic cardiac procedures. Sixty-five of these cases were ASD closure and 72 were mitral valve repair. There was no postoperative bleeding from the cardioplegia cannula site and no complications related to this novel method.

Comment

The development of robotic surgical systems allows surgeons to perform totally endoscopic procedures such as CABG, ASD closure, cardiac tumor resection, and mitral valve repair. However, as experience accumulates, it has become clear that perfusion and cardioplegia delivery techniques specially designed for robotic cardiac surgeries are needed. Moreover, even though cardioplegia delivery systems with endovascular clamping of the aorta have been in clinical use for many years, some limitations and complications remain.

The endovascular balloon clamping technique was used successfully in totally endoscopic mitral valve surgery and ASD closure in some series [1–4]. However, serious complications such as invisible balloon requiring detection by fluoroscopy, balloon migration, balloon rupture, vascular injury, and malperfusion of vital organ have also been reported [6, 7]. Although most of these problems have been reduced with advances in technology and availability of better balloon systems, the use of a remote access perfusion and endoclamping technique increases the total cost of the procedure in general. Furthermore, the use of a small-caliber cannula limits the volume of cardioplegia that can be delivered per minute and poses difficulty with removal of air.

Percutaneous cannulation of the coronary sinus [8] is another method for delivering retrograde cardioplegia in minimally invasive cardiac surgery. However, this method has 1 issue. Coronary sinus rupture is a rare preventable complication of cannula insertion for retrograde cardioplegia. In the hands of an inexperienced surgeon this complication has the risk of potential mortality and morbidity, and its repair is technically challenging.

The transthoracic aortic clamping and antegrade cardioplegia delivery, which is a standard technique used in conventional CABG, is employed in robotic mitral valve surgery by many surgeons [4]. These procedures are performed through a small right minithoracotomy in which the cardioplegia cannula and line are inserted. After removal of the antegrade cardioplegia cannula the cardioplegic site is closed with a purse-string suture that is tied manually, or using endoscopic instruments such as a knot pusher to stop bleeding. Hand assist is needed because placing and tying the purse-string suture under the da Vinci surgical system is still technically demanding as the robotic surgery is basically a one-man surgery.

Our elastic suture technique allows tying and suturing of the cardioplegic cannula insertion site with robotic instruments only under total endoscopic observation. With this technique, the conventional transthoracic aortic clamping and antegrade cardioplegia delivery is adapted to robotic surgery, without the need for a 5-cm thoracotomy. From our experience of this technique in 137 totally robotic-assisted, totally endoscopic cardiac procedures, the suture technique reliably closes the cardioplegia cannula insertion site, with no postoperative bleeding and no complications related to this method.

In summary, the major advantages of the method described above are the following.

1. All the procedures required for cardiac arrest, from cardioplegia delivery to removal of the cardioplegic cannula and hemostasis, can be performed endoscopically.
2. The method is simple and reliable, and the procedures are basically conducted in the same manner as the classic technique.
3. This technique is safer compared with endovascular balloon aortic clamping.

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