

# Updates in Minimally Invasive Cardiac Surgery for General Surgeons



Muhammad Habib Zubair, MD<sup>a</sup>, John Michael Smith, MD<sup>b,\*</sup>

## KEYWORDS

- Minimally invasive cardiac surgery • Atrial septal defect
- Coronary artery bypass graft • Mitral valve • Robot

## KEY POINTS

- Significant improvement and development have occurred in minimally invasive cardiac surgery over the past 20 years.
- Although most studies have consistently demonstrated equivalent or improved outcomes compared with conventional cardiac surgery, with significantly shorter recovery times, adoption continues to be limited.
- In addition, cost data have been inconsistent. Further ongoing trials are needed to help determine the exact roles for these innovative procedures.

## HISTORY OF MINIMALLY INVASIVE CARDIAC SURGERY

The era of minimally invasive mitral valve (MV) surgery began in 1948 when Harken and Ellis<sup>1</sup> first described mitral valvulotomy through an intercostal approach. In 1994, Benetti and Ballester<sup>2</sup> from Argentina first described the left internal mammary artery (LIMA) to left anterior descending artery (LAD) anastomosis through a small left anterolateral thoracotomy; this was the first description of minimally invasive direct coronary artery bypass (MIDCAB) and was followed by Subramanian<sup>3</sup> in the United States in 1996. Cosgrove and Sabik<sup>4</sup> first described minimally invasive cardiac procedures in the United States in 1996 for the aortic valve (AV) followed by the MV.<sup>5</sup> Stevens and colleagues<sup>6</sup> invented the heart port platform in 1996, which opened the door to minimally invasive endoaortic cardiopulmonary bypass (CPB). Carpentier and colleagues<sup>7</sup> in 1996 did the first right minithoracotomy for a mitral valve replacement (MVR) followed shortly thereafter with the first robotic-assisted mitral valve procedure.

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<sup>a</sup> Division of General Surgery, Good Samaritan Hospital, TriHealth Heart Institute, Cincinnati, OH, USA; <sup>b</sup> Division of Cardiothoracic Surgery, Good Samaritan Hospital, TriHealth Heart Institute, 3219 Clifton Avenue, Cincinnati, OH 45220, USA

\* Corresponding author.

E-mail address: [jmichaelsmith62@gmail.com](mailto:jmichaelsmith62@gmail.com)

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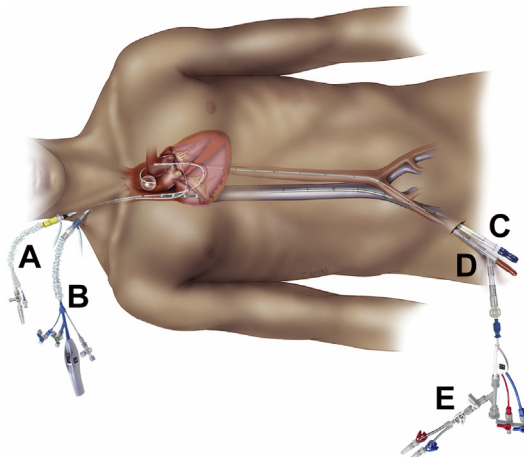
Techniques involving a nonsternotomy or partial sternotomy incision with or without the use of CPB are included under the later section, Minimally invasive cardiac surgery.

## HEARTPORT

The basic CPB requirements for robotic or minimally invasive cardiac surgery are achieved by a remote access system. One such system is the endoaortic balloon occlusion (EBO) system (Heartport, Redwood City, CA).<sup>8</sup> EBO is the only established system that enables port-only endoscopic cardiac surgery, without any cardioplegia cannula in the ascending aorta. A recent long-term follow-up by Kiessling and colleagues<sup>9</sup> showed no aortic degeneration or major complications over the course of 9 years. The ThruPort cannula (IntraClude, Edwards, Irvine, CA) is inserted into the common femoral artery. Then, under transthoracic echocardiography, a guide wire is advanced under transesophageal echocardiography into the ascending aorta. Then, the cannula is advanced. Venous drainage is provided by a single- or double-stage femoral venous cannula (Biomedicus 22–28 F, Edwards 24–28 F, or an ESTECH 23 or 25 F). After CPB initiation, the aortic occlusion balloon is inflated, and cardiac arrest is induced by injecting cardioplegia via the cardioplegia line. Bilateral radial artery pressure curves are used to avoid accidental occlusion of the innominate artery and to assist in monitoring balloon position. Major complications include aortic dissection, major vessel perforation, injury of intrapericardial structures, limb ischemia, myocardial infarction (MI), and neurologic events. Minor complications include minor vessel injury, groin bleeding, and lymphatic fistula. This platform allows most intracardiac procedures to be performed without sternotomy in a similar fashion to routine cardiac surgery (**Fig. 1**).

### *Minimally Invasive Direct Coronary Artery Bypass*

Coronary artery bypass grafting (CABG) can be performed with CPB or without. CABG without CPB can be performed with or without open sternotomy or with minimally invasive anterior small thoracotomy; anterior small thoracotomy can include MIDCAB and minimally invasive cardiac surgery off-pump coronary artery bypass (MICS-OPCAB).



**Fig. 1.** (A) Endovent; (B) EndoPlege; (C) femoral venous cannula; (D) femoral arterial cannula; (E) Endoaortic balloon.

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