

A New Live Animal Training Model for Off-Pump Coronary Bypass Surgery

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ABSTRACT

Training models are needed to perform accurate off-pump coronary artery bypass (OPCAB) surgery and to test evolving new technologies like minimally invasive devices and robotics. We describe a simple, effective and reproducible live animal training model to perform multiple arterial anastomoses on the beating heart that would maximize the use of available resources for training purposes.

INTRODUCTION

Training new users in off-pump coronary artery bypass (OPCAB) surgery and associated technologies (robotic telemanipulation systems, alternative anastomotic devices) is currently limited by the lack of adequate live animal models. The use of OPCAB is expected to expand, and an increasing number of surgical procedures will be performed on the beating heart [Zenati 1998]. However, a recent survey suggested that a majority of residents do not perform enough cardiac procedures on the beating heart, a circumstance that may adversely affect the expectations of future cardiac surgeons [Ricci 2000].

In the recent past we established a successful swine model for robotic OPCAB using the ZEUS™ Robotic Surgical System (Computer Motion Inc., Goleta, CA) [Zenati 2000]. The limitations of this model are the small size of the left anterior descending coronary artery (LAD) and the ability to perform only one end-to-side anastomosis per animal, reducing the potential for teaching multiple users.

To overcome these limitations, we have modified our swine model with two goals in mind: (a) creating a realistic beating heart environment, and (b) allowing the construction of multiple end-to-side anastomoses on the beating heart by multiple users in the same training session. This model can be used for manually constructed beating heart anastomoses under direct vision with standard suture or alternative anasto-

motric techniques (e.g., the U-clip System, Coalescent Surgical, Mountain View, CA), or it can be used in conjunction with robotic telemanipulation systems.

SURGICAL TECHNIQUE

Crossbred swine of either sex weighing approximately 45 kg are used. The animal is anesthetized and intubated according to standard technique as previously described [Zenati 2002]. The animal is then positioned supine on the operating table, and a full median sternotomy (or alternatively, a lower ministernotomy) is performed. The left and right internal thoracic arteries (ITAs) are mobilized using a skeletonizing technique. Heparin is given intravenously, and the left ITA is divided distally to be used as a bypass conduit *in situ*. The right ITA is divided proximally and distally as a free graft. A pericardial window (about 5 x 5 cm) is created on the anterior surface of the heart. The swine LAD crosses the midline from left to right, as opposed to the human LAD that crosses from right to left, roughly parallel to the divided sternal edges. The right ITA free graft is divided in segments of about one inch, and the conduit is then attached to the epicardium perpendicular to the LAD with two simple stitches of 5-0 polypropylene (Figure 1, ●). The result is a surrogate of a coronary artery of approximately 2.0 mm in diameter moving in synchrony with the beating heart. A stabilization system is applied to the graft and the target anastomotic site is immobilized. Using standard techniques, an arteriotomy is performed, an intracoronary shunt is positioned, and the end-to-side anastomosis between the left ITA (or any other graft available) and the graft simulating the LAD is completed. Additional anastomoses can be performed on a different site on the same one inch segment (up to three) after dividing the end-to-side anastomosis flush with the suture line.

To train users in robotic-assisted OPCAB, three 5 mm ports are created on the left chest on the parasternal line for placement of the endoscope and the right and left robotic telemanipulation instruments. The anastomosis is completed with the primary surgeon operating from a remote console.

Upon completion of the anastomosis, an additional one inch segment of right ITA can be secured to the epicardium and the process can be repeated with a different trainee. For quality control, the segments of right ITA bearing the stumps of the end-to-side anastomosis can be removed from the epicardium and the artery can be opened with micro-scissors.

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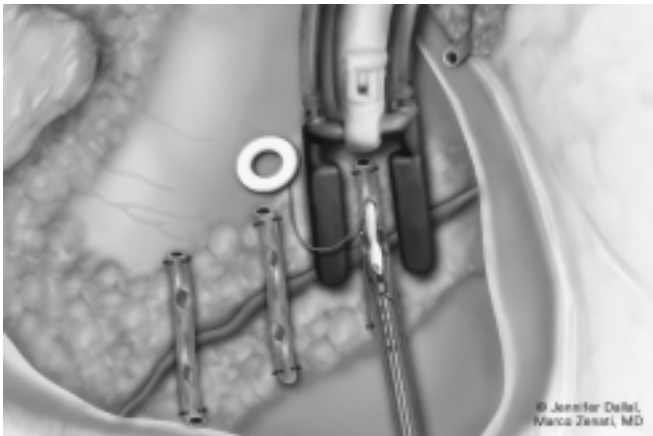


Figure 1. Segments of about one inch are obtained from the right internal thoracic artery free graft and sutured to the epicardium perpendicular to the left anterior descending coronary artery with two simple stitches of 5-0 polypropylene. A stabilizer is positioned and an intracoronary shunt may be introduced for training purposes.

The endoluminal appearance of the anastomosis can then be checked, and probes of different sizes can be passed across to assure patency and rule out technical errors.

CONCLUSION

A few mechanical and virtual reality models are being developed for training surgeons in OPCAB and endoscopic techniques [Satava 2001]. However, none of these is currently able to reproduce the biological environment that is encountered during surgery. We have described a new live animal model for OPCAB that allows multiple users to perform multiple end-to-side anastomoses on the beating heart, thus maximizing the use of resources for training purposes.

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