Training Models for Coronary Surgery

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ABSTRACT

This paper reviews currently used training models for coronary artery bypass grafting (CABG). Training models for CABG are extremely helpful not only for training surgical techniques, but also for the evaluation of new technologies and for research on bypass graft pathophysiology. Wet-lab models serve as training platforms for surgical residents and allow the evaluation of new technology (e.g., robotically enhanced CABG). The right coronary artery to left anterior descending artery model on the slaughterhouse pig heart is easily available, cheap, and effective. In vivo animal models for CABG are much more sophisticated and cost intensive. Pigs and dogs are the most commonly used animals for CABG training. Off-pump CABG techniques, totally endoscopic CABG, endoscopic gastroepiploic artery harvesting, and axillocoronary bypass grafting have been evaluated in animal models.

WHY DO WE NEED TRAINING MODELS FOR CORONARY ARTERY BYPASS GRAFTING?

Training models for such delicate operations such as coronary surgery are extremely helpful for several reasons. First, surgical residents can train the most critical part of a coronary artery bypass grafting (CABG) procedure (i.e., the bypass graft to coronary artery anastomosis) in a setting that does not set a patient at risk for myocardial infarction and that offers an immediate quality control by direct inspection of the anastomosis. Second, new technical developments can be tested and evaluated before going into the clinical setting. Third, animal models are prerequisites for the conduct of research in the field of bypass graft pathophysiology.

WET-LAB TRAINING OF THE VARIOSCOPE DEVICE ON PIG HEARTS

The Varioscope (Life Optics, Chicago, IL, USA) is a portable microscope with an integrated light source and a zoom function for achieving a range of different magnifications (Figure 1). In a small study, we used a wet-lab model of coronary surgery on the slaughterhouse pig heart. The right coronary artery is excised "pedicle like" and trimmed using standard surgical instruments. Consecutively, this right coronary artery pedicle is sutured to the left anterior descending artery using a continuous 7/0 prolene suture and standard surgical instruments. It takes some time to get used to working with this device, and comfort levels differ between different surgeons. However, a learning curve was found for the anastomotic time (Figure 2).

Falk and coworkers compared robotically sutured coronary anastomoses (which was a new technology in 1999) with conventionally handsewn anastomoses in a wet-lab pig-heart model [Falk 1999]. They found in both groups the same quality of the anastomoses (intactness of anastomosis and sutures, absence of dehiscence or intimal tears, lumen patency). An easy way to train robotic anastomoses is the suturing of synthetic material, but this inadequately simulates the handling of biologic tissue.

In a recent study at our university, Bonatti et al compared the effect of assistance maneuvers in a wet-lab setting of robotically enhanced coronary artery anastomotic suturing [Bonatti 2007]. For coronary surgery training with the da Vinci telemanipulation system (Intuitive Surgical, Mountain View, CA, USA), the described right coronary artery to left anterior descending artery suturing in the pig heart was demonstrated to be extremely helpful. Various parameters such as suturing time, occurrence of technical errors (e.g., thread rupture, knot formation, sling formation), and quality of the anastomosis (e.g., patency, dehiscence, correct suture alignment) can be addressed.

ANIMAL MODELS FOR CORONARY SURGERY

A variety of animal models for research on bypass graft pathophysiology is known [Schachner 2006]. For coronary anastomosis training, however, only large animal models can be taken into consideration. The pig model is ideal for coronary surgery training using a sternotomy approach. The left internal mammary vein can be anastomosed to the left anterior descending artery using standard off-pump techniques or using the heart-lung machine (Figure 3). It has to be considered that pig experiments are cost intensive and require a great amount of logistics (operating room, anesthesiologist, perfusionist, etc).
Bonatti et al demonstrated the feasibility of axillocoronary bypass grafting in pigs [Bonatti 2002]. Despite presenting the surgical technique, histological analysis of the left internal mammary vein grafts (eg, quantification of neointimal hyperplasia) was provided.

Boehm et al showed endoscopic left internal mammary artery harvesting and anastomosis to the left anterior descending artery (n = 6) using the ZEUS telemanipulator (Intuitive Surgical) and the Heartport femoral access perfusion system (Ethicon, Somerville, NJ, USA) in dogs [Boehm 1999]. In this study, the median left internal mammary artery graft flow rate was 38.5 mL/minute (range, 22 to 45 mL/minute), and at autopsy all explanted anastomoses showed a good patency.

Borst et al used a pig model to test a special technique of off-pump CABG without interruption of the coronary flow [Borst 1996]. Kiaii et al successfully performed endoscopic gastroepiploic artery harvesting in pigs using the Automated Endoscope System for Optimal Positioning (AESOP 3000; Intuitive Surgical) [Kiaii 2001]. This endoscopic technique could be helpful for the development of multi-vessel totally endoscopic CABG. In addition, other interesting parameters such as right gastroepiploic artery (RGEA) length, RGEA free blood flow, and RGEA Doppler flow were evaluated.

CONCLUSION

Training models for CABG are extremely helpful not only for training surgical techniques, but also for the evaluation of new technologies and for research on bypass graft pathophysiology. For future perspectives, the development of CABG simulators might also be worthwhile for surgical training.

REFERENCES


