The Heart Surgery Forum #2007-0704
10 (3), 2007 [Epub May 2007]
doi: 10.1532/HSF98.20070704

Online address: http://cardenjennings.metapress.com

Training Models for Coronary Surgery

Thomas Schachner, Nikolaos Bonaros, Elfriede Ruttmann, Daniel Höfer, Johann Nagiller, Guenther Laufer, Johannes Bonatti

Innsbruck Medical University, Innsbruck, Austria

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 (eg, 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 (ie, 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 conduction of research in the field of bypass graft pathophysiology.

WET-LAB TRAINING OF THE VARIOSCOPEDEVICE 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).

WET-LAB ANASTOMOSIS TRAINING OF ROBOTIC TECHNOLOGY ON PIG HEARTS

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 (eg, thread rupture, knot formation, sling formation), and quality of the anastomosis (eg, 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).

Presented at the 3rd Integrated Coronary Revascularization (ICR) Workshop for Interventional Cardiologists and Cardiac Surgeons, Innsbruck, Austria, December 6-8, 2006.

Correspondence: Thomas Schachner, MD, Department of Cardiac Surgery, Innsbruck Medical University, Anichstrasse 35, 6020 Innsbruck, Austria; 43-5125040; fax: 43-51250422528 (e-mail: Thomas.Schachner@I-med.ac.at).

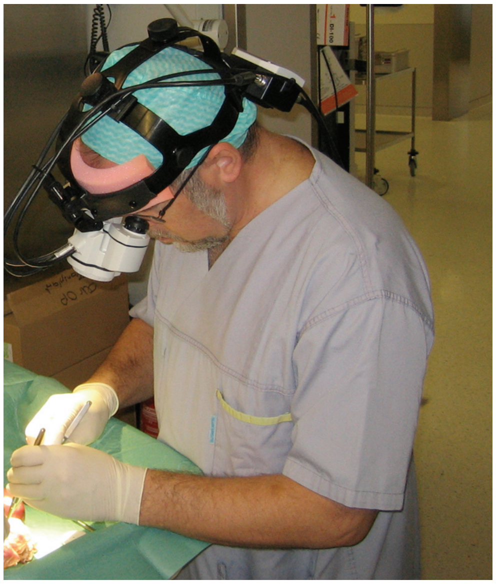

Figure 1. Wet-lab training of coronary anastomosis with the Varioscope on the slaughterhouse pig heart.

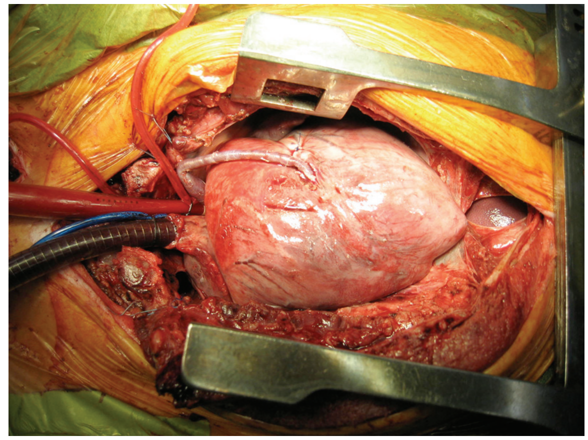

Figure 3. Left internal mammary vein to left anterior descending artery bypass in the pig after median sternotomy (on pump).

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.

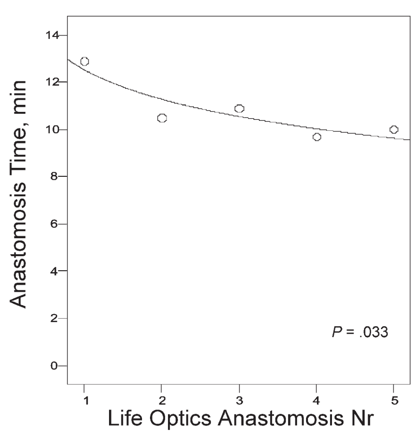

Figure 2. The learning curve for suturing a coronary anastomosis in a wet-lab model using the Varioscope. The curve follows the function: $y = 13 - 2 \times \ln x$ (x = anastomosis Nr).

Borst et al used a pig model to test a special technique of off-pump CABG without interruption of the coronary flow [Borst1996]. 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 multivessel 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

Boehm DH, Reichenspurner H, Gulbins H, et al. 1999. Early experience with robotic technology for coronary artery surgery. Ann Thorac Surg 68:1542-6.

Bonatti J, Alfadlhi J, Schachner T, et al. 2007. Do manual assisting maneuvers increase speed and technical performance in robotically sutured coronary bypass graft anastomoses? Surg Endoscopy [In press].

Bonatti J, Hangler H, Oturanlar D, et al. 2002. The axillocoronary bypass. Blood flow and short-term graft histology in a porcine model. J Cardiovasc Surg 43:625-31.

Borst C, Jansen EW, Tulleken CA, et al. 1996. Coronary artery bypass grafting without cardiopulmonary bypass and without interruption of native coronary flow using a novel anastomosis site restraining device ("Octopus"). J Am Coll Cardiol 27:i356-64.

Falk V, Gummert JF, Walther T, et al. 1999. Quality of computer enhanced totally endoscopic coronary bypass graft anastomoses—comparison to conventional techniques. Eur J Cardiothorac Surg 15:260-265.

Kiaii B, Kodera K, Abu-Khudair W, et al. 2001. An alternative arterial conduit for totally endoscopic multivessel coronary artery bypass. Heart Surg Forum 4:315-8.

Schachner T, Laufer G, Bonatti J, 2006. In vivo (animal) models of vein graft disease. Eur J Cardiothorac Surg 30:451-63.