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Editorial

Focus on Cardiomyoplasty

Dynamic cardiomyoplasty was first introduced as a surgical technique in 1985 by Drs. Carpentier and Chachques. However, after a limited period of clinical application it fell into disrepute. As stated in this issue [1]: “This is an inaccurate assessment, for many patients found the procedure to be beneficial. It is clear in retrospect that clinical outcomes could have been better had the technique been implemented with a more complete knowledge of the underlying basic principles… It will not be easy to change current perceptions, but the place of cardiomyoplasty in the surgical armamentarium deserves to be reconsidered.”

In this *Focus on Cardiomyoplasty,* international experts in the field present clinical experience of dynamic cardiomyoplasty and examine how it could be improved in the light of current scientific knowledge.

Recent developments in regenerative medicine have tended to overshadow other biological approaches to cardiac assistance. But, as Stanley Salmons recently wrote [2] and confirms in this *Focus*: “the current investment of time and resources in stem cells and tissue engineering should not be allowed to eclipse the potential of techniques based on skeletal muscle. In those terms, a skeletal muscle graft is a large, well vascularised and fully populated tissue construct”.

Here Salmons and Jarvis summarize more than 20 years of experience in muscle physiology applied to cardiomyoplasty [1]. They document better ways of preparing and stimulating a skeletal muscle for long-term cardiac bioassist. Preconditioning of the muscle, optimization of the number of bursts, a proper choice of heart synchronization ratio, and “on demand” stimulation are parameters that should be used to optimize cardiac bioassist from the latissimus dorsi muscle.

Grandjean, Chachques and Jegaden report the collective experience of six French centres [3] performing Dynamic Cardiomyoplsty (CMP). Since 1985, 212 patients have undergone CMP in France. The longest freedom from cardiac death or heart transplantation was dependent on pre-operative ventricular dysfunction. For right ventricular dysfunction, freedom from cardiac death or heart transplantation was 78% at 5 years, and 69% at 10 years; for left ventricular dysfunction it was 48% at 5 years, and 30% at 10 years; for biventricular dysfunction, it was 39% at 5 years, and 30% at 10 years. During follow up, 88% of patients improved by more than one NYHA Class. Heart transplantation was performed in 26 patients who did not benefit from CMP or had late recurrence of heart failure symptoms. For non-urgent cases, the outcome was similar to that expected for primary transplantation. Combination with cardiac rhythm management systems was safely achieved in 22 patients. Overall, CMP afforded long-term cardiac benefits, with the best outcome in isolated right ventricular failure.

Rigatelli and Carraro introduced the concept of activity-rest (on demand) stimulation to deliver fewer impulses per day than with the standard clinical protocol. This was achieved by providing the latissimus dorsi muscle wrap with daily periods of rest (demand stimulation) based on a heart rate cut-off. With the new protocol, muscle contractions were stronger and faster. The concept was applied in 4 patients from the outset and in 10 patients who had previously undergone CMP with continuous stimulation. These 10 subjects, who had no short-term to mid-term prospect of heart transplantation, were switched to demand stimulation because of a deterioration in their clinical condition. The long-term changes in latissimus dorsi muscle contraction speed were monitored by Tetanic Fusion Frequency (TFF) analysis (a mechanographic interrogation). In the 10 subjects switched after continuous stimulation, after two years “on demand” the TFF values were significantly higher than at the start of the demand protocol. Although long-term survival in this small group cannot be compared with that of transplant patients, demand Dynamic CMP continues to show encouraging results compared with classic CMP [4-5].

Kesar, Perumal, Santamore, and Binder-Macleod describe the potential advantage of using variable frequency trains of impulses to enhance the power of muscle contraction [6].

Stimulation of muscle during cardiomyoplasty is currently achieved with constant-frequency trains of impulse. Variable frequency trains, which consist of a high-frequency burst of two to four pulses at the onset of a subtetanic low-frequency stimulation train, have been shown to augment muscle performance during electrical stimulation.

Taking a different approach, Trumble describes his studies on the use of muscle as a power source for cardiac assist [7]. The biomechanical implant that he has developed converts muscle power, developed during electrically evoked linear contractions, into hydraulic power for the purpose of driving a circulatory support device. The article summarizes the rationale for using muscle in a linear configuration, reviews the current status of device development, and examines three possible mechanisms by which to assist the failing heart using skeletal muscle in situ.

We hope that these articles will prompt a reconsideration of the potential of cardiac bioassist for the treatment of chronic heart failure. Implementation of the latest findings on muscle preservation, activation, and energy transfer from muscle to heart, as well as the scope for combination with defibrillator and resynchronization devices, offers the prospect of further improvements in efficacy, quality of life, and survival. Furthermore, since it is still feasible to perform cardiac transplantation after cardiomyoplasty in cases of recurrent heart failure, Dynamic CMP could also provide a mid-term to long-term biological bridge to heart transplantation.

Revisiting Dynamic CMP will require a collaborative effort between cardiologists, cardiac surgeons, and industry in order to develop a suitable program of research projects and clinical trials. This is an exciting possibility, and should not be overlooked.

Eric Monnet, DVM, PhD, FAHA
Diplomate ACVS, ECVS
Professor, Small Animal Surgery
Colorado State University
Dept Clinical Sciences
Fort Collins, Co 80523, USA
Phone: 1 970 221 4535; Fax: 1 970 297 1275
E-mail : Eric.Monnet@ColoState.EDU
URL: http://www.cvmbs.colostate.edu/clinsci/faculty/monnet.htm

References

[1] Salmons S, Jarvis JC: Cardiomyoplasty reviewed: Lessons from the past, prospects for the future. Basic Appl Myol 2009; 19 (1): 5-16.
[2] Salmons S: Cardiac assistance from skeletal muscle: a reappraisal. Eur J Cardiothorac Surg 2008; doi: 10.1016/j.ejcts.2008.09.015
[3] Grandjean PA, Chachques JC, Jegaden O. for the French Cardiomyoplasty Investigators Workgroup: Long-term Outcome of Dynamic Cardiomyoplasty in France. Basic Appl Myol 2009; 19 (1): 17-24.
[4] Rigatelli GL, Carraro U: Latissimus Dorsi tetanic fusion frequency in clinical settings: Monitoring fast to slow muscle transformation during follow-up of Demand Dynamic Cardiomyoplasty. Basic Appl Myol 2009; 19 (1): 25-30.
[5] Rigatelli GL, Carraro U, Riccardi R, Rigatelli G: Demand Dynamic Bio-girdling 10-year Results. Eur J Cardiothorac Surg 2008, in press.
[6] Kesar T, Santamore WP, Perumal R, Binder-Macleod SA: Functional electrical stimulation of skeletal muscle – Implications for cardiovascular support. Basic Appl Myol 2009; 19 (1): 31-34.
[7] Trumble DR: Linear muscle power for cardiac support. Basic Appl Myol 2009; 19 (1): 35-40.