# Measuring cardiac efficiency: is it clinically useful?

**Frans Visser**
**Stichting CardioZorg-Parkstad Kliniek, Amsterdam, The Netherlands**

Correspondence: F. C. Visser, Stichting CardioZorg-Parkstad Kliniek, Burgemeester Roëllstraat 24–26, 1064 BP Amsterdam, The Netherlands.
E-mail: visser51@gmail.com

Have you ever wondered, in the management of patients with various cardiac diseases, what was the cardiac efficiency of your patient, and how treatment could possibly favorably change the cardiac efficiency of this patient? I, certainly, never considered this consciously, and I doubt that many of us do. Nevertheless, the concept of cardiac efficiency had already been proposed and studied by Bing et al [1] as long ago as 1949. Since then, cardiac efficiency has been studied in various cardiac diseases such as coronary artery disease, stunned and hibernating myocardium, and hypertrophic and dilated cardiomyopathy, during medical and resynchronization therapy for heart failure, and in hypertension. More importantly, from a clinical point of view, inefficiency is an important prognostic factor for patients. Kim et al [2], for example, showed that, in patients with dilated cardiomyopathy, inefficiency was the single, most important predictor of cardiac death.

Although the term ''cardiac efficiency'' may sound like a highbrow academic concept, in reality it is very simple: for work to be performed (whether by a car or by the heart), energy is needed, and the ratio between delivered work and input of energy is defined as ''efficiency''. For the pumping function of the heart, energy is needed. This energy comes from the oxidation of several fuels, such as fatty acids and glucose. However, the concentration of these fuels may vary over time (eg, after a meal), and it may be quite laborious to measure and calculate the energy input from these nutrients. Because oxygen is required for the oxidation of the nutrients, the amount of oxygen consumed can substitute for the energy input of the nutrients. The other part of the efficiency equation is the work delivered by the heart. This is usually expressed as left ventricular external stroke work, and is calculated from stroke volume, heart rate, and the mean arterial pressure. Cardiac efficiency is therefore the ratio between stroke work and oxygen consumption. As one can read in this issue, the efficiency of the normal heart is approximately 20–25% and, although this may sound low, the heart is far more efficient than a car.

Because efficiency is an important factor in various cardiac diseases, and because it is a relatively unknown field, the editorial board of *Heart and Metabolism* decided to devote this issue of the journal to the topic.

In the Main Clinical Article, Akinboboye discusses in detail the measurement of cardiac efficiency in various diseases, and concludes that measurement of efficiency is useful because it provides valuable insights into the pathophysiology of cardiovascular disease and into the beneficial effects of therapeutic interventions. The efficiency and inefficiency found in cardiac disease have, of course, a molecular basis, and in the Basic Article, Bugger and Abel report some fascinating data on how efficiency may be changed in diabetic cardiomyopathy.

Cardiac efficiency can be determined invasively during cardiac catheterization and non invasively mainly using positron emission tomography (PET). These two methodologies are discussed, respectively, in Refresher Corner by Steendijk and ten Brinke, and

# Editorial

*Frans Visser*

in the Metabolic Imaging article by Knaapen and Germans.

Among the key features of heart failure are the dyssynchrony and inefficiency of cardiac contraction. In the New Therapeutic Approaches article, Ginks and Rinaldi highlight the improvement in both cardiac function and clinical outcome that result from resynchronization therapy in these patients. The effect of treatment on the improvement of cardiac efficiency is also nicely demonstrated in the Case Report by Germans et al. After septal alcohol ablation performed in a patient with an obstructive hypertrophic cardiomyopathy, cardiac efficiency was greatly enhanced.

Finally, in the Focus on Vastarel article, Belardinelli discusses the use of trimetazidine in combination with cardiac rehabilitation for the treatment of patients with heart failure. Although cardiac efficiency was not specifically studied, one may speculate that trimetazidine improves cardiac efficiency in patients with heart failure.

After reading this issue of *Heart and Metabolism*, you should have a clearer picture as to what cardiac efficiency is, how it is measured, and how treatment of various cardiac abnormalities counteracts inefficiencies of the heart. The question is: do we need to assess cardiac inefficiency in our daily clinical practice? Measurement of efficiency requires special methodologies for cardiac catheterization, or PET imaging, or both, which are expensive and not readily available. Because of this, measurement of cardiac efficiency may not be appropriate for routine patient management. Nevertheless, as stated above, assessment of cardiac efficiency does give valuable insight into the pathophysiology of various cardiac diseases, and into the beneficial effects of pharmacological and non pharmacological treatments.

Enjoy your reading! ■

## REFERENCES

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2. Kim IS, Izawa H, Sobue T, et al. Prognostic value of mechanical efficiency in ambulatory patients with idiopathic dilated cardiomyopathy in sinus rhythm. *J Am Coll Cardiol*. 2002;39: 1264–1268.