

Invited commentary

to:

A reappraisal of concepts in heart failure:

Central role of cardiac power reserve

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Heart failure (HF) is frequent, essential and hard to define. A reappraisal of this pathophysiologic condition is, therefore, reasonable. The review paper of Williams and colleagues addresses the difficulty to define HF. In its first part, four presumably misleading concepts are presented.

Cardiac imaging and presentation of the left ventricular ejection fraction (EF) in order to describe cardiac function is widely employed. It is agreed that its usefulness to assess HF is limited. On the one hand, acute EF values or changes in EF might solely reflect conditions of the total peripheral resistance. On the other hand, an EF of 30% does not necessarily describe HF, as long as the patient's quality of life is maintained. The authors of the review article are wrong, as they claim that EF is misleading because it is measuring cardiac structure and not cardiac function: the more appropriate term "geometry" cannot simply be translated into function.

The second conceptual "flaw" pertains to myocardial contractility, a term that seems to be misperceived by the authors. Contractility was not primarily used to differentiate between normal and failing hearts. Sonnenblick [1, 2] and Siegel [3] presented the concept of contractility to better describe cardiac contraction and its properties independent of loading conditions and heart rate. It is also inaccurate to argue that "a major objective of therapy... became to... increase myocardial contractility". Contractile or systolic force would have been more accurate, as it is known that the accelerated development of force, i.e. an increase in contractility, is associated with "oxygen wasting" which is highly undesirable in the already compromised heart [4, 5]. Along the same line, levosimendan, as a Ca²⁺ – sensitizing agent, has purposely been developed to produce contractile force more economically [6, 7].

The definition of heart failure is discussed as the third misleading concept. It seems inadequate arguing against the "inability to meet the requirements of the metabolizing tissues" [8]. This definition does not only apply to conditions at rest, but can easily be extended to exertion, when oxygen supply no longer meets oxygen demand. The Task Force of the European Society of Cardiology describes this definition as a commonly used one, although stating that no definition would be entirely satisfactory [9]. The "inability to meet the needs of the body" [10] also presents an elegant definition, because it does not state which needs are actually

meant. One of the needs would seemingly be to create a high enough pressure to overcome critical closing pressures in certain regional circuits.

The assessment of any HF during resting conditions is presented as misleading concept number four. Sir William Osler pointed out that "...in these hearts, the reserve force is lost and with it the power of meeting the demands in maintaining the circulation during severe exertion" [11]. The authors now present their own definition: "HF is primarily the failure of the cardiac pump to function adequately to support the more dynamic circulation required during exercise" [12], which is similar to Osler's statement.

In the reappraisal, two measures to assess the cardiac pump function at rest and during (peak) exercise are widely discussed as well as the importance of cardiac functional reserve.

One of the two measures is peak oxygen consumption (VO_2). Although VO_2 has demonstrated to be an independent predictor of mortality in several studies, the authors specify shortcomings of that measure, one being the possibility that non-cardiac factors (muscle deconditioning, missing motivation or obesity) [13,14] affect maximum VO_2 . Amazingly, an uniformly-accepted cut-off point is missing, and suggested nominal values differ by 40% (10 $\text{mlO}_2/\text{kg}/\text{min}$ [15] vs 14 $\text{mlO}_2/\text{kg}/\text{min}$ [16]).

The cardiac power output (CPO) is the other – and preferred – measure of the authors. This measure includes cardiac output and mean arterial pressure and, thus, includes both variables which the heart is designed for.

According to an old concept of Barringer [17], the authors suggest a "cardiac pumping reserve" (maximal level minus baseline level) and a "cardiac pumping capability" which they define as the maximal performance during stimulation. This definition is somewhat confusing, as in their Figure 3 an "...individual maximal pumping capability" is mentioned. Beside this logical flaw, there are some concerns in using CPO in this concept, which are listed below:

- The term uses global measures of ventricular function and thus disregards a possible regional dysfunction.
- Invasive assessment of CPO is not desirable. Non-invasive assessment (e.g. echocardiography) is better feasible but introduces larger variability.
- So far, the cut-off points vary considerably: a maximal CPO <1 W was indicative of a poor 1-year survival [18]. In a similar study, a resting CPO <0.35 W or a maximal CPO <1 W discriminated between survivors and non-survivors [19]. In another study, however, a maximal CPO <2 W accurately identified patients with a poor short term prognosis [20]. This value was confirmed in another study [21].
- The studies mentioned above only employ a few patients, e.g. 36 [18], 28 [19], 50 [22], and 218 [21], respectively.

- Only one study presents results for the cardiac reserve: this measure was the only significant predictor of survival in 42 patients; its cut-off value was 1.5 W.
- Apart from the missing cut-off values, possible differences between acute and chronic heart failure is disregarded.
- Many other measures of ventricular systolic function account for individual differences, e.g. they are normalized to body surface.
- No mention is made whether or not antiischemic therapy was ongoing during the studies, thus masking the true amount of HF.

Searching in PubMed for the items "heart failure", "stress", and "prognosis" results in roughly 60 hits. A closer look shows a variety of younger studies that routinely try to assess HF not only at rest but also during stress, which is frequently induced by dobutamine. While electrocardiography serves as a useful tool to exhibit myocardial ischemia, echocardiography is used to assess global changes in ventricular geometry. In quite a few studies, regional function was assessed in terms of the wall motion score index. In contrast to the itemized studies of the review, 350 [23] and 552 patients [24] were employed in these more recent "smaller" studies. The "larger" studies employed more than 1200 [25], 2300 [26] or more than 7000 patients [27], such that their values could become a standard for further evaluating HF.

It is the merit of the review article by Williams and colleagues that they have drawn our attention to some points of importance. In the presence of many "canorous" items, clear definitions are mandatory for unequivocal understanding. Some of the definitions are not necessarily wrong, because they are old. Heart failure is one example for the existence of too many definitions. In addition, concepts should be well-defined, for example, whether HF is assessed only at rest or during exercise. And finally, clear cut-off points would be helpful for both prognosis and therapy. Unfortunately, they are missing in the CPO concept.

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