Assessment of the collateral circulation of the heart

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This editorial refers to 'Collateral-flow measurements in humans by myocardial contrast echocardiography: validation of coronary pressure-derived collateral-flow assessment'\(^7\) by R. Vogel et al., on page 157

Ever since the development of coronary angiography in the early 1960s, the collateral circulation of the heart has fascinated cardiologists and has been the subject of sometimes contradictory and speculative theories. The basis for systematic study of the collateral circulation has been provided by the seminal work of Schaper,\(^1\) who started to perform experimental studies as early as 40 years ago and who related coronary wedge or occlusion pressure to the extent of the collateral circulation.

Immediately after the introduction of coronary angioplasty, Grünzig also recognized that measurement of coronary occlusion pressure contained valuable information about presence of collaterals with the potential benefit of protecting the myocardium to ischaemia during balloon occlusion.\(^2\) Since then, coronary wedge pressure and its derivatives have often been related to collateral blood flow, but its quantification was hampered by lack of suitable devices for accurate measurement and of a theoretical model to relate coronary pressure to blood flow.

A fundamental breakthrough in this field was achieved in 1993 during which ultrathin 0.014 in. pressure guide wires became available and the concept of fractional flow reserve (FFR) was developed, providing the conceptual basis of assessing myocardial, coronary, and collateral blood flow by coronary pressure measurements.\(^3,4\) FFR expresses all these parameters as a fraction of normal maximum myocardial blood flow. In fact, maximum blood flow data could be interpreted now without the knowledge of the mass of the myocardium supplied because maximum blood flow to a particular myocardial distribution is related to normal maximum blood flow to that same area as it would be in a normal situation (Figure 1). Although the concepts of myocardial and coronary fractional flow reserve could be convincingly proved in many experimental and clinical studies\(^4,5\) in the years thereafter, validation of the concept of fractional collateral blood flow, also called collateral flow index by pressure (CFI\(_p\)), was more difficult. Its clinical relevance was demonstrated in several studies\(^6,7\) but validation in humans remained difficult.

Using this interesting index before and after administration of angiogenic growth factors, Seiler et al.\(^8\) demonstrated for the first time the efficacy of angiogenic therapy in humans. In 2002, Matsuo et al.\(^9\) validated this invasive pressure derived index for collateral blood flow semi-quantitatively vs. myocardial perfusion scintigraphy.

In the quest to assess myocardial perfusion by non-invasive means, more recently, Vogel et al.\(^10\) validated the use of contrast echocardiography to quantify absolute myocardial perfusion in humans.

Another important study by the same group is published relating this non-invasive technique performed both during coronary artery occlusion and after having restored normal maximum blood flow by stenting vs. the invasive collateral flow index by pressure measurement as described earlier.\(^11\) In this study, in patients with stable coronary artery disease, recruitable collateral blood flow during occlusion expressed as a fraction of normal maximum perfusion was compared with the quantitative data calculated by contrast echocardiography, and an excellent correlation between both indexes was found over a wide range of collateral blood flow. Therefore, this study not only confirms the suitability of myocardial contrast echocardiography for assessment of collateral blood flow, but also reinforces the basis of pressure-derived collateral blood flow assessment during coronary angiography and balloon occlusion.

The study by Vogel et al. was performed meticulously and the results (reflected in the most important figure of that paper, i.e. Figure 4D) are impressive.\(^11\) Although performing contrast echocardiography in the cathlab might be a bridge very far for many routine catheterization laboratories not dedicated to this type of research as much as the laboratory in Bern, the rather simple methodology to assess collateral blood flow by coronary pressure measurements is easy to perform. It is useful not only for the routine practice of coronary intervention to assess prognosis and outcome in patients, but also for more sophisticated applications as the evaluation of stem cell injection for either angiogenesis or myocardial regeneration referred to earlier.\(^7,8\)

Finally, some specific lessons can be learnt from the study by Vogel et al. First, it shows the linear relation between

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perfusion pressure and myocardial blood flow even at low perfusion pressures. This has been an issue often disputed in some earlier studies. The data provided by Vogel et al. suggest that at least at coronary hyperaemia, zero flow pressure is close to central venous pressure as earlier suggested by Klocke et al.12

Secondly, from the practical point of view, this study indicates that a simply obtainable index as coronary wedge pressure, bears considerable clinical significance with respect to the collateral circulation. Thirdly, the study by Vogel et al. unequivocally shows that coronary wedge pressure is a better indicator of collateral blood flow than absolute distal flow velocity at occlusion, both conceptually and from the point of practical performance.

Lastly, it demonstrates that when studying collateral blood flow by coronary pressure measurement, inclusion of central venous pressure is necessary to optimize the measurements.

In summary, this elegant study means a significant contribution to the state of the art in assessing the coronary collateral circulation of the heart and has implications not only for sophisticated research, but also for the routine interventional practice, because the results of this study can be applied in a rather simple way in the regular cathlab.

Conflict of interest: none declared.

References