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REVIEW

Fractional flow reserve: Concepts, applications and use in France in 2010

Mesure de la réserve coronaire : concept, indications et utilisation en France en 2010

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Revascularization

Summary Fractional flow reserve (FFR) is emerging as a useful clinical tool for assessing the functional significance of coronary atherosclerosis. As opposed to anatomical approaches, physiological measurements (particularly pressure-derived FFR) assess the function of the coronary circulation and offer the possibility of 'ad hoc' treatment. The use of FFR is still limited in France because there is no financial support. The present review will focus on coronary pressure-derived FFR.
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MOTS CLÉS
Réserve coronaire ;
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Revascularisation

Résumé La mesure de la réserve coronaire ou fractional flow reserve (FFR) est un outil très utile pour évaluer le caractère fonctionnel des lésions coronaires. Contrairement à l'approche anatomique, l'évaluation physiologique (et notamment la FFR) permet de déterminer directement en salle de cathétérisme si une sténose est hémodynamiquement significative. Cette sténose peut alors être traitée dans le même temps. L'utilisation de la FFR en France est encore limitée en raison de l'absence de remboursement. Cet article est une revue des outils de physiologie coronaire et s'intéresse plus particulièrement à la FFR.
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Abbreviations: CABG, coronary artery bypass graft; CFR, coronary flow reserve; FFR, fractional flow reserve; IMR, index of microvascular resistance; LMCA, left main coronary artery; PCI, percutaneous coronary intervention; Pd, distal coronary arterial pressure; Pv, coronary venous pressure; R, resistance of the coronary microvascular compartment; Tmn, mean transit time.

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Introduction

The goal of any treatment is to improve patients' prognosis and/or symptoms. Accordingly, the goal of any diagnostic tool is to guide decision-making, to apply optimal treatment to individual patients. Any diagnostic tool not fulfilling these requirements should not be used in patients. FFR is emerging as a useful technique for the assessment of coronary artery stenosis. FFR evaluates the functional significance of coronary artery stenosis and helps interventional cardiologists with 'on the spot' decision-making [1,2]. This is especially relevant when a coronary angiogram shows mild-to-moderate coronary atheroma. The usefulness of FFR is also further clinically validated in complex bifurcation lesions, ostial stenoses, multivessel disease and left main stenoses [3]. As opposed to anatomical approaches, physiological measurements (particularly pressure-derived FFR) assess the function of the coronary circulation and offer the possibility of 'ad hoc' treatment [4]. The use of this tool is still limited in France because there is no financial support. The present review will focus on coronary pressure-derived FFR.

Coronary circulation

To comprehend the concept of FFR, the coronary circulation can be viewed as a two-compartment model. The first compartment consists of large epicardial vessels (> 400 microns), which are also referred to as 'conductance vessels' because they have minimal resistance to blood flow. Therefore, the pressure in the distal part of a healthy human coronary artery should be equal to central aortic pressure. The second compartment consists of arteries smaller than 400 microns, or 'resistive vessels' (Fig. 1). Myocardial flow is controlled predominantly by resistive vessels.

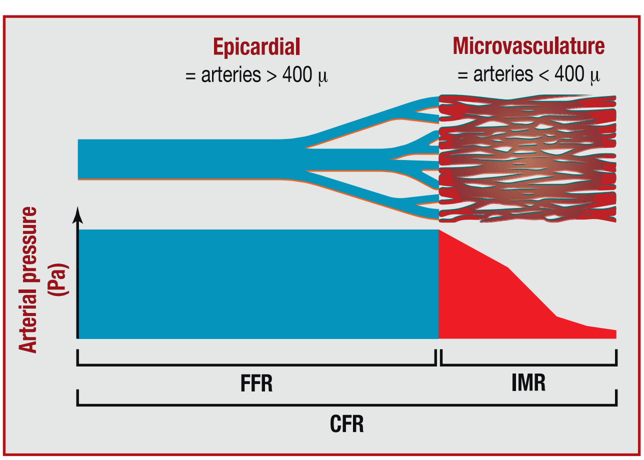

Figure 1. Coronary circulation. As the epicardial vessels contribute only a minimal fraction of the total vascular resistance there is no significant pressure drop along the conductance vessels. In contrast, passage through the resistive vessels produces a large drop in pressure. CFR: coronary flow reserve; FFR: fractional flow reserve; IMR: index of microvascular resistance.

Physiological indices of the coronary circulation

In the next few paragraphs, we will discuss some of the relevant indices of coronary physiology that can be used to estimate coronary circulatory function as a guide to clinical decision-making. FFR is the best validated of all of these physiological indices. In the first part of this section, we will briefly describe the other indices before focusing on FFR.

Coronary flow reserve

CFR is defined as the ratio of hyperaemic blood flow (Q max) to resting myocardial blood flow (Q rest) (i. e. CFR = Q max/Q rest). The normal value for CFR is still not well defined and normal values differ from study to study [5,6]. There is some consensus of opinion, however, suggesting that a value > 4 should be considered as normal, which means that microvascular resistance can decrease by a factor of 4 [7]. As absolute myocardial flow is not easy to determine, surrogate markers of flow are commonly used, such as flow velocities assessed by the Doppler Wire (FloWire, Volcano Inc., Rancho Cordova, CA, USA) or Tmn assessed by the PressureWire (Saint Jude Medical Systems Inc., Uppsala, Sweden). Regardless of the method used to measure CFR, this technique has several limitations: resting flow is highly variable; there is considerable spatial heterogeneity of flow velocity distal to an epicardial stenosis; hyperaemic flow is directly dependent on systemic blood pressure; the hyperaemic and resting measurements are performed simultaneously not successively; and CFR is not specific for an epicardial stenosis, as the CFR value depends on both epicardial vessels and microcirculation. When CFR is low, it is impossible to distinguish whether this value is related to an epicardial artery stenosis alone, microcirculatory dysfunction alone or a combination of both. Owing to these limitations, CFR is not used routinely in clinical practice to assess the haemodynamic significance of a coronary stenosis and has limited value in clinical decision-making.

Index of microvascular resistance

The resistance of a vascular system is defined as the ratio of the pressure gradient divided by the flow across that particular system. Accordingly, the resistance of the coronary microvascular compartment is equal to the ratio (Pd—Pv)/Q, where Pd is distal coronary arterial pressure and Pv is coronary venous pressure or right atrial pressure. In the coronary circulation, Pv is often almost negligible. Fearon et al. [8] introduced the concept of IMR, considering that the Tmn during maximal hyperaemia is inversely proportional to hyperaemic flow.

Therefore, during maximal hyperaemia, IMR = Pd/1/Tmn = Pd × Tmn. IMR is specific for the microcirculation and is simple to obtain, as Pd and Tmn can be obtained simultaneously with the PressureWire. This technique has been well validated in animals and was recently used in the setting of acute coronary syndromes to predict clinical outcomes and assess the effect of treatment [5,7—12]. Nevertheless,

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