Letter by Saito Regarding Article, “Collateral Donor Artery Physiology and the Influence of a Chronic Total Occlusion on Fractional Flow Reserve”

To the Editor:

I read with interest the article by Ladwiniec et al.1 in which they assessed the functional effect of recipient artery revascularization on donor artery stenosis in patients with chorionic total occlusion. One of the main conclusions of their study is that a large increase in fractional flow reserve (FFR) is associated with greater coronary stenosis severity. However, this conclusion is not surprising. I recently published an article in which the donor–recipient artery interaction is clarified by using a mathematical model.2 When the donor artery FFR is defined as $\text{FFR}_1$, the recipient artery FFR, as $\text{FFR}_2$, and $n$ as the ratio of microcirculatory resistance of the recipient artery to the donor artery, the donor artery FFR after releasing the recipient artery stenosis is calculated as per the following Equation (1):

$$\text{FFR}_1' = \frac{(n\text{FFR}_1 + \text{FFR}_2)(\text{FFR}_1 - \text{FFR}_2) + \text{FFR}_2(1 - \text{FFR}_1)}{n(\text{FFR}_1 - \text{FFR}_2) + \text{FFR}_2(1 - \text{FFR}_2)}$$

(1)

Thus, the increase in FFR in the donor artery is calculated as follows:

$$\text{FFR}_1' - \text{FFR}_1 = \frac{(n\text{FFR}_1 + \text{FFR}_2)(\text{FFR}_1 - \text{FFR}_2) + \text{FFR}_2(1 - \text{FFR}_1)}{n(\text{FFR}_1 - \text{FFR}_2) + \text{FFR}_2(1 - \text{FFR}_2)} - \text{FFR}_1$$

$$= \frac{\text{FFR}_2(1 - \text{FFR}_2)(n + \text{FFR}_2)}{n(\text{FFR}_1 - \text{FFR}_2) + \text{FFR}_2(1 - \text{FFR}_2)}$$

(2)

The partial differentiation of Equation 2 with respect to $\text{FFR}_1$ becomes

$$\frac{\partial (\text{FFR}_1' - \text{FFR}_1)}{\partial \text{FFR}_1} = \frac{-\text{FFR}_2(1 - \text{FFR}_2)^2(n + \text{FFR}_2)}{(n\text{FFR}_1 - \text{FFR}_2 + \text{FFR}_2(1 - \text{FFR}_2))^2} < 0$$

(3)

The above inequality (3) indicates that the FFR increase in the donor artery stenosis monotonically decreases when the donor artery FFR becomes larger, which is in accordance with the results of the study of Ladwiniec et al.1 Similarly, the partial differentiation in Equation 2 with respect to $\text{FFR}_2$ and $n$ are calculated as follows:

$$\frac{\partial (\text{FFR}_1' - \text{FFR}_1)}{\partial \text{FFR}_2} = \frac{n(1 - \text{FFR}_1)(\text{FFR}_1 - \text{FFR}_2)^2 + \text{FFR}_2(1 - \text{FFR}_1)}{(n\text{FFR}_1 - \text{FFR}_2 + \text{FFR}_2(1 - \text{FFR}_2))^2} > 0$$

(4)

$$\frac{\partial (\text{FFR}_1' - \text{FFR}_1)}{\partial n} = \frac{-n(1 - \text{FFR}_1)(1 - \text{FFR}_2)(\text{FFR}_1 - \text{FFR}_2)}{(n\text{FFR}_1 - \text{FFR}_2 + \text{FFR}_2(1 - \text{FFR}_2))^2} < 0$$

(5)

The inequality (4) demonstrates that the FFR increase in the donor artery stenosis is more significant when the recipient artery FFR is larger. This indicates that the richer the collateral, the stronger the effect of the recipient artery recanalization. The inequality (5) demonstrates that the FFR increase in the donor artery stenosis is less significant when $n$ is larger. This indicates that the smaller the territory that the donor artery supplies through the collateral arteries, the smaller the effect of the recipient artery recanalization. These considerations derived from the inequalities (4) and (5) would also be true; however, the study of Ladwiniec et al.1 failed to prove this. A future study that involves a much larger sample size should prove these considerations.

Disclosures

None.

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References


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