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CASE IMAGE

Impact of collateral circulation with fractional flow reserve derived from coronary computed tomography angiography

Kollateral dolaşımın bilgisayarlı tomografik anjiografi ile elde edilen oransal akım yedeğine etkisi

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A 73-year-old man was admitted with a complaint of chest pain. Coronary computed tomography angiography (CTA) and a three-dimensional, volume-rendered image of the coronary tree revealed mild- to-moderate stenosis with spotty calcification at the left anterior descending proximal (LAD) artery (dotted line), occlusion of the first diagonal branch (D1), as seen from the arrowhead, and a well-developed collateral circulation (Figure 1A and B; arrow). The CTA-derived fractional flow reserve (FFR_{CT}, HeartFlow Inc., Redwood City, CA, USA) at the LAD artery was 0.97 just before the bifurcation of the D1; however, this dropped to <0.50 immediately at its distal portion (Figure 1C; dotted line). The vessel lumen of D1 seemed to be obstructed on the FFR_{CT} image. (Figure 1C; arrowhead). For further evaluation, invasive coronary angiography was performed ,and this showed the same findings as CTA. There wase mild-to-moderate stenosis in the proximal LAD artery (Figure 1D; dotted line; Video 1* and 2*) and occlusion of D1 (Figure 1D; arrowhead; Video 1* and 2*), which was perfused via a well-developed collateral circulation (Rentrop classification: Grade 3) from the distal LAD artery (Figure 1D; arrow; Video 1* and 2*). Invasive FFR was not measured. For 2 years, the patient had not experienced any cardiovascular symptoms and events after invasive coronary angiography.

In the present case, the hemodynamic significance of mild-to-moderate stenosis in the donor artery could have influenced FFR_{CT} because it supplied a well-developed collateral circulation to the recipient artery. To the best of our knowledge, this is the first report of a mismatched result between FFR_{CT} and invasive coronary angiography assessment caused by collateral circulation. It is suggested that care should be taken in the interpretation of FFR_{CT} in patients with a pacemaker and in those with post prosthetic valve replacement, severe calcified coronary arteries, arrhythmia, or extreme obesity. However, there have been no reports about patients with collateral circulation. The precise mechanisms of FFR_{CT} decline in the donor artery with well-developed collateral circulation still need to be explained; however, there are several reports on the relationship between FFR decline as assessed by invasive FFR and collateral

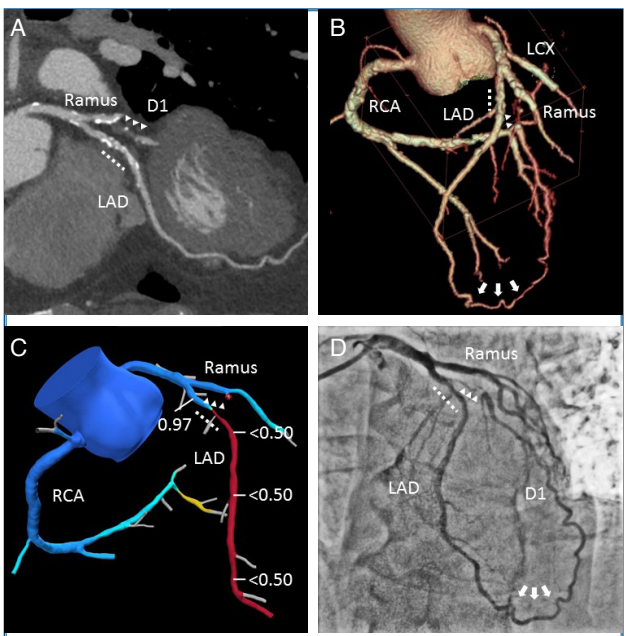

Figure 1. (A) Computed tomography angiography. **(B)** Three-dimensional volume rendered image of the coronary tree showing mild-to-moderate stenosis in the proximal left anterior descending artery (LAD) (dotted line), occlusion of the first diagonal branch (D1; arrowhead), and well-developed collateral circulation. **(C)** Computed tomography angiography derived fractional flow reserve showing that the LAD artery is 0.97 just before the bifurcation of D1 and <0.50, immediately after D1 (dotted line); the vessel lumen of D1 seems to be obstructed on the FFR_{CT} image. **(D)** Invasive coronary angiography showing mild- to-moderate stenosis in the proximal LAD artery (dotted line), occlusion of D1 (arrowhead), and well-developed collateral circulation from the distal LAD artery (arrow).

circulation. Maximal blood flow is proportional to the myocardial mass to be supplied, and the presence of the collateral circulation causes an increase in the myocardial mass that must be supplied, thereby resulting in a high blood flow in the donor artery at maximal hyperemia. The pressure gradient between the proximal and distal coronary arteries depends on the coronary blood flow at maximal hyperemia. Taken together, high blood flow increases the pressure gradient between the proximal and distal areas in the coronary artery, eventually leading to FFR decline. A similar mechanism may have occurred in FFR_{CT}. The limitation of this case is that invasive FFR was not performed because the degree of coronary stenosis in the LAD artery was underestimated as mild, based on visual appearance. Quantitative functional ischemia assessment was not performed, and ischemia may have been overlooked. Notably, the presence of well-developed collateral circulation caused FFR_{CT} to be ≤0.80. FFR_{CT} plays an important role as a gatekeeper for the diagnosis of functional ischemia. FFR_{CT} assessment in the presence of collateral circulation is likely to be incorrect and may result in unnecessary medical costs. The present case highlights that care must be taken when interpreting FFR_{CT} in patients with mild-to-moderate stenosis of a donor artery with well-developed collateral circulation. FFR_{CT} may have the potential to be overestimated because of the coronary steal phenomenon that occurs when the donor artery perfuses a large myocardial area.

Written informed consent was obtained from the patient for the publication of the case image.

*Supplementary video files associated with this article can be found in the online version of the journal.