Coronary Artery Collaterals

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After hearing a lecture I gave on chronic stable angina, a friend of mine and fellow cardiologist from Florida, Steven Shang, MD, approached me to discuss the relevance of coronary artery collateral blood flow.

Introduction

He made the point that potential coronary artery collaterals are present before they are needed. They appear angiographically when the epicardial coronary artery is either occluded or has a high grade proximal stenosis resulting in myocardial ischemia in that distribution.

Early Anatomic Observations

Baroldi and Scmazzone, in their elegant work, described vessels in the normal human heart that were interconnecting and anastomotic vessels, but generally less than 200 microns in diameter.¹ They felt that these vessels served as the precursor of the collateral circulation.

These are not the vessels that we usually see angiographically. They reasoned that if a major artery becomes occluded, the pressure gradient that occurs drives blood through the small interconnecting anastomotic vessels, which may then dilate and become visible angiographically. This strongly suggests that there are nonfunctioning, interconnecting vessels that do not appear angiographically until the need arises (the need being myocardial ischemia).

Personal Thoughts About Collaterals

Since those observations were made in the 1960s, I have always believed that collaterals do not appear angiographically unless ischemia is present in the distribution of those collaterals. I also never believed that if the collateral provides excellent blood flow to the ischemic zone, ischemia will disappear and the collateral will remain. In other words, visible collaterals only exist if ischemia is present. In my personal experience, I have seen many patients with angiographically visible collaterals who also have ischemia as defined by a perfusion abnormality or a transient regional wall motion abnormality after stress in that distribution. In fact, I still believe that the presence of angiographically visible collaterals defines myocardial ischemia and thus

myocardial viability in that portion of myocardium. However, although collaterals may not be completely protective against myocardial ischemia, I will admit that ischemia may be more difficult to provoke when good collaterals are present. Another observation I believe to be true is that patients who have a first infarction and no collaterals to the infarction zone have a worse outcome (maybe larger infarction) than patients who have luxuriant collaterals. Often, the patients with a first myocardial infarction and visible collaterals have had angina pectoris preceding their myocardial infarction.

Early Observations About Collaterals

In 1974, Levin reported observations of collaterals in 200 coronary angiograms and left ventriculograms of patients with significant coronary disease.² He noted that collateral circulation was seen only when the degree of coronary artery narrowing exceeded 90% (ischemia was not assessed in these patients). In a group of patients with “adequate” collaterals, regional left ventricular contraction was normal in 43%, mildly hypokinetic in 52%, and akinetic or dyskinetic in 5%. In the group lacking “adequate” collaterals, regional contraction was normal in only 11%, mildly impaired in 16%, and severely impaired in 73%. No assessment of the presence or absence of myocardial ischemia was done (other than regional wall motion). The conclusion from this observational study was that collateral circulation plays an important role in preserving myocardial contraction in patients with coronary disease. In this study, collateral circulation was not seen at the time of coronary angiography when the degree of arterial narrowing was less than 90% of the lumen diameter.

Do Collaterals Prevent Myocardial Ischemia?

If collaterals are to prevent myocardial ischemia, they must provide enough flow and oxygen to the dependent myocardium. However, all collaterals seen at coronary angiography may be protective against or limit infarction but may not provide adequate flow to prevent myocardial

ischemia and regional myocardial dysfunction. Obviously there may be some collateral flow that is not visible at the time of coronary angiography that may influence myocardial infarction size. As far as I can tell, the only way to determine collateral flow not visible by coronary angiography would be with nuclear perfusion studies that demonstrate normal regional wall motion under conditions of stress in an area that is poorly perfused by an epicardial vessel and no visible collaterals seen at angiography.

Effects of Collaterals on Cardiac Function and Survival

In 1976, Williams and colleagues evaluated twenty patients with acute myocardial infarction who underwent coronary angiography and ventriculography.³ There were six patients with “adequate” collateral vessels and fourteen with no or inadequate collateral blood vessels directed to the area of myocardial infarction. They noted differences in diastolic pressure, cardiac index, ejection fraction, and area of dysynergy that was favorable in all the patients who had adequate collateral vessels. In addition, all those patients survived, whereas 10 of 14 patients without adequate collaterals had evidence for cardiogenic shock, 8 of 14 of whom died. They also noted that in those with adequate collaterals, angina pectoris was more common preceding the infarction than in those without adequate collaterals.

Do Collaterals Attenuate Exercise-induced Myocardial Ischemia?

More recently in 1980, Wainwright and colleagues investigated 65 patients with coronary artery disease documented angiographically using thallium scintigraphy to determine the role of collateral circulation during dynamic exercise.⁴ These investigators also developed a scoring system for collaterals as follows:

Grade 0: Absence of collateral vessels

Grade 1: Poorly developed collateral vessels with no prominent distal channel visualized

Grade 2: Moderate collaterals giving faint but delayed opacification of a prominent distal channel

Grade 3: Good collaterals giving clear opacification of a prominent distal channel

Grade 4: Excellent collaterals giving full and brisk opacification of prominent distal vessels

They found that there was excellent correlation between “good” collaterals with complete protection from ischemia and poor or absent collaterals in which no protection was noted. Of 53 patients with occlusion of a proximal epicardial coronary artery, 17 had occlusion without myocardial infarction, and collaterals were noted to provide protection in 9 of 15 occlusions where no protection was seen in 5 occlusions without collaterals.

One of the conclusions from their observations was that if the angiographer finds grade 4 collaterals they are probably functionally important and provide myocardial protection against infarction and also probably ischemia.

Conclusions

I still believe that dormant collaterals (which may not be present in every patient) are recruited and become angiographically visible when stimulated by myocardial ischemia (perhaps lactates or other factors) may be important to limit infarction size. I do not believe that all angiographically visible collaterals eliminate myocardial ischemia, but they may make ischemia more difficult to provoke.

References

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