Case Report

Unexpected Opening of a Totally Occluded Septal Branch Originating From an Atheromatous Lesion Successfully Treated with Angioplasty and Stenting

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In about 50% of patients who undergo a percutaneous coronary intervention for an atheromatous lesion there is a side branch that is involved in or borders on the lesion. In such cases, the invasive cardiologist must make every attempt to rescue this branch. We present an unusual case of unexpected opening of a side branch of a coronary artery after balloon angioplasty and stenting of the main vessel. In a patient with subtotal occlusion of the anterior descending coronary artery, angioplasty and stenting caused the opening of a previously totally occluded septal branch that originated from within the treated atheromatous lesion. This case is an unusual example of atheromatous plaque shift that had an unexpectedly beneficial result.

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In around 50% of patients with an atheromatous lesion under treatment with angioplasty there is a side branch that is involved in or borders on the lesion. The invasive cardiologist must make every attempt to rescue this branch. Here we present an unusual case, not of obstruction, but of unexpected opening of a side branch after angioplasty in the main vessel.

Case description

A man aged 60 years, a smoker and hypertensive, who had been complaining of typical angina class CCS II since two months before and had recently had a positive exercise stress test, was referred for coronary angiography. The patient had received the indicated medication (clopidogrel and aspirin) in preparation for probable follow on angioplasty.

Approach was via the right femoral artery using a 6F sheath. Selective left coronary artery catheterisation was performed using a left Judkins 4 catheter while a right modified Amplatz was used for the right coronary artery. Left ventriculography was carried out using a pigtail catheter. The coronary angiogram revealed an AHA/ ACC type A lesion in the proximal part of the left anterior descending (LAD) coronary artery branch (though to some degree it could have been considered a type B, since its length was borderline, around 10 mm, it was not absolutely concentric and there was also some opacification that could have been indicative of a small quantity of thrombus), which was causing subtotal occlusion of the vessel with TIMI 1-2 flow (Figure 1). The remainder of the vessel showed no haemodynamically significant stenosis, as was also the case with the circumflex and right coronary arteries, even though the latter were atheromatous vessels. It was decided to perform percutaneous transvenous coronary angioplasty with stent implantation at the site of the lesion in the LAD.

A type XB 3.5 6F guiding catheter (Cordis) was employed, through which a soft angioplasty guidewire (Balance Middleweight

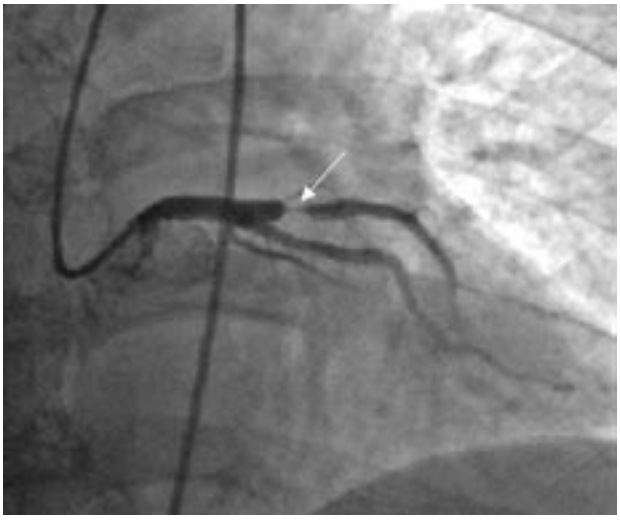

Figure 1. Subtotal occlusion of the left anterior descending coronary artery (white arrow). There is no sign of a septal branch in the region of the lesion.

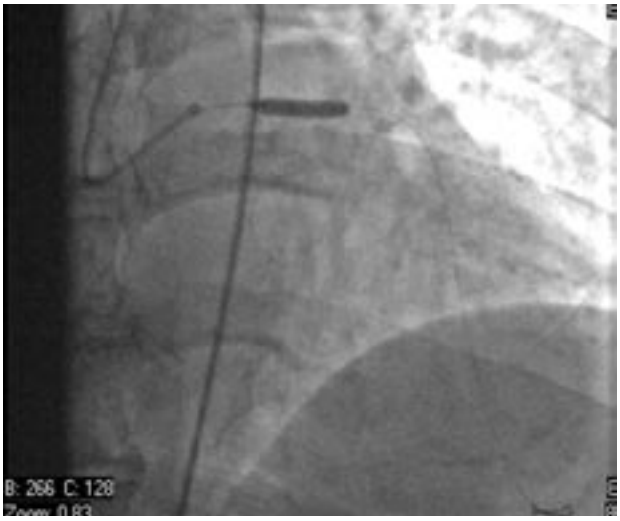

Figure 2. Balloon dilatation and stent deployment at the site of the lesion in the anterior descending artery.

ACS, BMW, Guidant) was introduced to the distal part of the LAD. A single operator exchange balloon catheter (Evolution, Medical Technologies, Inc.), 2.5 mm in diameter and 15 mm long, was advanced along the wire to the site of the lesion. The balloon was inflated at 6 atmospheres, resulting in a small improvement in the flow inside the vessel. Then, a Diamond Flex stent (Phytis Intelligent Diamond Technologies), 4 mm in diameter and 16 mm long, was deployed and balloon inflation was repeated at 16 atmospheres (Figure 2), achieving complete restoration of flow in the vessel and an excellent angiographic result.

In subsequent angiographic projections used to check the result of the angioplasty, a septal branch was observed, of mean diameter 1-1.5 mm, originating from around the middle of the lesion (Figure 3, white arrows). This septal branch was not visible prior to the angioplasty (Figure 1) and also appeared with a significant ostial stenosis >50%, though with good TIMI 3 flow.

Discussion

This case is presented as an unusual result of balloon angioplasty, regarding the fate of a side branch closely bordering on or originating within the lesion of the main vessel in which angioplasty was performed. In cases of angioplasty where a side branch is involved the invasive cardiologist must make every effort to avoid compromise of the side branch at the time the main vessel is opened, in order to ensure the best possible overall perfusion of the ischaemic myocardium. Of course, when the side branch is small its occlusion is not always clinically significant and there is a likelihood of flow restoration in the future. However, the case presented here shows exactly the opposite situation, where during angioplasty of a main vessel not only was a side branch not compromised, but rather a previously unknown septal branch was opened at the same time. This branch originated from within the atheromatous plaque of the lesion, which was of sufficient size to cause subtotal occlusion of the LAD. In addition, however, the septal branch was of small diameter, 1-1.5 mm, and had a significant ostial lesion. Clearly the above conditions taken together would facilitate the occlusion of a previously open septal branch. Of course, the presence of an ostial lesion of a septal branch, appearing after balloon angioplasty, does not amount to logical proof of its prior existence. Furthermore, the angle at which the branch arose from the LAD, around 90˚, would not predispose to occlusion, as often occurs with septal branches, which have a lower rate of occlusion than do diagonal or marginal branches involved in bifurcation lesions. Thus, one might hypothesise that the septal branch was always open and that the redistribution of atheromatous material during balloon angioplasty of the main vessel caused that ostial lesion. However, if this was the predominant pathophysiological scenario, then the septal branch should have become opacified on the pre-angioplasty angiograms, albeit slowly, and that did not happen (Figure 1). In addition, the presence of such a large mass of atheromatous material in the LAD, which caused subtotal occlusion of the vessel

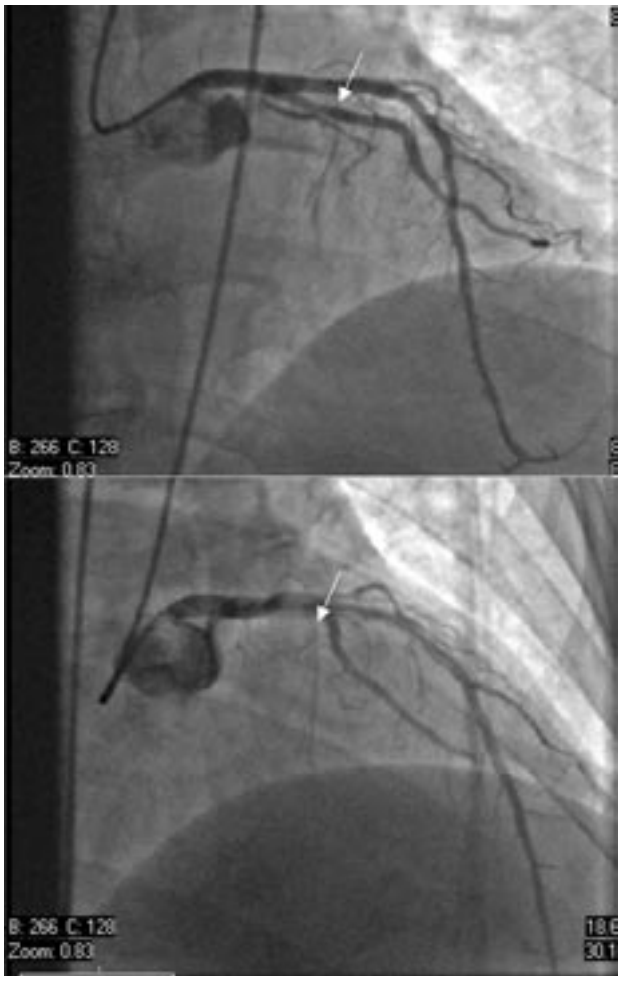

Figure 3. Two projections (upper and lower) after angioplasty and stenting, showing complete opening of the vessel and the excellent angiographic result. At the same time, a septal branch is visible, 1-1.5 mm in diameter, arising from around the middle of the original lesion and with an ostial lesion of its own (white arrows).

and indeed in a concentrated fashion, renders it rather unlikely that a small-diameter vessel could arise from within the atheromatous matter and still remain open. The opening of a previously occluded septal branch arising from within the boundaries of the atheromatous lesion, as well as the opening of such a lesion in the LAD, represent an unusual case of atheroma shift (snow plough effect), of a type that has never been reported before in the literature.

Side branches of the coronary arteries that fall within the boundaries of an atherosclerotic lesion in which angioplasty is to be performed are often an important factor influencing the reperfusion strategy. We know that angioplasties of "true" bifurcation lesions make up 4-16% of the total, while 20% of significant lesions in a main coronary vessel involve a side branch with mild stenosis.[1] If, however, we also take into account branches of small diameter (<1 mm) it has been estimated that the percentage of angioplasties that involve a side branch touches 50%, as reported in a recent review.[2] Factors that need to be evaluated regarding compromise of a side branch during an angioplasty are its size, the ratio of its diameter to that of the main vessel, the presence of an ostial lesion in the branch,[2] the degree of stenosis of the main vessel, the angle at which the side branch arises, and the myocardial region perfused by the branch.

The size of the vessel may be assessed either in a semi-quantitative way by visual estimation, or by using quantitative coronary analysis. The literature holds various classifications that have been used in reference to the size of branches, such as <1 mm, >1 mm, or >1.8 mm. Apart from the size of the branch, however, the region of myocardium it supplies is of particular importance. A classification system used by Alderman et al[3] in the BARI study took that into account as follows: small quantity of perfused myocardium = length of vessel <1/3 of the distance from the base to the apex; moderate quantity of perfused myocardium = length of vessel 1/3-2/3 of the distance from the base to the apex; large quantity of perfused myocardium = length of vessel >2/3 of the distance from the base to the apex.

As regards ostial lesions in side branches, which are associated with a five- to tenfold greater relative risk of occlusion during angioplasty of the main vessel, various classifications have been used, such as >50%, <50%, or 20-99%. A practical recent classification system, which apart from the ostial location of the lesion also takes account of the presence of atheromatous plaque within the two first millimetres from the branch's origin, is as follows: absence of ostial lesion = 0% stenosis; mild to moderate = <50% stenosis; moderate to severe = >50% stenosis. It should also be noted that, while aortocoronary bypass surgery can achieve anastomosis in vessels of diameter >1 mm, the corresponding limit for angiography, with or without stenting, and with satisfactory long-term results is 2.5 mm, especially since the introduction of drug-eluting stents into clinical practice. Taking all these considerations into account, a newer, more clinically orientated classification scheme[2] has been proposed for side branches (Table 1). Traditionally, three models have been proposed for the classification of bifurcation lesions:

- In the one adopted by Safian and Freed[1] bifurcation lesions are classified as type 1 to 4, according

Table 1. Classification of side branches.

Small side branches	<1.5 mm, small area of perfused myocardium, surgical anastomosis impossible, no angioplasty or stenting.
Medium side branches	1.5-2.5 mm, moderate area of perfused myocardium, surgical anastomosis feasible, angioplasty feasible, no stenting
Large side branches	>2.5 mm, large area of perfused myocardium, surgical anastomosis feasible, angioplasty and stenting possible.

to the extent of the boundaries of the atheromatous lesion in the main vessel, and as A or B, depending on whether the side branch has >50% ostial stenosis or not. Thus: type 1 bifurcations include lesions in which the atheromatous plaque extends before and after the origin of the side branch; type 2 includes lesions that extend before the origin of the side branch, but not after; type 3 includes lesions that extend after but not before, while type 4 refers to lesions only in the side branch. Type 1A bifurcation lesions are also referred to as "true" bifurcation lesions.

- In the system adopted by Topol,[4] bifurcation lesions are classified as type A to F. In type A lesions the atheromatous plaque extends before the origin of the side branch, which has no ostial lesion; in type B the plaque extends after the origin of the side branch, which has no ostial lesion; in type C the plaque extends both before and after the origin of the side branch, which has no ostial lesion; in type D the plaque extends both before and after the origin of the side branch, which has an ostial lesion; in type E the atheromatous plaque is only within the ostium of the side branch, while in type F the plaque extends before the origin of the side branch, which also has an ostial lesion.
- In the structure adopted by Lefevre et al[5] the bifurcation lesions are classified as type 1 to 4, also including types 4A and 4B.

The mechanisms involved in the obstruction of side branches are atheromatous plaque shift within the side branch (snow plough effect), dissection of the intima of the side branch, thrombosis, embolisation of atheromatous material, and spasm. During stenting the struts are also likely to impede flow in the side branch, either partially or completely (stent jail). The risk of side branch occlusion during angioplasty, with or without stenting, is estimated to be around 10% and depends on various factors, the most important of which are as follows: the diameter of the side branch, the degree of stenosis in the main vessel, and the branching angle. In vessels of <1 mm diameter the risk of obstruction is 15-20%,[6] while in vessels >1 mm this drops to 4%. If there is an ostial lesion in the side branch the risk of obstruction during stenting is 25%, but just 2% if there is not.[7] Other studies have reported that in bifurcation lesions where there is >50% stenosis of both the main vessel and the ostium of the side branch the risk of occlusion is 14-34%,[8] while the risk of increasing the degree of stenosis is 27-41%.[9] The origin of a side branch at an acute angle is also known to be associated with a higher risk of obstruction, while when this angle approaches 90° the risk decreases.

The type of stent deployed in the main vessel in bifurcation lesions has no effect on the risk of side branch occlusion. In an older study,[10] which compared three different designs of standard stents (Crossflex coil stent, NIR slotted tube stent, GFX hybrid stent) found no differences between them in relation to the occlusion of side branches. Newer drug-eluting stents do not appear to affect the risk of side branch obstruction. In one study[11] involving patients of the RAVEL trial, similar rates were found for both occlusion of side branches during angioplasty and their long-term rechannelling, in patients who received standard stents and in those in whom newer, drug-eluting stents were implanted. Balloon dilatation at high pressure seems to increase the risk of side branch obstruction.[12] Thus, both inflation at a pressure >15 atmospheres and repeated inflations (>3) are associated with a greater risk of occlusion. Data concerning direct stenting remain rather contradictory,[13,14] although it is possible that direct stenting could be associated with a lower incidence of side branch compromise. In the cases studied, the morphology of the lesion[15] was a significant parameter affecting the rate of occlusion of the side branch. Lesions of types D and F, according to the classification system adopted by Topol,[4] more often predispose to occlusion. Safian and Freed[1] have proposed a simple classification rule for the risk of side branch occlusion in bifurcation lesions

during angioplasty of the main vessel. Based on this classification, the risk is small (<1%) if the side branch is not directly in contact with the lesion but is obstructed transiently during balloon dilatation, moderate (1-10%) if the side branch arises from within the atheromatous lesion in the main vessel but is free of stenosis, and high (14-35%) if the side branch has >50% ostial stenosis and arises from within the atheromatous lesion in the main vessel.

The clinical significance of side branch compromise during angioplasty is related to the size of the vessel and the area of myocardium it perfuses. In general, side branch obstruction has a benign course, since in 81% of cases it later opens spontaneously.[2] It is characteristic that the occlusion of side branches <1 mm in diameter is associated with a clinical syndrome of chest pain in only 6% of cases, while an increase in myocardial enzymes is almost never seen. In contrast, in the case of occlusion of a side branch >1 mm in diameter, chest pain occurs in 15% of cases, while a concomitant increase in myocardial enzymes is seen in 12%. In the case presented here, the septal branch was of small diameter but was quite long, and so would have contributed to the better perfusion of the interventricular septum.

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