How to treat small coronary vessels with angioplasty

Coronary arteries are, by definition, small vessels. When Grüntzig was about to move his balloon technique from the peripheral vessels to coronary arteries, people knew that it would never work. They knew that this was pushing the limits of the technique too far. The dissections, known to be germane to balloon angioplasty from looking at the postinterventional angiograms of leg arteries at the time, needed space not to obstruct flow and cause acute closures. People were wrong. The high flow in epicardial coronary arteries that further accelerates during diastole seems to make up for small size to a certain degree. Acute occlusions did occur more frequently in coronary than in femoral arteries but they still were confined to fewer than 10% of cases.

Nevertheless, a relation between the risk of acute closure and the diameter of the treated coronary artery became apparent. Small coronary arteries are not the friends of interventional cardiologists and very small ones are their nightmares.

The disadvantages of small coronary arteries are shown in table 1. The only advantage of small coronary vessels is that they generally subtend less myocardium, which translates into less clinical risk in case of an occlusion of the artery.

Peculiarities of angioplasty for small coronary arteries

Ever since the first case of coronary angioplasty (which I experienced as Grüntzig’s assistant) the rule was: if the case does not need at least a 2.5 mm balloon, there is no case. Of course, this policy has been violated on occasions by Grüntzig himself, yet the cases that I saw him start with a balloon of ≤ 2.0 mm can be counted on one hand, as can the ones in my practice. Dealing with mainly a white population, vessels that will not take a 2.5 mm balloon or larger are usually not worth the trouble of revascularisation. This may be different in Asia where not only people but also coronary arteries are on average downsized.

Approaching small coronary arteries requires an even more lean and swift procedure than coronary angioplasty in general. To avoid complete blockage (wedging) of the small coronary orifice, guiding catheters with diameters of ≤ 2.0 mm (6 Fr or less) are advantageous. If a larger guiding catheter is used, a side hole is often necessary. Of the atherectomy devices, only the Rotablator and perhaps a small laser probe are feasible, but data suggest to stick with a sleek balloon and a low profile stent in case of need.

The coronary guidewire will have to have a very short J tip. A long J tip will be straightened in a small coronary vessel and steerability will be lost. Once established, wire position should be maintained by all means until the completion of the procedure, which may be one of the few arguments against a Monorail system1 because any modification of the wire tip configuration requires giving up the passage already accomplished in the coronary artery.

When it comes to balloon advancement, the balloon should not have been inflated before and should be under continuous negative pressure to benefit from its best profile. There will be more friction and good guiding catheter back up has to be attained. This requires skillful manipulation using soft and small guiding catheters.

The selected balloon should have only moderate compliance and it should not be oversized. If the lesion is resistant, high pressures may have to be used and the parts of the balloon not opposed by the tougher section of the lesion may show “dog boning” and dissect the adjacent segments. If the lesion cannot be passed or cracked (extremely rare with modern low profile and high pressure balloons), there emerges one of the remaining indications for preparing the lesion with a laser or a Rotablator burr.

Complications with small coronary vessels

Dissection is an integral part of coronary angioplasty. In small vessels, it is more likely that an intimal flap will obstruct flow significantly leading to thrombotic occlusion of the vessel. This asks for prudence in selecting the size of the balloon and the pressure used for dilatation. It also argues against balloons that are significantly longer than the lesion. In contrast to some recommendations in textbooks, stenting should be used more liberally in small vessels than in large ones because the main feature of stenting is prevention of acute occlusion. The same may hold true for the novel and expensive glycoprotein IIb/IIIa antagonists. Should an occlusion occur, it is more difficult to renegotiate the occluded segment and a ball-tip wire3 may be advantageous. A small vessel occluded acutely may also be given up more easily because the myocardial infarction to be expected is usually limited and does not warrant emergency surgery or jeopardise the patient’s life.

Restenosis in small coronary vessels

Among the factors predisposing to restenosis following angioplasty, vessel size is a prominent one. This has been shown both on the basis of reference vessel diameter (figs 1 and 2)4 as well as on the basis of the post-procedure lumen

![Figure 1](http://heart.bmj.com/) Restenosis rates for different balloon diameters used in 927 patients.
In a seminal paper by Foley et al it was demonstrated that the absolute late loss (the composite effect of constrictive remodelling and intimal proliferation) is fairly independent of the reference vessel diameter. Thus the relative late loss is greater for small vessels. Long lesions in small coronary vessels
An ominous combination is a long stenosis in a small coronary artery. It represents a risk for both acute or abrupt closure and restenosis. Primary stenting is hardly a solution because long stents in small vessels are prone to failure. Bailout stenting, however, for an inadequate result after balloon dilatation or an impending occlusion will quite frequently become necessary. It becomes mandatory if flow is slow. In cases of a very long dissection without any cul-de-sac retaining contrast medium and with brisk and unimpeded flow, it is probably better to forego stenting. If, on the other hand, a discrete place can be made out in a long dissection where the contrast medium stagnates (indicating that blood will be caught, clot, and increase the size of the pouch thereby obstructing the remaining lumen), a short stent for that particular segment may be the solution.

Restenosis correlates with the length of the dilated segment with or without stent implantation. Risk for a restenosis in a large vessel with a stenosis shorter than 5 mm is below 10%, but it is more than 90% for a lesion that is several centimetres long in a small vessel. In this scenario, stenting clearly helps in the case of threatening or accomplished acute occlusion, but it has not been shown to be beneficial under any other circumstances. There is only little hope that it will with upcoming data.

General comments
Coronary lesions in small vessels are bad news, particularly if they are long. The results of coronary angioplasty, generally gleaned from procedures in short lesions of larger vessels, cannot be translated without a correcting factor. A clear line has to be drawn where the expected benefit is no longer worth the investment. This decision should be based on the myocardium at stake (rarely a large amount in small vessels), the risk of acute failure, and the risk of iterative restenosis on one hand, and the technical intricacies and investment of sophisticated and expensive equipment on the other. For coronary angioplasty one will find out rapidly that small is not beautiful, and small and important is worst.

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Figure 2 Restenosis rates for different vessel diameters in the M-Heart study.®

Figure 3 Restenosis rates for different post-procedure lesion diameters.®