RECURRENT ANGINA FOLLOWING CORONARY ARTERY BYPASS SURGERY SOLUTIONS IN THE CURRENT ERA

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CORONARY artery bypass grafting is the most common cardiac surgical procedure performed all over the world. In patients with significant obstructive coronary artery disease, bypass grafting is performed primarily to relieve angina in those symptomatic despite medical therapy and also to improve life expectancy in those with particular anatomical substrate such as left main coronary artery disease, three vessel disease with left ventricular dysfunction, and two or three vessel disease with normal left ventricular function, provided there is significant disease of the proximal left anterior descending coronary artery. Undoubtedly, the most striking beneficial effect to the patient after a bypass surgery is the reduction in angina severity and frequency which occurs in atleast 80-85% of survivors of surgery. Bypass surgery is clearly superior to medical therapy and was also to coronary angioplasty before the current methods of revascularization and drug eluting stents were available, at rendering the patient free of angina. More than 350,000 coronary artery bypass surgeries are performed per year in US alone and this number in India is estimated at about 30,000. It is definitely a much cheaper alternative to percutaneous intervention in multivessel coronary artery disease, because multiple devices and drug eluting stents will have to be used for complete revascularization [1-7].

Though coronary artery bypass surgery has stood the test of time, it has significant limitations, both in the immediate post operative period and in the long term, despite the fact that procedure related mortality in most standard centres is less than 2-3%. Peri operative myocardial infarction occurs in about 5-10% of patients undergoing bypass surgery and it is the most common cause of mortality. Overall incidence of peri operative stroke is 1-2%. Subtle or obvious cognitive impairment is detectable in a substantial number of survivors - 25% at 6 months and 40% at 5 years [8-10].

Following coronary artery bypass surgery, about 7% of the saphenous vein grafts gets occluded within the first week and another 15-20% within one year, most commonly due to graft thrombosis, leaving a venous graft patency of an average 75-85% at the end of one year [11]. In addition to the technical problems, size of the coronary artery to which the graft is anastomosed and the distal run off into the native vessel are decisive in the fate of the graft during the first year. Radial artery graft has the problem of spasm in the post operative period which could lead to graft closure.

Bleeding, sepsis, pain and prolonged recovery time are the other issues associated with coronary artery bypass surgery in the immediate post operative phase. Minimally invasive and off pump bypass surgery has reduced the post-operative morbidities to a significant extend in the past few years. It has promised less recovery time, less cognitive problems and a much shorter hospital stay.

When technical issues are well addressed, only antiplatelet therapy has shown a reduction in the incidence of graft thrombosis. Radial artery graft spasm and subsequent closure can be addressed by administration of calcium channel blockers. Peri operative myocardial infarction could be helped by early administration of antiplatelet drugs. Incidence of post operative arrhythmias can be limited by early administration of beta blockers. Avoidance of CPB and current advanced anaesthesiological support has done away with most issues related to it.

Actual problems after coronary bypass surgery is not in the immediate post operative period, but later. Though venous graft occlusion is uncommon between 1- 5 years post surgery (1-2% per year) it is a vexing problem thereafter. Rate of graft occlusion due to intimal fibrosis and atherosclerosis accelerates after 6 years and at 11 years only 50-60% of the grafts will be patent. Only 40% of the patent venous grafts will be free of disease at 10 years. This problem is partly solved by the introduction of arterial grafts, especially the left internal mammary artery, which offers a patency rate of over 90% at 10 years when anastomosed to left anterior descending

coronary artery. Other arterial grafts like right internal mammary artery, Gastro epiploic artery or segments of radial artery are associated with a mean graft survival in between that of left internal mammary artery and saphenous vein grafts. Although arterial grafts are superior, limited number of arterial anastomoses that are possible mandates continued heavy reliance on venous grafts. It is also a concern that the technical difficulties posed by the performance of graft surgery by limited exposure on moving targets in minimally invasive coronary graft surgery might actually lead to less graft survival, both in the immediate phase and long term [10,11].

A patient who has recurrence of symptoms after a bypass surgery is a major challenge to the treating physician. Many a time , issue is complicated by co-morbidities and deterioration of the left ventricular function. Morbidity of this disease is at times is much more grievous than the mortality. When the angina is limiting, despite optimal medical management, the only way out is a repeat revascularization procedure. A redo surgery has an operative mortality 2-3 times higher than that of the initial operation and the probability that it will alleviate angina completely is only about 50-60%, limiting its advocation to a very select number of patients [12]. Expertise all over the world in redo surgery is limited. It is associated with not just higher mortality, patients requiring redo coronary artery bypass surgery are likely to have more bleeding, higher incidence of cerebro vascular accidents, wound sepsis and need for re-exploration in addition to the potential danger of injuring functional grafts upon opening up of the sternum, especially the left internal mammary artery graft.

Patients who are not good candidates for a redo surgery are often offered only medical management, which is obviously inadequate in most of the instances. Interventional cardiology these days could help many such patients, thanks to the advancements in the understanding of the pathophysiology of graft disease and development of devices, techniques and support measures to tackle such complex issues. Late recurrence of angina following coronary artery bypass surgery are due graft disease, development of fresh lesions beyond the grafted segments or previously non grafted vessels, accelerated atheroscelerosis, more calcification and fibrosis of the pre existing lesions in the native disease which was bypassed, but bounce back to the picture once the graft gets disease.

Fresh disease developing in a previously non grafted vessel is not a major issue since it can be tackled most of the time in the very same way any other lesions would be treated. Though challenging, fresh disease in native vessel beyond the grafted segment can be approached through the graft . Many a times it is difficult to visualize simultaneously both the guide catheter and the lesion in the same angiographic field during treatment of a native vessel or distal anastomotic lesion through a graft, especially the mammary graft. This could lead to inadvertent damage to the graft at ostium which could be disastrous.

When the graft is diseased, most of the time native vessel disease angioplasty when feasible is the first choice, since long term result is likely to be better than that of graft disease if immediate result is good. Once the vessel is bypassed and if the native vessel disease is very significant, most of the distal blood flow will be through the graft. This can lead to complete cessation or further reduction of flow through the native lesion and it can close off completely. Once a lesion in a vessel totally occludes it for long, it develops more accelerated athereoscelerosis, gets more calcified and becomes less crossable with coronary guide wire. For that matter, any lesion over a period of time, is likely to become more fibrotic and calcific making them more challenging to tackle. Such lesions are difficult to crack with usual balloon angioplasty even when crossed. When the lesion is more tubular, fibrotic and calcific, cutting balloon angioplasty followed by stenting may be a better option, provided the bulkier cutting balloon would cross the lesion; which is demanding (*Fig.* 1).

Rotational atherectomy is another important adjunct, especially in a densely calcified lesion, diffuse disease, small vessel, restenotic lesion and when lesion is too tight where balloon would not even negotiate it. Adjunct balloon angioplasty and stenting is almost always necessary. Technically, it is feasible to treat the native vessel disease through both the native vessel and the graft using these gadgets (*Figs.* 2, 3a, 3b).

Aim of treatment of native vessel disease is to achieve a good immediate result and to maintain it in the long term. We believe that a good long term result can be expected only when the immediate result is good. Adequate debulking of fibrotic and calcific lesions is very important for optimal stent deployment. Endovascular repair is especially when we have to deal with such complex lesions. It is virtually a repair of the lesion from within, which includes adequate controlled debulking , leading to the exclusion of the plaque from within the lumen to the vascular wall, pulvarizing the tough calcific plaque by rotablation or excising the plaque with an atherectomy device so that there is no much limiting plaque material, complemented by further balloon dilatation if needed and then stacking up of the vessel wall with a stent, which usually adds to the vessel lumen gained. Newly developed drug eluting stents containing Paclitaxel and Sirolimus which inhibit smooth muscle proliferation will help to keep this immediate result intact for a long time, preventing restenosis which is extremely important in this setting (*Fig.* 4).

Left internal mammary graft anastomotic problems are

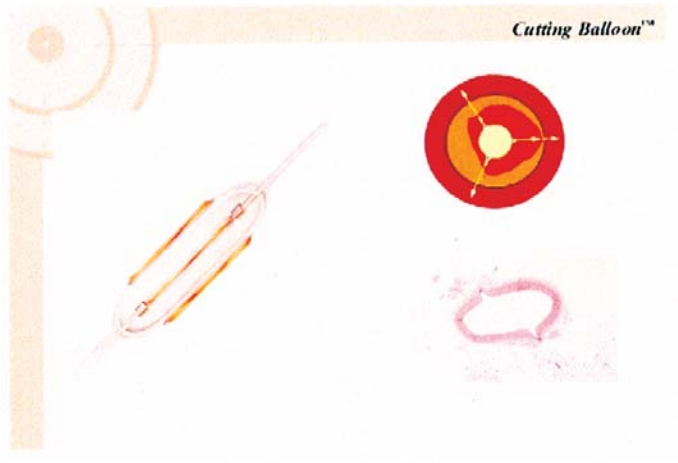

Fig.1. Cutting balloon allows controlled dissection of atheroma enabling better debulking.

less frequently encountered these days owing to the growing surgical expertise. Depending on the lesion, plain balloon angioplasty or cutting balloon angioplasty can be done with or without stenting for anastomotic lesions . Drug eluting stent is not a necessity in many such lesions since there is no atherosclerosis .

Treatment of a venous graft is much more complex. Vein graft occlusion in early days of surgery is frequently not recognized. When there are technical problems at anastomotic site, if recognized, can be treated percutaneously. Graft at this early stages behaves unlike a degenerated vein graft, anastomotic narrowing can undergo plain balloon angioplasty or cutting balloon angioplasty with or without a stent. Difficulty in such cases is that the balloon should inflate against the suture.

Thrombosed vein graft is likely to be more messy and

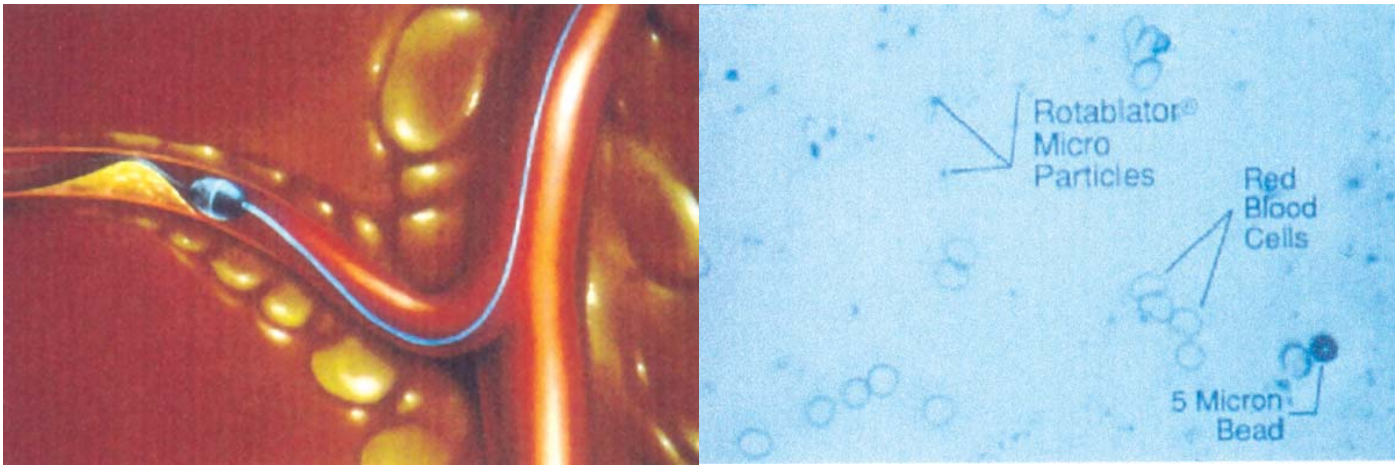

Fig.2. Rotablator pulverizes plaque material small enough to pass through micro circulation.

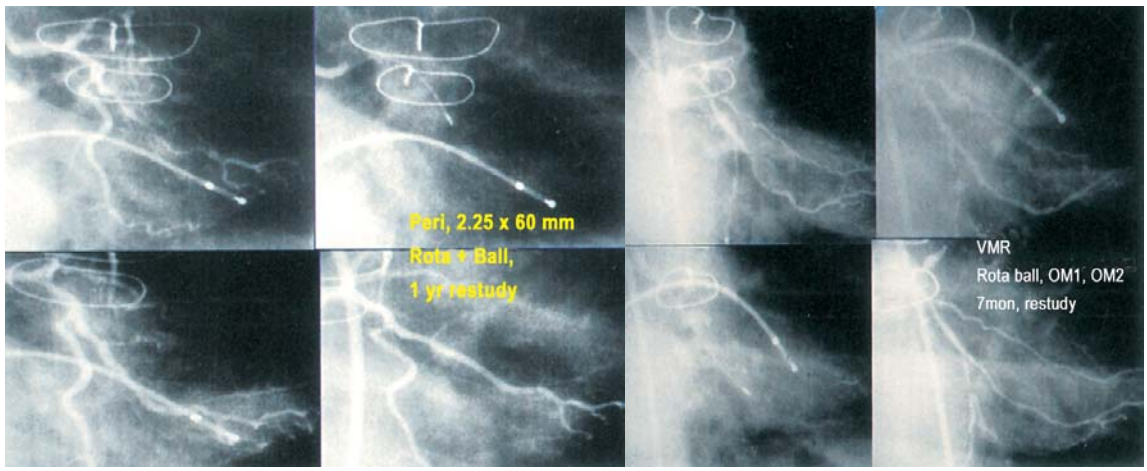

Fig. 3a. Rotablation and balloon dilatation for native vessel disease in calcific disease following CABG.

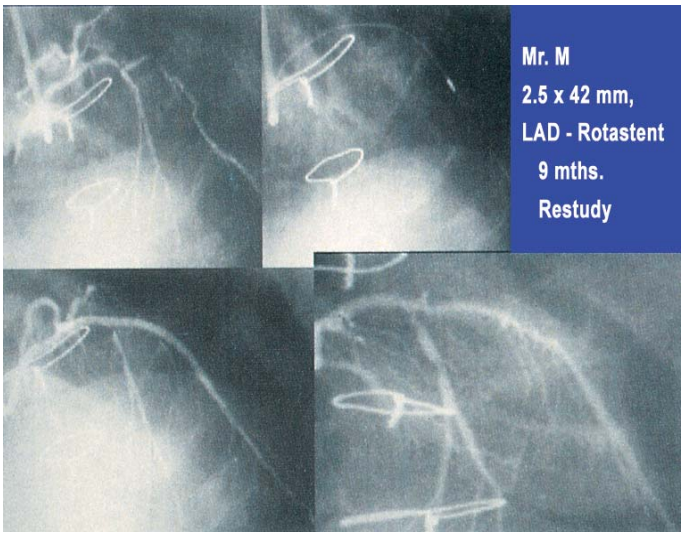

Fig. 3b. Rotablation and stenting for native LAD disease.

For a long time, there was no definite answer for tackling such complex lesions. Regular balloon expandable coronary stents were considered less useful, because, despite stenting restenosis rates remained high. In SAVED trial, Palmaz Shcatz stent group patients had a restenosis rate of 37%, NIR stents in registry data 25% and radius stent 29% at 6 months [13]. Multi link ultra is a high coverage stent system specially designed for saphenous vein graft interventions. It has more metal to artery ratio and low unsupported surface cover. This stent also did not make a big difference in the out come. Self expanding versus balloon expandable stents was another aspect tried, thinking that such stents will be less traumatic to the graft. But in the WINS trial, self expanding Wall stents had a recurrence rate of 39% versus 41% in the balloon deployed PS stent group, making it no much different.

Because of the intrusion of the degenerated plaque material through the stent struts when it is not covered, even

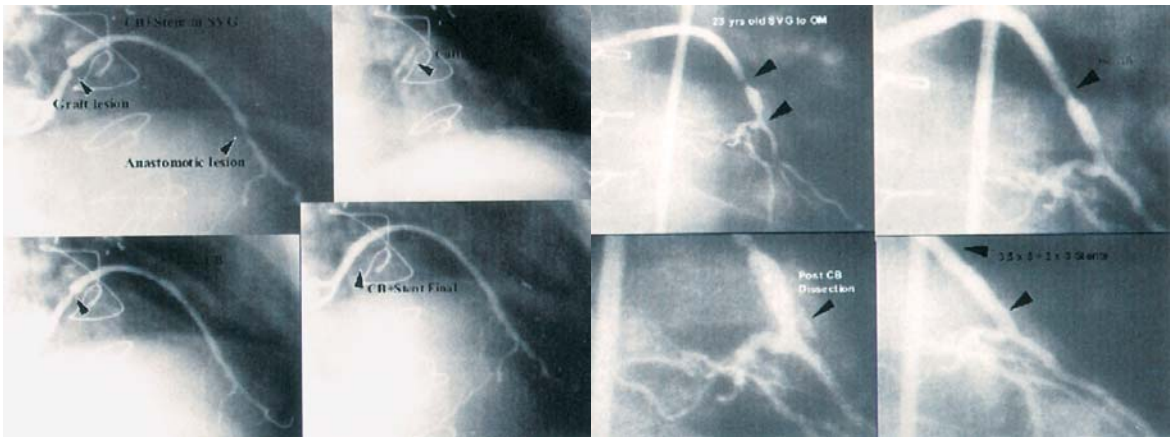

Fig. 4. Graft and anastomotic disease, cutting balloon and stenting.

outcome is poor since the thrombus could migrate and plug the native vessel. Thrombectomy devices and distal protection devices could be used to reduce the thrombus burden and establish forward flow and limit distal embolism. However stent is not a primary treatment device in such cases unless you find a significant narrowing or dissection.

Degenerated vein graft is a real therapeutic challenge in patients with recurrent limiting angina following coronary artery bypass surgery, when native vessel cannot be treated. The graft usually is diffusely diseased, is filled with degenerated plaque material, over which there is frequently thrombus. Plain balloon angioplasty is inadequate, distal embolism, abrupt graft closure and high restenosis rates makes the procedure unacceptable as a primary treatment modality. In the SAVED trial, angioplasty alone arm had a restenosis rate of 46% at 6 months [13].

when the immediate result is good, late loss and restenosis remained high for obvious reasons in degenerated vein graft interventions. This lead to the concept of covered stent systems. Two types of the same is available, balloon mounted covered stent system - the Jo stent coronary stent graft, which has expandable poly tetra flouro ethylene membrane between two layers of stent struts and self expanding poly tetra fouro ethylene covered Symbiot stent. In the recovers trial, where covered Jo stent graft was compared with non covered stent, occlusive and non occlusive restenotic rates were not different (24.2% vs 24.8% and 10.6% vs 10.4%), off setting the hype behind the covered stents. Also, adverse event rates, especially the non QMI were significantly higher in the covered stent group [14].

Symbiot self expanding stent, however changed the way we looked at the venous graft intervention. When compared

with the WINS registry data, where self expanding non covered Wall stent was used, all adverse event rates were significantly lower in the Symbiot group. 30 days major adverse coronary events was lower by 67 % (13.5% vs. 5.2%). Restenosis at 6 months was reduced by 81% (36% vs. 7%) . Interestingly, there was no post procedural no reflow phenomenon in Symbiot treated patients. Major advantage of symbiot stent is that it is easy to deploy, most of the time there is no need for distal protection device use, plaque intrusion is not a problem and there is no pre dilatation of the lesion or post dilatation of the stent required most of the time(*Fig.* 5). However, they are not without problems, size disparity is an issue when stent has to be partly be placed into the native artery in distal graft lesions. It is technically demanding to deploy the stent at the graft ostium as stent can telescope distally into graft beyond the lesion. Ostial lesions may have to be debulked. Fore shortening of the stent is another issue. Pre dilatation of the lesion may have to be done in tight lesions due to the large profile of the stent and a large thrombus can get dislodged by the passage of the stent itself leading to distal embolism.

Thrombus in degenerated vein graft is another major problem. Available armamentarium include the platelet receptor blockers, distal protection devices and thrombectomy devices. Data on the use of Abciximab in SVG intervention is not very encouraging [11,15,16]. Distal protection devices and thrombectomy devices are the cornerstones in thrombus management (*Fig.* 6).

Rheolytic thrombectomy devices like X-ciser and Angiojet can safely be used to reduce the thrombus burden and lesion can be addressed better. The device works by fragmentation of the thrombus and then aspirating it out without injuring the vessel wall though rarely dissection of the vessel wall can occur. Since the device moves forward in direction in the vessel removing thrombus, chance of distal embolism is very minimal [11,16-20].

Both occlusion and filter devices are useful in protecting the distal vascular bed from emboli during treatment of graft, if predilatation is needed, Symbiot is not used or there is fear that the thrombus could get embolysed when symbiot is advanced. Percusurge guard wire and export aspiration catheter work by balloon occlusion of the graft beyond the lesion if patient can tolerate such ischemia and aspiration of the thrombus and debris once the procedure is completed using aspiration catheter. Filter devices like EPI filter, angioguard,Spider device, microvena etc. prevent distal embolism by filtering the blood flow beyond the lesion while the lesion is addressed. Filters can be removed once the procedure is over. There is a small risk of trauma at the site where this devices are placed and a thrombus could potentially be dislodged when these devices itself is deployed. In the SAFE study, distal protection devices use in venous graft intervention lead to a reduction in the MACE rate by 73% vs. control. In SAFER trial, were guard wire was used, there was 42% relative risk reduction in cumulative 30 day major adverse coronary events, 56.5% relative risk reduction in mortality and 41.5 % relative risk reduction in myocardial infarction [11, 22].

Our own data on the treatment of post coronary artery bypass surgery problems are encouraging (*Figs.* 7-11). We treated 96 lesions in 66 patients with a mean age of 62 + 4 in the last 2 years. 37 graft lesions and 59 native vessel lesions were addressed. Mean number of lesions treated per patient was 1.7. Presenting symptoms in 52.2% of patients were unstable angina and reminder had stable angina pectoris. 30% of the population was diabetic. Cutting balloon was used in 38.6% and Rotablation in 26.2% of the native vessels treated. Symbiot stent was used in 95% of graft lesions treated and drug eluting stents in 97% of native vessels treated. Platelet receptor blockers were used in 13.5% of the patients. 12% of the patients with saphenous vein grafts required distal protection devices because of the need for predilatation, presence of thrombus or both. Two patients had treatment failure of native vessel, in both, lesion could not be opened up despite multiple attempts.

One patient (1.7%) had Q wave myocardial infarction during hospital stay and 5 patients (7.8%) had cardiac enzyme elevation more than 3 times the upper limit of normal. Transient electrocardiographic changes were noticed in 5 patients (7.8%). There was no incidence of stent thrombosis. None required urgent coronary artery bypass surgery and there was no death.

Out of the eligible 66 of 96 patients at 6 months clinical follow up, none reported recurrent angina. There were no incidence of myocardial infarction, target lesion failure or target vessel failure. Objective evidence for ischemia by tread mill test was present in two patients, treated vessels were patent in both, one patient required angioplasty in another vessel where there was fresh disease. Angiographic follow up at seven to eight months was available in 22 patients. None had restenosis, either in the native vessel or in the graft.

It is feasible to address most issues and problems associated with recurrence of angina in the post coronary artery bypass setting in the current era. Adjunct devices like Rotablator and cutting balloon has made tackling of the long standing native vessel disease to get a good immediate result . Thrombus management devices and distal protection devices in venous grafts have decreased the major adverse coronary event rates to phenomenally low levels. Drug eluting stents in the native vessels and Symbiot stents in the venous grafts helps to freeze the immediate result in time. It should be aimed to revascularise the patient as complete as possible, for good long term prognosis.

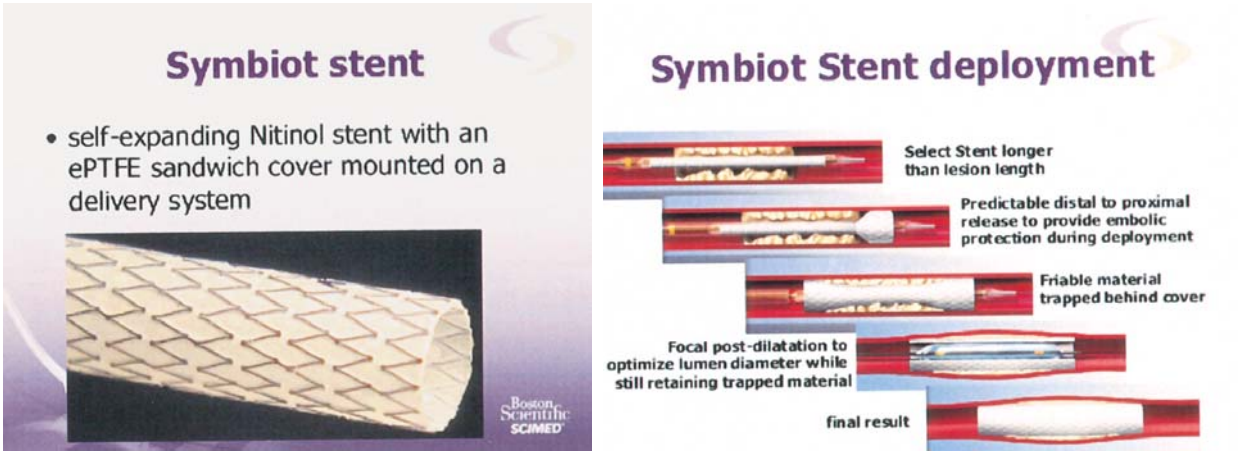

Fig. 5.

Fig. 6.

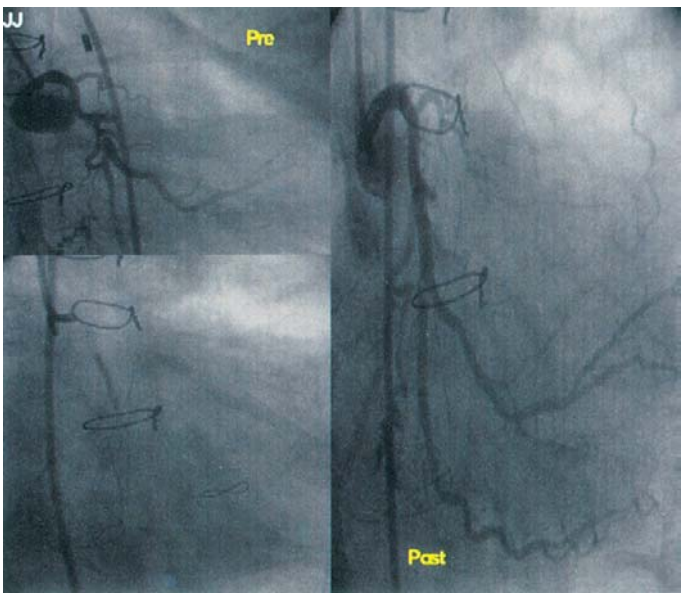

Fig. 7. Sole surviving vessel in a patient following CABG, all grafts occluded CB PTCA and stent done under IABP support in a 70 year old man.

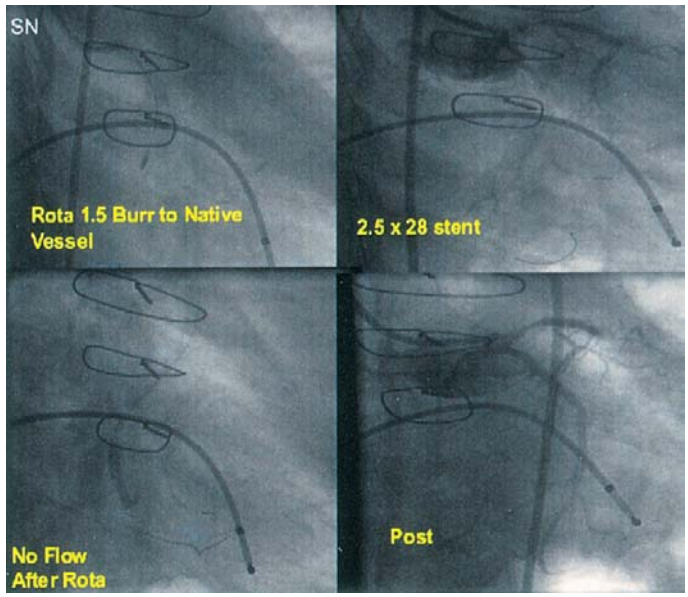

Fig. 8. Native circunfles disease treated with Rotablation and multiple stents.

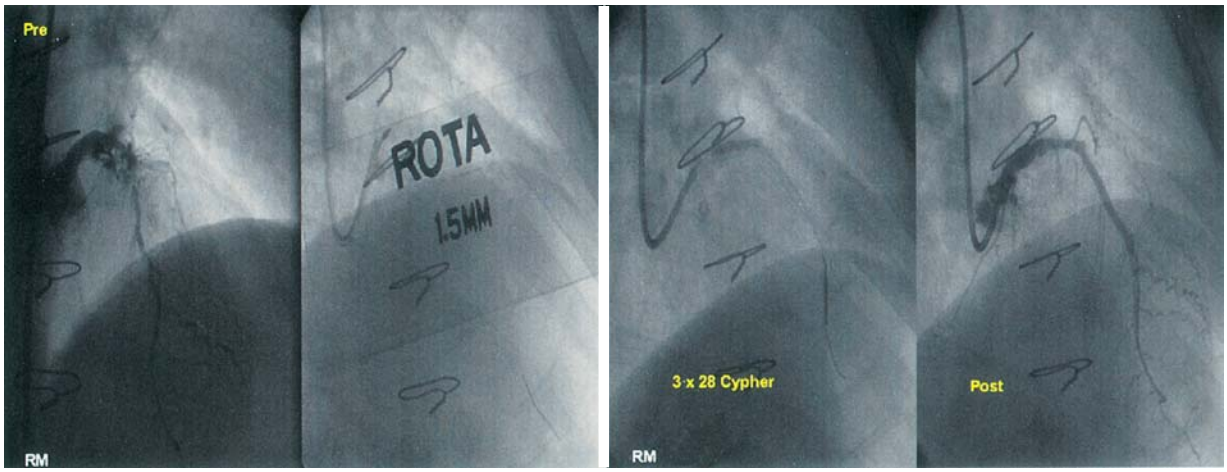

Fig. 9. Heavily calcified native vessel disease 10 years after CABG

Drug eluting stent used, good result.

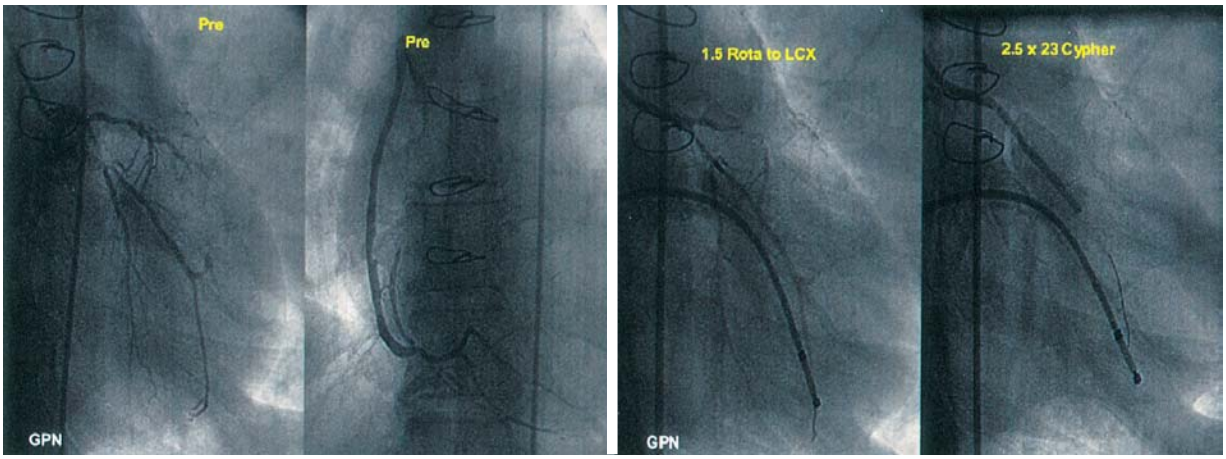

Fig. 10. Graft and native vessel disease 10 years after CABG.

Rotablation and DES for native vessl disease.

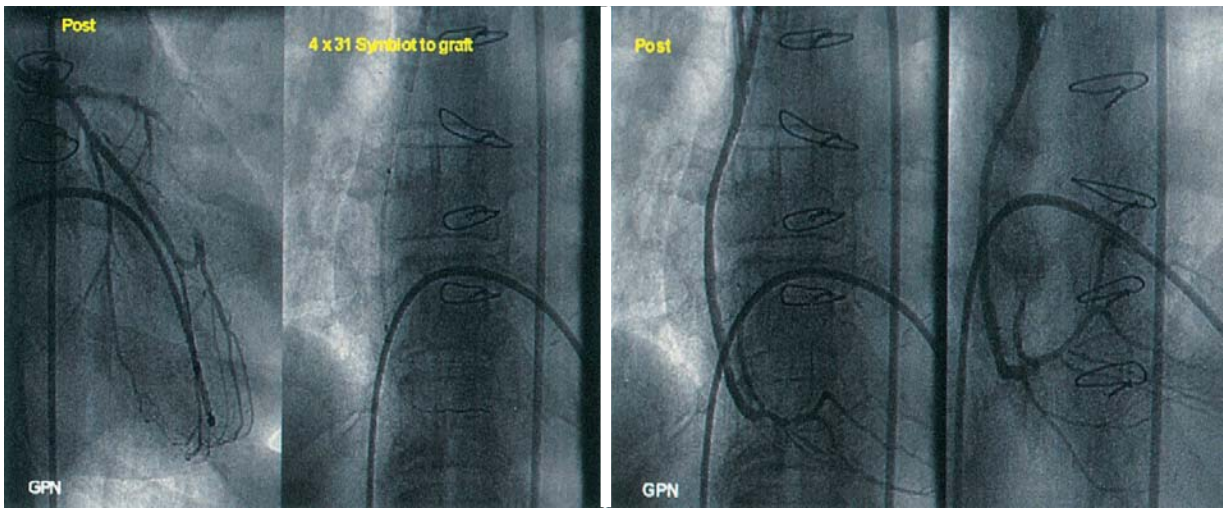

Fig. 11. Outcome in native vessel, symbol stent being deployed to graft.

Outcome in graft followimg symbol stenting.

Recurrent limiting angina despite optimal medical management is no longer the end of the road for patients following coronary artery bypass graft surgery. Interventional cardiology has a lot to offer these days at a much lower morbidity and mortality compared to a redo coronary artery bypass surgery.

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