Saphenous Vein Graft Disease Interventions

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Abstract

In the current era, coronary artery bypass grafting (CABG) is being increasingly performed using total arterial revascularization or a hybrid procedure of stenting of non-LAD disease and minimal access left internal mammary artery (LIMA) to LAD grafts, in order to minimize the need for vein grafts. Still, we encounter saphenous vein graft (SVG) disease, and it might require PCI, which often presents with unique challenges. The current favored strategy is to attempt PCI of the native coronary, if feasible, especially in long degenerated SVG disease, as it has shown better short- and long-term outcome. PCI is preferred over repeat CABG for early recurrent symptoms after CABG in patent LIMA graft and amenable anatomy patients. Balloon predilatation is not recommended unless delivery of an EPD or stent is not possible. Distal protection should be considered the standard of care for percutaneous coronary intervention (PCI) in most patients with older vein grafts, as periprocedural myocardial infarction and no reflow are the Achilles heel of SVG PCI. Intragraft vasodilators should be used liberally, even before balloon angioplasty/stenting. Avoid postdilatation, and usage of undersized but a longer stent length to reduce plaque extrusion through stent struts is preferred. Consider thrombectomy in lesions with a heavy thrombus burden. Keep activated clotting time on the higher side than in conventional PCI. Prolonged dual antiplatelet therapy (DAPT) based on the DAPT score is recommended. With all the precautions and care, we still need a fair wind in our favor to sail through the vein grafts disease.

Keywords
► saphenous vein graft
► percutaneous coronary Intervention
► distal embolization
► no reflow phenomenon
► embolic protection device

Introduction

Coronary artery bypass grafting (CABG) is the preferred treatment for patients with multivessel disease and other factors that affect the outcome of coronary artery disease (CAD) and is associated with a better clinical outcome than medical management.[1] Despite being linked with a high rate of graft occlusions, the saphenous vein graft (SVG) has been the most commonly used graft in most patients from the beginning of CABG. Almost 10 to 25% of SVGs occlude in the first year, with 3 to 5% occluding each year after that.[2,3] Only half of them remain functional after 10 years postsurgery, necessitating revascularization. The optimal treatment of such SVG occlusions remains a difficult and complicated

therapeutic conundrum, with percutaneous coronary intervention (PCI) with stents now being the preferred treatment.

Distal embolization, no-reflow, periprocedural myocardial infarction (MI), and late restenosis are increased risks linked with PCI of SVG. The standard for vein graft intervention is the use of stents and distal protective devices. In the case of SVG graft interventions, randomized clinical trial evidence is scarce and undefined. In this review, we will try to dissect the various aspects of SVG interventions and clear the dust from the holy grail of its technical and pathophysiological aspects

SVG disease (SVGD) usually begins early in the course and steadily advances over time, based on certain variables or risk factors, resulting in the disease, which we shall shortly describe.

Saphenous Vein Graft Disease Risk Factors

SVG illness manifests itself in three stages: early (before hospital discharge), intermediate (1 month to 1 year), and late (after hospital discharge) (beyond 1 year). Thrombotic occlusion occurs early in the course of anastomosis due to vasospasm. Mechanical factors associated with surgery, including inadequate distal drainage, graft kinking, and small distal arteries, predispose grafts to early occlusion.[4]

One month later, there is a focal injury resulting in hyperplasia as soon as the vein takes the arterialized pressure and flow, and this localized area results in plaque disease progression, with platelets aggregation and smooth muscle proliferation causing disease building.[5]

The main mechanism for graft failure beyond the first year is aggressive atherosclerotic constriction happening over the previously defective endothelium.

The osteal and proximal locations of SVG early disease were more often ostial or proximal (62 percent vs. 42 percent, respectively). The arteries in early SVG failures are smaller than those in late failures (ref: 2.47 ± 0.86 mm vs. 3.26 ± 0.83 mm, $p = 0.001$), but the lesions are similar in length; also, early SVG failure is more focal, so better responsive to PCI.[6]

The following are some of the risk factors for SVGD:

Saphenous Vein Graft Disease Pathophysiology

Various causes are contributing to SVG degeneration and occlusion, which may necessitate revascularization in the future. Within the first year, 10 to 15 percent of SVGs occlude, and 50 percent fail after 10 years. When an SVG is connected to the artery system, it changes its physiologic pressure flow dynamics and undergoes adaptive remodeling, which begins with fibrointimal hyperplasia.[7] This hyperplasia creates the nidus for atherosclerosis to emerge, which takes 5 to 10 years to develop and is commonly accompanied by thrombus and friability.

Very Early Failure (Less than 1 Month)

Technical failure or thrombosis are the most common reasons, occurring most commonly at the site of anastomosis, owing to graft endothelial injury during harvesting, which promotes platelet adhesion, and thus thrombosis, as well as high pressure distension to check graft appropriateness, which damages the intima, exposing the media to even before the graft is used.[7] Vasospasm is caused by shear stress caused by arterialized flow damaging the endothelium.

Early Post-CABG SVG Occlusion (12 to 18 Months)

Platelet aggregation, growth factor secretion.

Endothelial dysfunction, inflammation.

Plasminogen activator inhibitor-1 upregulation and marked intimal hyperplasia contribute to early SVG occlusion.[7–9]

Occlusions of the SVG following CABG (after 12–18 Months)

There is lipid deposition within intimal hyperplasia, eventually forming atherosclerotic plaque.[4] Increased pressure load from vein graft arterialization induces this development of neointimal growth and atherosclerosis[10]. Deteriorating SVG lesions also possess thinner, more friable fibrous caps compared with native coronary artery lesions which increases chances of plaque rupture.[11]

SVG Interventions—Issues Related to Poor Outcomes

SVG interventions are linked to debris embolization in distal capillaries as well as the release of serotonin, a neurohormonal factor that can cause vasospasm. Slow or no-reflow events, which are linked to both periprocedural angina and ischemic ST-segment alterations and constitute the Achilles heel of SVG interventions, may develop.

When compared with PCI for native coronary circulation, it is associated with greater incidence of periprocedural MI, target vessel revascularization (TVR), in-stent restenosis, and in-hospital mortality.

Factors associated with worse outcomes: The following are the key predictors of 30-day major adverse cardiac events (MACE) following SVG intervention:

1. Angiographic estimations of SVG degeneration and plaque volume.[12,13]
2. Lesion length. A study analyzing distal embolic protection reported that lesion length has the strongest correlation with short-term adverse events (AEs). A graded increase in MACE was observed with increasing lesion lengths, perhaps correlating to the increase in SVG plaque burden.[14]
3. Impact of gender. The data on the impact of gender have provided mixed results. One study suggested that male patients were more inclined to have worse outcomes, but another study reported that female patients had a higher 30-day cumulative mortality rate (4.4% vs. 1.9%, $p = 0.02$). Female patients also had significantly higher rates of

vascular complications (12% vs. 7.3%; $p = 0.006$) and post-procedural acute renal failure (8.1% vs. 4%; $p = 0.02$) compared with male patients.

4. Chronic renal insufficiency (serum creatinine $\geq$ 1.5 mg/dl). A significant predictor of 1-year MACE in patients who underwent SVG intervention with drug-eluting stents (DES) (hazard ratio [HR] 2.2; 95% CI [1.1–4.3]; $p = 0.03$).[15,16]

There was also a trend toward higher rates of TVR in the renal insufficiency group (21.8% vs. 10.3%; HR 2.42; 95% CI [0.94–6.24]; $p = 0.059$).

5. Elevations in levels of creatine kinase-myocardial band (CK-MB). Around 15% of SVG intervention patients had CK-MB levels that were five times the upper limit of normal (ULN), increasing the one-year death rate from 4.8 percent to 11.7 percent in normal CK-MB patients ($p < 0.05$ analysis of variance [ANOVA]). Even a little increase in CK-MB levels (from more than 1 to less than 5 times ULN) was linked to a 6.5 percent increase in one-year mortality ($p < 0.05$ ANOVA).[16]

Alternatives to Complex SVG Intervention—Native Vessel Intervention

PCI of the native vessel that supplies the same territory as the SVG failing is usually superior and should always be considered, if possible,[17] but native vessel PCI is difficult and not an option in acutely ill sicker patients. The difficult issues with native vessel PCI include interventions in left main coronary artery (LMCA) stenosis, calcific ostial stenosis, chronic total occlusion (CTO), and diffusely thinned vessels representing chronic low flow; therefore, in light of all these factors, the concept of acute SVG PCI with staged native vessel PCI (when complex) has been proposed, meaning that do an acute SVG PCI, as it is technically easier than attempting native PCI once the patient is stable after the acute coronary insult, specifically in multiple within-graft intervention patients.

Indications for PCI

When compared with native coronary procedures, SVG therapies show significant differences. Due to poor guide support, finding the graft as well as engaging and delivering equipment can be a challenge. Additionally, the perspectives to delineate the disease are distinct and not standard. SVG has a high risk of distal embolization and MI. SVG has a greater rate of restenosis. SVG patients are typically elderly and have a higher risk of AEs.

Indication of SVG PCI (►Fig. 1)

PCI to SVG within 30 days of CABG, if technically possible
PCI between 1 to 3 years of CABG, especially with discrete lesions and near normal left ventricular (LV) function.

PCI of SVG more than 3 years after CABG, especially if left internal mammary artery (LIMA) graft is patent and there is significant disease in other vessels.[18]
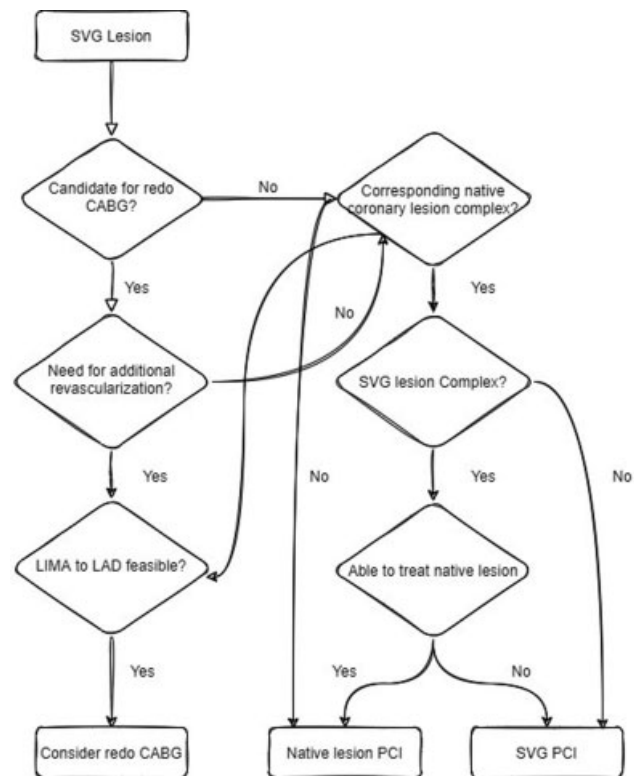

Fig. 1 Approach to saphenous vein graft disease (SVGD).

Contraindications to PCI

Technical advances have made all the contraindications relative.

- Unprotected LMCA stenosis.
- High thrombus burden.
- Occluded grafts.
- Severe calcific stenosis.
- Grafts with diffuse distal native disease.
- Multiple target lesions (native/SVGD).
- Impaired LV function where complete revascularization is preferred, and redo-CABG is possible.

Redo-CABG is Usually Reserved for Patients

- When percutaneous revascularization not feasible or failed
- Unused LIMA to left anterior descending (LAD) artery.[12,19]

How to Evaluate the SVG Lesion

Patient symptoms and evidence of cardiac ischemia in SVG areas are the main reasons for SVG revascularization.

In SVG lesions, fractional flow reserve (FFR) has not been extensively explored. It has a low sensitivity, but an allowable specificity and negative predictive value when compared with stress myocardial perfusion imaging in determining the seriousness of SVG lesions, according to limited studies.[20] Myocardial perfusion imaging provides a high specificity for diagnosing ischemia following CABG, but it has a low sensitivity for detecting graft stenosis that is angiographically significant.[21]

Positive remodeling on intravascular ultrasound (IVUS) is a powerful predictor of postintervention no-reflow; hence, it could be useful in evaluating SVGD.[22] IVUS, on the other hand, has not been thoroughly evaluated in a randomized control trial (RCT) on SVG to justify intervention based only on IVUS findings.

Given their reduced motion and huge lumens, multi-detector computed tomography (MDCT) enables adequate visualization of SVGs.[23] Despite the fact that it has 96% sensitivity and 95% specificity in measuring graft patency,[24] it is restricted in its ability to visualize anastomosis sites in the distal area. To catch up to the gold standard of coronary angiography, more progress is required.

Selection of Patient

The Intermediate Lesions
As SVG lesions can be quick, PCI of intermediate SVG lesions has been recommended. A total of 57 patients with moderate (30–60 percent) SVG stenosis were randomized to medical treatment alone or revascularization with DES in the moderate vein graft lesion stenting with the taxus stent and intravascular ultrasound (VELETI) trial.[25] MACE events were lower in the DES group than in the treatment group at 1 (3 percent vs. 19 percent, $p = 0.09$) and 3 (3 percent vs. 26 percent, $p = 0.02$) years.[26,27] For clinical endpoints, the VELETI RCT was underpowered.

Occluded SVG
Thirty-four participants with chronic complete SVG occlusions were included in a study that found that the success rate of stent insertion for recanalization was poor (68 percent).[27] After an 18-month follow-up, the TVR and in-stent restenosis rates in successfully stented patients were both quite high (61 percent and 68 percent, respectively).[28] In those patients, percutaneous revascularization is not indicated.

SVG PCI—The Peculiarities

Access Site and Guiding Catheter Choice
For SVG, there is no specific reason to choose either the radial or the femoral approach besides the known risks/benefits of each access site, the choice of the patient, and the experience of the operator.

Guide Selection

When using Radial Access
A left radial approach is more suitable for SVG, originating from the left anterior wall of the aorta and directed to the LCA.

AL guides are better suited for left-sided grafts, but engagement of right-sided grafts can be challenging. From a left transradial approach, AL and MP guides engage the right-sided graft with relative ease.

When SVG is Buttoned High in the Ascending Aorta
The femoral approach with JR is better suited for left-sided grafts and preferable hooked in right anterior oblique (RAO) view. The right radial offers poor support in higher origins and the choice of the guiding catheter remains complicated and a matter of trial and persistence.

SVG from the Right or Posterior Wall of the Aorta

The right and left radial approaches, which are usually directed to the right coronary artery (RCA) or the circumflex area, are equivalent.

The choice of the correct guiding catheter is critical, as MP and AR1 are better aligned and more coaxial.

When executing the procedure via the femoral or radial artery, the SVG to the RCA, the multifunctional or AR catheter has the best alignment and support. The catheter engagement can be done in the left anterior oblique (LAO) view.

In the case of femoral access, Judkins right or left coronary bypass catheters are used for vein grafts coming from the left anterior surface and commonly linked to left-sided arteries. Amplatz left catheters can be utilized if additional support is required. In the RAO view, engagement is possible. The left radial artery is the preferred method for approaching these bypasses via the radial approach. Extra backup-shaped or Amplatz left catheters are two options for guiding catheters.

When guides are unable to engage the SVG ostium, guide extension can be taken once the wire is passed into the graft from nonselectively hooked catheter to opacify the graft and deliver stents. Shorter length guides should be used when performing PCI on very distal lesions or distal to a sequential graft, in order to ensure the balloon shaft is long enough to deliver the balloon/stent to target.

Embolic Protection

The only strategy, up till now, soundly proven to reduce distal embolization and periprocedural MI. Indeed, PCI of SVG should always be performed under embolic protection device (EPD).[29]

In SVG interventions, there are the following three types of EPDs: distal occlusion devices, distal filter devices, and proximal occlusion devices[30,31]

Distal Protection Devices in Clinical Use

Distal balloon occlusion: PercuSurge Guard- Wire (Medtronic, Inc., MN, USA) and Tri- Activ FX system (Kensey Nash, PA, USA).

Distal filtration: FilterWire EX/EZTM (Boston Scientific Corp., MA, USA), Spider/SpiderRXTM (ev3 Inc., MN, USA for carotid artery stenting), Interceptor (Medtronic Vascular)

Proximal occlusion: Proxis (St Jude Medical, Inc., MN, USA).

The mechanism of the distal occlusion device is as follows: Before the PCI, a compliant balloon, which is directly present in the distal tip of a guidewire, is positioned distal to the lesion and inflated at low pressure during the procedure, occluding the vessel temporarily. After the PCI, an aspiration catheter is introduced through the guiding catheter over the
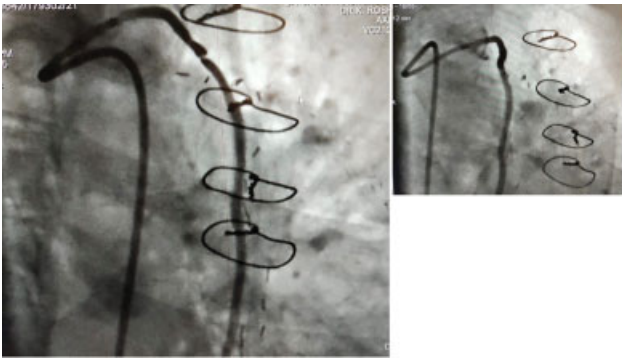
Fig. 2 Discrete lesion of saphenous vein graft (SVG) to obtuse marginal (OM) treated with direct stenting without the use of embolic protection device (EPD) as lesion length is an important parameter for distal embolization and no-reflows.

Fig. 3 Osteoproximal lesions of saphenous vein graft (SVG) are difficult to treat, and proximal embolic protection device (EPDs) cannot be used also, as placement of stent is of utmost importance and various orthogonal views help in perfect placement.

specific wire to suction the stagnated blood/debris, and the balloon is deflated.

This device was proven to dramatically lower the incidence of MACE at 30 days in the Saphenous Vein Graft Angioplasty Free of Emboli Randomized (SAFER) RCT. The reduction in the rate of periprocedural MI was largely responsible for this effect.

A distal filter is a porous filter that is inserted distally to the lesion prior to PCI, in order to capture embolic particles and retrieve it afterward. The Filter Wire Randomized Evaluation (FIRE)[32,33] was a large, randomized trial that found the filter to be noninferior to the previously described "occlusion and aspiration" device.

The proximal EPD includes a balloon inflated proximal to the lesion, occluding blood flow, creating a column of stagnant blood, and allowing debris released during the PCI (which is done through the device itself) to be aspirated from the vessel using the same catheter. During SVG intervention, Proximal Protection The PROXIMAL trial compared this proximal protection device to currently existing distal protection devices (either occlusion-based or filters), demonstrating that the device was noninferior.[33]

In cases of very localized lesions in small (3.5 mm) grafts, protection devices can be avoided (►**Fig. 2**). The technique in this circumstance should involve soft-tip coronary guidewire and direct stenting without predilatation or postdilatation.

Choosing the Type of Protection Device Depends Mainly On

a. The location of the lesion. Every protection device needs a vein graft disease-free landing zone of around 3 to 5 cm (►**Fig. 3**), so in osteal lesions, proximal devices, and in distal lesions, distal protection devices cannot be used.
b. Ability to tolerate prolonged ischemia. In all occlusion devices, 3 to 5 minutes of ischemia needs to be tolerated; if patient is unable, then filters should be preferred in such unstable patients with poorer LV function or in SVG with a very large area of myocardium downstream.
c. Physicians' experience with the device. Direct stenting should be performed after the protection device is in
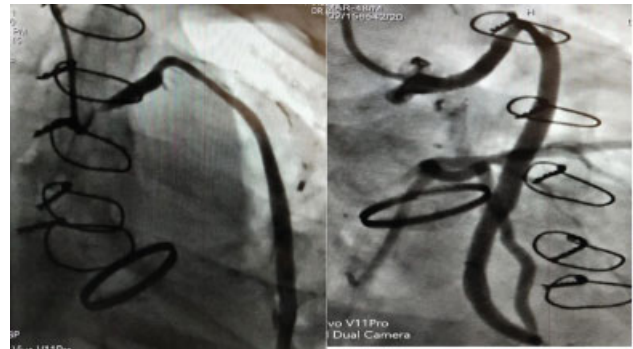
place, and high-pressure postdilatation should be performed with the protection device in place if the stent has been considerably underdeployed. Before removing the occlusion, direct aspiration of at least 5 mL of blood from the device should be conducted after the stenting process is completed with proximal device insertion.

When using a distal occlusion device, utilize the appropriate manual aspiration device and aspirate two syringes containing 20 mL of blood.

If a filter is utilized, it must be carefully closed using a specific retrieval catheter before the filter is retrieved.

Recommendations of Filters

In the American College of Cardiology (ACC)/American Heart Association (AHA) PCI guidelines, EPD use is a class I recommendation, however it was recently downgraded to a class IIa recommendation in the European Society of Cardiology (ESC) guidelines, based on observational data that is, nevertheless, subject to significant bias.[34]

If at all possible, EPDs should be employed during SVG intervention.

Despite being independently related with a decreased incidence of no-reflow (OR 0.68; $p = 0.032$), the ACC analyzed 19,546 SVG PCI interventions in the National Cardiovascular Data Registry and concluded that EPDs were used in just 22% of instances.[35]

Despite the huge body of evidence and guidelines, EPDs are nevertheless neglected in everyday practice.

The high cost of these devices appears to be a major factor.

The pace with which they are adopted in clinical practice is also influenced by their learning curve.

Transcatheter Debulking Strategies

Debulking methods, including directed atherectomy, transluminal extraction, and laser angioplasty, are occasionally necessary to reduce atherothrombotic debris and improve distal runoff and outcomes in SVG stenosis.

The majority of the trials have yielded negative findings.[36,37] In the CAVEAT II randomized trial, directional

atherectomy in vein grafts outperformed balloon angioplasty in terms of early angiographic outcomes, but at the expense of a much higher rate of distal embolization and non-Q-wave MI.[38] There was no discernible difference in restenosis after 6 months.

In 146 patients with vein graft disease, Safian et al evaluated the transluminal extraction catheter. Immediate complications such as embolization, no-reflow, and abrupt closure affected 20% of patients, and in the long-term, 69 percent of patients developed restenosis and 29 percent of SVGs were occluded.[39]

Excimer Laser Angioplasty

The most used debulking method for osteal lesion. The success rate of excimer laser angioplasty in old SVGs was 94 percent, with 1% in-hospital death, 0.6 percent emergency bypass surgery, and 2.4 percent Q-wave MI.[40] Despite the low risk of complications, the use of laser angioplasty in vein grafts was limited by a 55 percent restenosis rate.

Rheolytic Thrombectomy

The Vein Graft AngioJet Study (VeGAS) 2, a randomized comparison of immediate thrombectomy with AngioJet versus a prolonged infusion of intracoronary urokinase for the treatment of thrombotic lesions, found that this device is promising for reducing distal embolization in acute thrombotic lesions.[41] AngioJet therapy was linked to a higher rate of procedural success (86 vs. 72%), fewer bleeding problems (5 vs. 12%), a lower rate of MACE (16 vs. 33%), and a lower rate of periprocedural MI (16 vs. 33 percent).

The X-Sizer

The X-Tract study[42] compared the X-Sizer with stent implantation to stenting alone and found no difference in MACE between the two groups. As a result, it can be employed in longer lesions and difficult-to-place stents such as the ostea.

Another device that was ineffective as a supplement to percutaneous intervention was the coronary thrombolysis device. In the ATLAS trial, there was a considerably greater incidence of AEs when compared with abciximab. The abciximab group had a better angiographic success rate, whereas the device group had a higher MACE (including MI) rate.[43]

Which Type of Stent In SVG PCI

Stenting has been definitely proven superior to balloon-only angioplasty in SVG intervention, although the specific type of stent (bare metal or drug-eluting) is still a matter of debate because SVG lesions were excluded in almost all pivotal randomized trials.

The mechanisms of the in-stent restenotic process in SVG are different when compared with native arteries.

The problem of higher local prothrombotic conditions in SVG and the expected delay in endothelial healing after DES placement are claimed to be possible drawbacks of DES

implantation in SVG, as they can potentially lead to a higher risk of stent thrombosis.

The multicentre, single-blind "Reduction of Restenosis In Saphenous vein grafts with Cypher stent" (RRISC) trial compared 75 patients sirolimus-eluting stents and the respective uncoated bare metal stents (BMS). [44]

In the "Stenting of Saphenous Vein Grafts" (SOS) trial, 80 patients were compared with paclitaxel-eluting stents and polymer sirolimus-eluting stents versus BMS.

At 1-year follow-up, all of these trials found that DES significantly reduced angiographic and clinical restenosis as compared with BMS. Longer-term follow-up assessments of the RRISC and SOS trials, on the other hand, revealed contradictory clinical results.

The SOS trial found that DES considerably reduced the number of repeat revascularization procedures while having no significant effect on mortality.

The RRISC trial found a significant increase in mortality with DES, even with equivalent revascularization, compared with uncoated BMS.

The largest ISAR-CABG trial, which randomized 610 patients with failing SVG to first-generation DES or BMS, found that DES were linked to lower rates of target-lesion revascularization and met the primary end point of 1-year MACE.[45] The 5-year findings of the big ISARCABG trial revealed that DES' early benefit in decreasing revascularization following SVG lesion interventions was lost when compared with BMS. This late catch-up event was found 2 to 3 years after the index procedure, sparking a discussion concerning the efficacy and safety of DES in SVG-treated lesions. The long-term results of the ISAR-CABG trial, on the other hand, were not outcomes of a prespecified posthoc analysis of a randomized study, which was not predefined to be reviewed; therefore, this is not data with definitive outcomes.

The same limitation applies to the posthoc analysis of the long-term results from the DELAYED RRISC (excessive all-cause mortality with no variation in MI or TVR with DES) and SOS (sustained benefit regarding MACE with DES) trials[46]; moreover, these results were even more limited by a rather short follow-up and more patients underwent multiple TVR procedures in the BMS group compared with the DES group, which was not adjusted in the final outcomes which further supports the superiority of DES in treating SVG lesions.[47]

The BASKET-SAVAGE trial was the first study to assess for clinical end points without routine angiographic follow-up (cf.ISARCABG)and provide an important addition to the literature, namely, that DES reduces "robust" clinical end points, without being influenced by routine angiography-triggered revascularization.

The BASKET-SAVAGE trial is the only randomized clinical trial among patients undergoing stenting of SVG lesions with a prespecified long-term follow-up of 5 years. The results show a lower rate of the primary composite endpoint MACE after DES implantation at 1 year with a sustained benefit throughout the study period compared with BMS. This benefit is mainly driven by a reduction of subsequent MIs and TVR at 1-year follow-up and a need for TVR procedures

up to 5 years (35.5% vs. 56.1%, HR, 0.40; 95% confidence interval [CI], 0.23–0.68,). Moreover, following initial BMS implantation, more patients required multiple TVR interventions during the whole study period compared with patients randomized into the DES group.

The DIVA trial was designed to compare the efficacy of DES with BMS for the treatment of de novo SVG lesions in a contemporary setting. In this multicenter trial, 597 (17%) of the 3482 screened patients were randomized to either treatment arm. There was more use of direct stenting and smaller diameter stents; with generous use of newer generation stents, the DIVA trial showed no difference in MACE or TVR. Notably, this is the only study that failed to demonstrate the superiority of DES over BMS in SVG lesions at 1-year follow-up in spite of using newer generation stents.

The absence of benefit with DES in DIVA is unclear but could be related to the following:

1. The premature termination of the study after enrollment of 76% of the anticipated recruitment goal.
2. The systematic use of thin strut stent platforms. Use of more powerful and prolonged dual antiplatelet therapy (DAPT) as well as more aggressive secondary prevention of atherosclerotic disease progression in the past decade might have mitigated the differences between the DES- and BMS-treated arms.
3. Short follow-up duration of the DIVA trial of only 2.7 years. It is possible that a divergence in outcome may occur at a later point in time (given the sustained benefit of DES over BMS found in the BASKET-SAVAGE trial).
4. The double-blinded study design,
5. Different stenting technique (as indicated by the numerically greater stent diameter of 3.7 mm in BASKET-SAVAGE vs.3.4 mm in DIVA).

All these data underline the fact that DES can be considered effective and safe at short-term (1 year) follow-up as consistently shown in several studies; however, longer-term follow-up of adequately performed studies is required to confirm that DES remain safe and effective also after 1 year.[48] Keeping this in mind, the BASKET-SAVAGE investigators trial published in 2020 suggested long-term results and had very important implications, defining the strategy and solving the puzzle.

Other types of stent, so-called "covered" stents, have also been tested in SVG lesions to prevent distal embolization. However, this theory proved false: polytetrafluoroethylene (PTFE)-covered stents, in comparison to BMS, did not reduce the amount of distal embolization and the rate of periprocedural MI, and showed no different, or even worse, clinical and angiographic restenosis.

Newly developed systems comprising a BMS platform with a polymeric net attached to its surface (supposedly able to entrap fibrothrombotic material M-guard stent) appears to be a potentially interesting innovation, which was tested in the INSPIRE trial to prevent distal embolization and no-reflow in SVG PCI.[49] However, this data is preliminary and based on a small number of patients: once again, therefore, larger trials are definitely needed. In the mean-

while, this device should be used only in the setting of clinical studies.

So as per the current evidence, DES and BMS are equally effective with no definite consensus; the choice of stent is individualized, based on lesion type, diameter, and long-term DAPT tolerance, as these are usually frail and elderly

Currently, the DIVA and ISAR-CABG trials, both of which demonstrated no benefit (but also no penalty) with the use of DES in SVG PCI, have simplified stent selection in SVG PCI. BMS should be utilized in nations where DES is significantly more expensive than BMS. In nations where the DES and BMS prices are comparable, either option is appropriate.

No Reflow

In the absence of a residual mechanical coronary obstruction (stenosis, dissection, or thrombus), it is defined by a decrease in epicardial blood flow.[50,51] A substantial risk factor for periprocedural MI and death is the development of no-reflow.[52]

The contemporary approach to prevent it is named "minimally invasive vein graft intervention."[53]The following are some of the technique's key components:

Routine Use of Direct Stenting
Limiting the number of pre- and poststenting balloon inflations.

Avoiding very high pressure inflations ($\geq$ 16 atm).

Refraining from excessive balloon oversizing (which may have a deleterious "cheese-cutting effect").

Restricting use of atheroablative devices.

The importance of avoiding stent overexpansion in treating vein grafts and undersizing the stent is emphasized.

Vasodilating Drugs in Treating No-reflow[54,55]

The use of vasodilators to prevent no-reflow is indicated. No-reflow was successfully reversed by nicardipine in all 23 patients with no-reflow during vein graft intervention, according to Huang et al.[56] Calcium channel blockers, adenosine, and nitroprusside are all examples of calcium channel blockers. Intracoronary nicardipine has been shown to be especially effective in the treatment of no-reflow. Intracoronary nitroglycerin, on the other hand, is ineffective for no-reflow.

Adjunctive pharmacology: Various pharmacological techniques can be used to reduce ischemic problems during SVG intervention.

Glycoprotein IIb/IIIa Inhibitors

For use of these medicines in SVG lesions, the ACCF/AHA/ Society for Cardiovascular Angiography and Interventions (SCAI) guidelines propose a class III (no benefit) indication,[35] which can be tried in very high thrombus burden. In other treatment modalities for heavy thrombus burden, the following strategies can be employed (with or without EPD),

although their clinical benefits have not been well-demonstrated in large clinical trials. Mechanical thrombectomy with either the AngioJet thrombectomy system (Boston Scientific) or CT RX catheter (Penumbra's Indigo System) is used for the removal of a large thrombus. Aspiration thrombectomy with dedicated aspiration catheters such as Pronto (Teleflex) or Export (Medtronic) or guide extensions such as GuideLiner (Teleflex) or Guidezilla (Boston Scientific). Laser atherectomy and laser atherectomy. Anecdotally, bailout use of intragraft fibrinolytics such as tPA can be preferred over GP2b3a inhibitors

DAPT and Anticoagulants

Prior to hospitalization, DAPT recommendations for effective management of SVG illness are identical to those for native coronary vessel PCI.[35]

However, the ideal anticoagulants for SVG intervention have not been particularly established. Acute Catheterization and Urgent Intervention Triage Strategy (ACUITY) trial enrolled the subset of SVG intervention patients (60). Bivalirudin alone had fewer minor bleeding complications compared with heparin plus a GP IIb/IIIa inhibitor (26% vs. 38%; $p = 0.05$).

Heparin is still a drug of choice for all forms of PCI, and also ACCF/AHA/SCAI guidelines recommend a class I indication for its use in this setting as well.[35]

Vasodilators

Microcatheters from intragraft microcatheters can maximise pharmacotherapy delivery to these vessels. Pretreatment with intracoronary adenosine, a strong dilator of arteries and arterioles, reduces the risk of MI after elective PCI.[57] It reduces the risk of no-reflow and improves myocardial flow in patients with acute MI.[58] When compared with low doses (less than five boluses), high doses of intragraft adenosine (at least five boluses of 24 g each) significantly improved final thrombolysis in myocardial infarction (TIMI) flow grade (2.7 0.6 vs. 2.0 0.8; $p = 0.04$) and led to more slow and no-reflow reversal (91 percent vs. 33 percent; $p = 0.02$).

Intragraft verapamil (100–500 g) increased flow in all 32 no-flow episodes (TIMI flow grade 1.4 0.8 pre- to 2.8 0.5 postintragraft verapamil; $p = 0.001$) and reestablished TIMI flow grade 3 in 88 percent of cases.[58]

Complications

The SVG interventions are marred by a very high risk of distal embolization, which is different from non-SVG intervention. EPDs can minimize the risk of distal embolization but do not eliminate it. SVG aneurysm is also unique complication and exotic to native coronary anatomy.

Aortocoronary Saphenous Vein Graft Aneurysms

The typical clinical presentation of SVGAs ranges from an asymptomatic patient with an incidental radiological dis-

covery to a life-threatening hemorrhage related to SVGA rupture. Multislice computed tomography (CT) scanning has allowed the early diagnosis of saphenous vein graft aneurysms (SVGAs) and the avoidance of its consequences.

It can be managed with surgical and catheter-based options. Type of aneurysm, clinical presentation, and aneurysm size and graft patency finally determine the treatment in coordination with the surgical team.

Slow-Flow or No Reflow

Although prevention is crucial with EDPs and liberal vasodilators, if it is post-SVG stent insertion and filter-based embolic protection, aspiration thrombectomy is indicated to remove any freed debris that may be blocking the filter. To restore antegrade flow, the filter may need to be removed; further angioplasty and stent insertion should not be done until normal antegrade flow has been restored.

Perforation in SVG

It is a rare but significant complication that can leak into the mediastinum and be difficult to control. It is usually caused by the insertion of large stents. Before removing the stent balloon, it is a good idea to take a test shot. If the SVG perforates, the stent balloon is inflated immediately to prevent blood flow into the pericardium. If the patient develops tamponade, an emergency pericardiocentesis can be performed. If pericardial leaking persists after extended balloon inflation, a second artery access is acquired, and a covered stent is supplied with a second 7 or 8 Fr guide catheter to reduce the amount of time the perforation site is exposed.

Another potential complication of SVG intervention is equipment entrapment. When an embolic filter is utilized for embolic protection, the usage of buddy wires is discouraged to reduce this danger. Standard procedures, such as the tiny balloon technique or loop snares, can be used to recover lost stents or wire fragments.

Conclusion

In the current era, CABG is being increasingly performed, using total arterial revascularization or a hybrid procedure of stenting of non-LAD disease and minimal access LIMA to LAD grafts, to minimize the need for vein grafts. Still, we encounter SVG disease, and it might require PCI, which often presents with unique challenges; the current favored strategy is to attempt PCI of the native coronary, if feasible, especially in long degenerated SVG disease, as it has shown better short- and long-term outcomes. PCI is preferred over repeat CABG for early recurrent symptoms after CABG in patent LIMA graft and amenable anatomy patients. Balloon predilatation is not recommended unless delivery of an EPD or stent is not possible. Distal protection should be considered the standard of care for percutaneous intervention in most patients with older vein grafts, as periprocedural myocardial infarction and no reflow are the Achilles heel

of SVG PCI. Intragraft vasodilators should be used liberally even before balloon angioplasty/stenting. Avoid postdilatation, and usage of undersized but a longer stent length to reduce plaque extrusion through stent struts is preferred. Consider thrombectomy in lesions with a heavy thrombus burden. Keep activated clotting time on the higher side than in conventional PCI. Prolonged DAPT based on the DAPT score is recommended; with all the precautions and care, we still need a fair wind in our favor to sail through the vein grafts disease.

Conflict of Interest
None declared.

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