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Review

Intravascular Lithotripsy for Calcified Saphenous Vein Graft Stenosis Post-CABG: A Review of Literature and Experience

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Abstract

Percutaneous intervention for calcified saphenous vein graft (SVG) stenosis poses significant challenges. Intravascular lithotripsy (IVL) addresses these limitations through low-pressure acoustic energy that selectively fractures calcium while preserving vessel integrity, enabling safer stent delivery and expansion in fragile vein grafts. Current evidence suggests IVL achieves effective calcification modification with reduced risks of embolization and perforation compared to conventional atherectomy techniques. This review summarizes contemporary experience with IVL for calcified SVG lesions, evaluates its technical advantages over alternative approaches, and identifies future research priorities to advance clinical adoption.

Keywords: intravascular lithotripsy; saphenous vein graft; calcified lesion; percutaneous coronary intervention; coronary artery bypass grafting

1. Introduction

Coronary artery bypass grafting (CABG) remains a cornerstone in the treatment of complex coronary artery disease, especially in left-main and three-vessel disease [1,2]. Saphenous vein grafts (SVG) are commonly used in CABG procedures due to the convenience of harvest and versatility.

However, the long-term patency of SVGs is not satisfying, as they show a notoriously high failure rate. Studies show the prevalence of SVG failure is approximately 15%–40% at 1 year and 50% at 10 years [3,4]. The underlying mechanism of SVG failure or stenosis include trauma during harvesting, endothelial inflammation, intimal hyperplasia, and early atherosclerosis [5]. As a result, a large proportion of patients with SVG CABG will be consequently in need for graft revascularization [6].

Percutaneous coronary intervention (PCI) is the preferred method for revascularization in these patients [7]. Yet PCI for SVGs presents unique challenges. SVGs are more vulnerable to perforation during PCI, especially chronic total occluded lesions [8]. They are also more friable and embolic, leading to distal embolization and increased risks of no-reflow or periprocedural infarction [9,10]. Calcification is another problem which could cause worse outcomes of PCI [11].

Intravascular lithotripsy (IVL) is a novel calcification modification technique that was developed from the acoustic treatment of urolithiasis [12]. It's a balloon-based system that generates acoustic pressure waves to fracture intimal and medial calcium within the vessel wall of coronary arteries, thereby improving stent delivery/expansion and procedural success rates and also outcomes [12]. The safety and efficacy of IVL have been reported previously [12–16], but so far there's relatively limited studies and reports of its use in severely calcified SVG lesions.

Because only a few isolated case reports and small series are available, a synthesis is especially valuable to identify recurring procedural patterns, safety signals, and reporting gaps. This review aims to summarize the currently limited evidence regarding the use of IVL for calcified SVG stenosis after CABG, highlighting preliminary experience, outlining its limitations, and proposing priorities for future study.

2. Current Experience With IVL in Calcified SVG Stenosis

The "off-label" application of IVL for calcified SVG stenosis has been supported by growing reports of clinical experience [17–24]. The key information of these studies are listed in Table 1 (Ref. [17–24]). IVL consistently demonstrates effective calcification modification in SVGs across these published reports.

Meijer *et al.* [24] reported four patients with peri-stent calcification in SVGs. IVL showed effective calcium cracking, optimal stent expansion, and minimal residual stenosis, which is also confirmed by quantitative coronary analysis (QCA) and intravascular ultrasound (IVUS) methods. This aligns with earlier isolated reports [17–22], showing satisfying calcium fracture, improved minimal stent area, and better balloon/stent expansion.

Another major advantage of IVL is its safety profile in fragile SVGs. Van Gameren *et al.* [17] reported no perforations, dissections, or no-reflow phenomena during IVL for a circumferential calcified SVG lesion, attributing this to

Table 1. Key information of published case reports on IVL in calcified SVG.

Study (Year)	Number of cases	Adjunctive therapies	Follow-up period (months)	Key findings
Numasawa *et al.* (2025) [18]	1	Pre-dilatation with NCB; IVL followed by cutting balloon and DCB	6	Successful calcium modification with IVL; no angina at 6 months
van Gameren *et al.* (2020) [17]	1	NCB failed; IVL followed by DES implantation	NA	IVL enabled calcium fracture and optimal stent expansion; no complications
Wańczura and Stecko (2021) [19]	1	NCB under-expanded; IVL followed by NCB and DCB	21	Good stent expansion achieved; patient asymptomatic at 21 months
Iwańczyk *et al.* (2021) [20]	1	NCB failed; IVL followed by DES implantation	NA	IVL enabled stent delivery and expansion; no procedural complications
Bawamia *et al.* (2021) [21]	1	Rotational atherectomy + IVL; DES implantation	NA	Combined RA + IVL effective for severe calcification; no complications
Russo *et al.* (2021) [22]	1	IVL for calcific ISR; DES implantation	NA	IVL successfully fractured calcium; good acute gain in MLA
Øksnes and McEntegart (2021) [23]	5	IVL followed by DES (4 cases) or DEB (1 case)	2–12	One MACE at 12 months; others free of events; TIMI 3 flow in all cases
Meijer *et al.* (2025) [24]	4	IVL used in-stent; post-dilatation with NCB; DES implantation in some cases	6–12	No MACE; effective calcium modification and stent expansion in all cases

IVL, intravascular lithotripsy; SVG, saphenous vein graft; NCB, non-compliant balloon; DES, drug-eluting stent; DCB, drug-coated balloon; DEB, drug-eluting balloon; RA, rotational atherectomy; ISR, instent restenosis; MLA, minimal lumen area; NA, not applicable; MACE, major adverse cardiovascular events.

low-pressure balloon inflation (4–6 atm). Similarly, in Øksnes and McEntegart's series of five SVG cases [23], IVL preceded PCI without in-hospital adverse events. Follow-up across these studies [19,23] showed no major adverse cardiovascular events (MACE) in 13/14 patients, with one death unrelated to IVL treatment itself (case 5 reported by Øksnes and McEntegart [23]).

The cumulative experience (Table 1) demonstrates high procedural success and minimal complications with IVL in calcified SVGs. While no randomized data exist, the consistency of outcomes across these cases supports IVL as a viable option for lesions where calcium impedes stent delivery or expansion.

3. Comparison of IVL With Alternative Techniques

Other techniques have also been introduced in calcified SVG lesions. Rotational atherectomy (RA), a widely used technique for calcification, has been reported in SVGs [21,25–27]. RA achieves plaque debulking via high-speed abrasive burrs (140,000–180,000 rpm), leading to procedural success rates in selected SVG cases [27]. However, the rotational mechanism could produce microparticulate debris, posing significant risks of distal embolization and perforation in fragile venous grafts [2,28]. Unlike RA, IVL induces calcific fracture via acoustic energy without producing embolic particles [12]. Although this could be theoretically safer in fragile SVGs, the definitive evidence is lacking, and current impressions of safety are based solely on small case reports and should be interpreted with caution.

Excimer laser coronary atherectomy has been used in interventional cardiology for more than 3 decades. The use of excimer laser coronary angioplasty (ELCA) in SVGs has also been previously described [29,30]. The mechanism of ELCA relies on photochemical ablation to vaporize calcific and thrombotic plaque [29]. This technique carries inherent risks of thermal injury to the graft wall, potentially leading to complications such as distal embolization, no-reflow phenomena, and dissection [30]. The Coronary Graft Results Following Atherectomy with Laser (CORAL) trial also indicated safety limitations, reporting an 18.4% 30-day MACE incidence in 98 enrolled ELCA-treated patients, primarily driven by periprocedural infarction [31].

Compared to IVL, ELCA exhibits several challenges and concerns [29,30]: its photothermal energy, while effective for thrombus vaporization, may paradoxically promote platelet activation and increase embolic risk without adjunctive distal protection—a particular concern in friable SVGs. Furthermore, ELCA demands significant operator expertise and relatively long learning-curve. Most critically, ELCA often requires adjunctive high-pressure balloon inflation that increases perforation risks, especially in thin-walled SVGs. Therefore, IVL may still be a preferred technique for these cases.

4. Limitations and Future Directions

The current evidence for IVL in calcified SVG stenosis is limited almost entirely to isolated case reports and very small series, the largest published cohort including only five patients [23]. The absence of randomized controlled trials or prospective registries leaves us with several uncertainties regarding problems such as safety, long-term efficacy, and cost-effectiveness. This raises the risk of publication bias, as successful cases are more likely to be reported, while failed procedures are rarely published. This may overstate both safety and efficacy. While this limitation is fundamental, collating these early reports remains useful to inform current practice and to guide the design of multicenter registries and randomized trials.

Another key limitation is the lack of standardized reporting of baseline patient characteristics. Most case reports omit critical data such as comorbidities, SVG age, and calcification severity, preventing subgroup analyses. Special high-risk cohorts such as SVG chronic total occlusions, in-stent restenosis with heavy calcification, multiple sequential SVG lesions, or multivessel SVG disease, remain essentially unstudied. We therefore propose a minimum dataset for future publications, including demographics, comorbidities, graft age, calcification grading, IVL procedural parameters, and follow-up outcomes. Large-scale multicenter prospective registries with standardized protocols are also required to fill in the current gap.

5. Conclusion

IVL represents a promising technique for calcified SVG stenosis, with early case reports and small series suggesting high procedural success and acceptable short-term safety. However, current evidence remains preliminary, and its definitive outcomes and safety information have not yet been well-established. The unique low-pressure acoustic mechanism offers theoretical advantages in fragile vein grafts, but SVG patients represent a particularly high-risk subgroup with limited revascularization options. Barriers to broader clinical adoption—including device cost, off-label status, and the requirement for operator training—must also be recognized. Future research should be extended to clarify outcomes, cost-effectiveness, and optimal patient selection.

Author Contributions

All authors contributed to the design of this work and to the interpretation of data and references. YX and JG drafted the work. SW, JS, and ZL revised the manuscript critically for important intellectual contents. All authors read and approved the final manuscript. All authors agree to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

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