Safety and Short-Term Efficacy of Intravascular Lithotripsy for Treatment of Peripheral Arterial Disease: A Systematic Review

Eshani J. Choksi[1]   Antony Sare[2]   Pratik A. Shukla[3]   Abhishek Kumar[3]

[1] Rowan-Virtua School of Osteopathic Medicine, Stratford, New Jersey, United States

[2] Yale University School of Medicine, New Haven, Connecticut, United States

[3] Division of Vascular and Interventional Radiology, Rutgers New Jersey Medical School, Newark, New Jersey, United States

Address for correspondence Abhishek Kumar, MD, Department of Radiology, Division of Vascular and Interventional Radiology, Rutgers – New Jersey Medical School, 185 South Orange Ave. MSB F-560, Newark, NJ 07103, United States (e-mail: kumarab@rutgers.edu).

Abstract

Intravascular lithotripsy (IVL) is an emerging treatment for calcifications in patients with peripheral arterial disease (PAD). The objective of this article is to evaluate the safety and efficacy of IVL for PAD management by performing a systematic review of existing literature. A systematic literature search was performed using the PubMed database. A literature search was performed in accordance with Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. Outcomes variables analyzed in each study include preprocedure ankle–brachial index, preprocedure lesion length, preprocedure calcified length, preprocedure diameter stenosis, average number of IVL pulses, success rate, adjunctive treatments given, postprocedure diameter stenosis, acute vessel gain, and specific complications. Three-hundred fifty-seven articles were reviewed on PubMed and 14 studies were ultimately included, comprising 857 patients and 991 lesions. Thirteen of the 14 studies reported a 100% procedural success rate. Mean preprocedure lesion length was 68.94 (20-103.4) mm and mean preprocedure calcified length was 86.5 (50.5–140.9) mm. The average preprocedure diameter stenosis was 77.44% and postprocedure diameter stenosis was 26.14%. All studies reporting both pre- and postprocedure diameter stenosis stated there was a significant reduction in the vessel diameter stenosis and acute gain following IVL therapy alone. About 8.2% of patients had reported dissections and 0.29% had perforations. There was no reported distal embolization, thrombus formation, or abrupt closure of the vessel in any study. IVL appears to be a safe and effective treatment for calcified lesions in patients with PAD, with a low rate of complications and successful luminal gain for most lesions. Further prospective studies are needed to help validate the effectiveness of IVL therapy.

Keywords
► shock wave lithotripsy
► peripheral arterial disease
► calcifications
► intravascular lithotripsy

Introduction

Multiple societal guidelines on the management of lower extremity peripheral arterial disease (PAD) have recommended that endovascular therapies be utilized as a first-choice treatment modality for several lesion types.[1] There are several available treatment modalities for plaque modification in PAD patients, including percutaneous transluminal angioplasty (PTA), drug-coated balloons (DCBs), drug-eluting stents (DES), and atherectomy. Treatment for

femoropopliteal lesions has included the usage of DES and DCB,[1,2] whereas the preferential therapies for below-the-knee lesions include DCB and PTA.[3–5] However, the treatment of more complex cases of lower extremity calcifications remains a challenge with current technology. For example, complex cases with severe calcifications often inhibit adequate Paclitaxel drug uptake in DCB therapy[6] and the treatment of thicker plaques with PTA have often resulted in dissection and the need for bailout stenting.[7–9] Additionally, several studies have identified that intravascular calcification is associated with poorer prognosis, as the calcifications can lower the procedural effectiveness of endovascular therapies and result in increased risk of distal embolization, perforation, and dissection.[10–13] Some studies have also identified that the calcium itself can act as a physical barrier and impair drug absorption from DCBs, reducing the efficacy of endovascular treatment modalities.[14,15]

Extracorporeal shock wave lithotripsy is a minimally invasive treatment that was introduced in the 1980s and has historically been used as a treatment for nephrolithiasis.[16–18] The technology emits high-intensity sonic pressure waves into the body to fragment stones without harming surrounding important soft tissue.[19] Over the past decade, this technology has been adapted to break up calcified plaques and improve the compliance of vasculature in patients with cardiovascular disease[20–22] and now in more recent years, has been used in patients with PAD. Termed intravascular lithotripsy (IVL) (Shockwave Medical, Fremont, California, United States),[23] the novel application of this existing technology serves as an adjunctive minimally invasive endovascular treatment for calcified plaques in the lower extremities of patients. It is advantageous in PAD management in that rather than mechanical vessel expansion, drug therapy, or cutting into a plaque, this device can emit sonic waves directly towards the plaque, and has the unique ability to simultaneously fracture both intimal and medial calcifications to improve vessel patency, with minimal to no surrounding tissue injury.[23]

The true efficacy of IVL is still being explored and warrants extensive investigation in larger study populations to better understand the utility of this treatment. The purpose of this study was to evaluate the safety and efficacy of IVL by conducting a systematic review of existing literature.

Materials and Methods

A systematic review was conducted of the existing literature pertaining to the usage and safety of IVL for the treatment of calcified plaques in patients with lower extremity PAD. Literature search findings were reported in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines.[24] Since no human subjects were studied in this research, this systematic review was exempt from official Institutional Review Board (IRB) approval. All studies were uploaded to EndNote and were screened using the Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia, www.covidence.org). Literature screening was performed by two authors, which included initial identification, abstract screening, and full-text assessment.

Literature and Search Strategy

In March 2023, the PubMed database was queried for the literature search. The database was searched for any articles pertaining to the utilization of IVL for treatment of calcified plaques in patients with diagnosed PAD. Any article published between 1981 to 2023 was analyzed. The following string of search terms was used: ([intravascular lithotripsy] OR [lithotripsy] OR [shock wave]) AND ([peripheral] OR [lower extremity]).

Eligibility and Search Criteria

Article selection was conducted by two independent authors. Articles were selected for by first screening through all abstracts for relevance, followed by full-text assessment according to the determined inclusion and exclusion criteria. Duplicate articles were removed in Covidence.

Selected articles that were included in the systematic review met the following inclusion criteria: (1) the study enrolled adult patients (>18 years), (2) the patients in the study had a diagnosis of PAD, (3) the study consisted of patients who underwent intravascular lithotripsy alone for calcified lesions in the lower extremities, and (4) the article reported outcomes data following the IVL procedure, (5) all included articles included a minimum of 4 patients. Articles that analyzed the efficacy of lithotripsy in the context of patients with nephrolithiasis or coronary artery disease or intravascular lithotripsy in combination with another therapy were excluded. Any studies that were (1) case series including less than 4 patients, (2) individual case reports including less than 4 patients, or (3) review papers were excluded.

Data Extraction

Data extraction was conducted on each article that was deemed eligible from full-text assessment. A custom table was generated in Microsoft Excel (version 2019; Microsoft, Redmond, Washington, United States) to organize the data extraction and ensure that the desired study characteristics were being collected. Study characteristics that were collected included: Title of article and authors, year published, type of study design, procedure performed, number of patients who received the IVL procedure, mean age of patients, ratio of male to female participants, ankle–brachial index, preprocedure lesion length (mm), preprocedure calcified length (mm), preprocedure diameter stenosis of vessel (%), average number of IVL pulses delivered, percent success rate of IVL procedure, any adjunctive treatments that were administered, post procedure diameter stenosis (%), acute gain (mm), and specific complications. In studies that determined efficacy of IVL by measuring pain-free walking distance, the pre- and post-procedure

walking distance, time at which postprocedure distance was measured, and improvement in quality of life (QoL) factors were collected.[25,26] In studies that reported IVL efficacy via improvement in the limb blood flow, pre- and postprocedure transcutaneous oxygen pressure ($TcPO_2$), pre- and postprocedure skin perfusion pressure (SPP), and pre- and postprocedure ^{99m}Tc-TF Perfusion Index were collected.[27] Reference sections of each full text were extensively searched to ensure that no eligible papers were missed during the initial PubMed literature search.

Statistical Analysis

Aggregate data of all outcomes variables were obtained. All average values were calculated using the weighted average mean approach. In instances where only the median and interquartile range of an outcome variable was provided, the average was calculated using Hozo's formula.[28] All standard deviation calculations were performed using Hozo's pooled standard deviation formula.[28]

Results

Study Selection

After the duplicate studies were removed by Covidence, there were 451 published studies identified during the initial PubMed literature search. The titles and abstracts of these studies were screened, and 30 studies were deemed eligible for full-text assessment. Upon completing full-text assessment, 17 studies were ultimately included in the systematic review.[25–27,29–42] Papers were excluded during full-text assessment for the following reasons: did not report appropriate outcomes data ($n = 6$), review papers ($n = 4$), and full-text was unavailable ($n = 2$, 1 in a foreign language). ►Fig. 1 shows a PRISMA chart that highlights the selection process for eligible studies, as well as reasons for exclusion.

Study Characteristics

Of the 17 total eligible studies, seven studies were classified as a prospective, nonrandomized multicenter study,[29–34,36] seven studies were classified as a prospective nonrandomized single center study,[26,27,37,38,40–42] and three studies were classified as a randomized controlled trial (RCT; ►Table 1).[25,35,39] All included studies were full-text publications and were published between 2012 to 2023. There were three types of outcomes data reported amongst the studies: 14 of the 17 studies reported change in vessel diameter stenosis following IVL,[29–42] two studies reported change in pain-free walking distance following IVL,[25,26] and one study reported change in $TcPO_2$, SPP, and ^{99m}Tc-TF Perfusion Index in the ischemic limb following IVL (►Table 1).[27]

Patient Characteristics

There was a total of 976 patients among the 17 studies who received intravascular lithotripsy for treatment of calcified plaque in the lower extremity for 1162 docu-
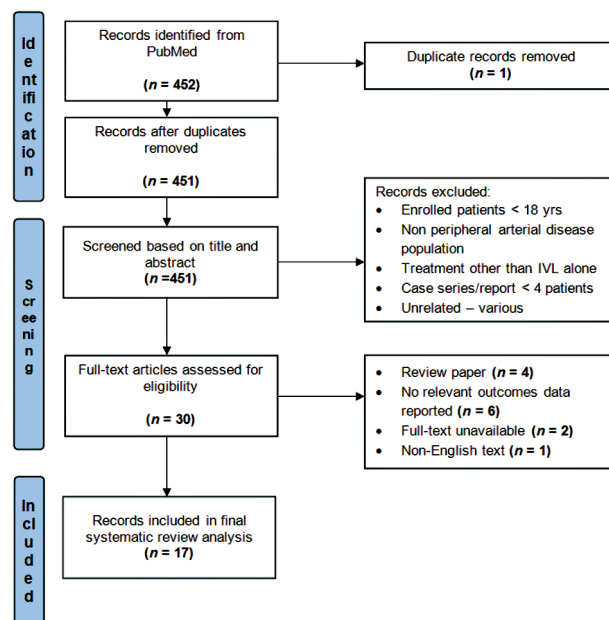
Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA 2020) diagram. IVL, intravascular lithotripsy.

mented calcified lesions. The mean age of patients was 72.93 ± 3.26 years, with males representing 69.6% of total patients included (►Table 1). Six-hundred seventy-nine of the 976 enrolled patients had the locations of their lesion(s) identified. Four-hundred thirty-six patients had a single identified lesion, either in the common iliac artery (77), external iliac artery (17), left iliac artery (3), right iliac artery (4), common femoral artery (66), superficial femoral artery (191), popliteal artery (79), unnamed infra-popliteal vessel (5), anterior tibial artery (47), posterior tibial artery (26), tibioperoneal trunk (40), or the peroneal artery (21). Sixty-two patients had multiple lesions treated, including 47 with both the common and external iliac artery, 5 with both the superficial femoral and popliteal artery, 9 with the anterior tibial, posterior tibial and peroneal arteries,[27] and 1 with the anterior tibial and posterior tibial arteries.[27]

Effect of IVL on Vasculature Compliance

Fourteen of the 17 studies analyzed preprocedural lesion length, preprocedural calcified length, pre- and postprocedural diameter stenosis, and acute gain as the outcomes data (►Table 2). The average preprocedure lesion length was 76.88 ± 28.66 mm, average preprocedure calcified length was 101.52 ± 38.89 mm, and average preprocedure diameter stenosis was $77.70 \pm 11.56\%$. The average postprocedure diameter stenosis was calculated to be $24.72 \pm 9.86\%$ and the average acute gain was 2.80 ± 0.64 mm. Notably, Radaideh et al reported a 0% postprocedure diameter stenosis following IVL.[37] Eleven of the 14 studies reported a 100% procedural success rate following IVL therapy.[29–38,40,42] Tepe et al reported a 65.7% procedural success rate.[39] The average number of pulses

Table 1 Baseline study characteristics of included papers in systematic review

Author, year	Study type	Total no. patients (lesions)	Mean age[a]	M:F ratio	Baseline ABI[a]	Outcome measured
Adams et al 2020[29]	NRMCS	197 (220)	72.5 ± 8.7	148:49	0.7 ± 0.3	Diameter stenosis and acute gain
Adams 2021	NRMCS	101 (114)	72.5 ± 9.7	76:25	0.81 ± 0.33	Diameter stenosis and acute gain
Aftanski 2023	NRSCS	51 (85)	71.0 ± 8.7	40:11	0.6 ± 0.26	Diameter stenosis and acute gain
Armstrong et al 2020[31]	NRMCS	118 (200)	70.4 ± 8.0	78:40	0.7 ± 0.3	Diameter stenosis and acute gain
Brodmann et al 2019[33]	NRMCS	60 (60)	71.5 ± 8.3	46:14	—	Diameter stenosis and acute gain
Brodmann et al 2018[32]	NRMCS	19 (21)	79.0 ± 9.6	14:5	—	Diameter stenosis and acute gain
Brodmann et al 2019[34]	NRMCS	21 (21)	71.9 ± 10.1	16:5	—	Diameter stenosis and acute gain
Colacchio et al 2022[40]	NRSCS	13 (15)	75.0 ± 9.19	7:6	—	Diameter stenosis and acute gain
Ciccone et al 2012[35]	RCT	12 (19)	67.0 ± 9.0	10:2	0.58 ± 0.19	Diameter stenosis and acute gain
Harwood et al 2018[25]	RCT	15 (15)	64.3 ± 9.4	9:6	0.67 ± 0.24	Pre and post-IVL pain-free walking distance
Nardi et al 2021[36]	NRMCS	108 (108)	80.5 ± 6.2	61:47	—	Diameter stenosis and acute gain
Radiaideh 2021	NRSCS	24 (24)	70.7 ± 9.9	17:7	0.75 ± 0.1	Diameter stenosis and acute gain
Radaideh 2019	NRSCS	7 (7)	67.3 ± 6.7	5:2	0.57	Diameter stenosis and acute gain
Serizawa et al 2012[26]	NRSCS	12 (19)	71.3 ± 9.0[$$$]	10:2	0.57 ± 0.15	Pre- and post-IVL pain-free walking distance
Stavroulakis et al 2023[41]	NRSCS	55 (71)	75.0 ± 8.0	27:78	0.64 ± 0.41	Diameter stenosis and acute gain
Tara et al 2014[27]	NRSCS	10 (10)	71.3 ± 9.0	9:1	—	Pre- and post-IVL transcutaneous oxygen tension, skin perfusion pressure to evaluate blood flow
Tepe et al 2021[39]	RCT	153 (153)	72.2 ± 8.0	106:47	0.74 ± 0.20	Diameter stenosis and acute gain

Abbreviations: ABI, ankle–brachial index; IVL, intravascular lithotripsy; NRMCS, nonrandomized multicenter study; NRSCS, nonrandomized single-center study; RCT, randomized controlled trial.

[a]Mean calculated using Hozo's formula, using range and median ($), Standard deviation calculated using Hozo's formula, utilizing range and median ($$), Standard deviation borrowed from study of similar sample size ($$$).

delivered throughout all the studies was 204.02 ± 55.34 pulses. Arterial dissection was the most common complication reported following IVL. There were 72 total patients who suffered from dissections following IVL procedures (7.47%). Thirty-four patients had a Grade A to C (minor) dissection (3.52%), 9 patients were reported to have a Grade D to F (major) dissection (0.93%), and 29 patients did not have a specified dissection type reported (3.0%). Nardi et al and Stavroulakis et al each reported one case of perforation

following IVL.[36,41] Stavroulakis et al also reported one case of peripheral embolization. There were no reported events thrombus formation, no-reflow, or abrupt closure of the vessel. No device related mortalities were noted.

Effect of IVL on Pain-Free Walking Distance

Harwood et al and Serizawa et al analyzed outcomes related to pre- and postprocedure ambulation metrics as well as QoL. Both studies reported the postprocedure

Table 2 Lesion characteristics and outcomes for studies measuring change in vasculature compliance

Study	Arteries treated[a]	Preprocedure lesion length (mm)[b]	Preprocedure calcified length (mm)[b]	Preprocedure diameter stenosis (%)[b]	Postprocedure diameter stenosis (%)[b]	Acute gin (mm)[b]	Procedural success rate	Average pulses[b]	Complications
Adams et al 2020[29]	Common Iliac (n = 32) CFA (n = 27) SFA (n = 121) Popliteal (n = 31) Infrapopliteal (n = 5)	103.4 ± 71.9	140.9 ± 89.6	80.8 ± 17.9	23.6 ± 9.7	3.4 ± 1.2	100%	205.3 ± 122.4	Type D/E/F dissection (n = 2)
Adams 2021	ATA (n = 39) TPT (n = 38) PTA (n = 18) Peroneal (n = 19)	64.7 ± 54.7	52.9 ± 43.1	83.4 ± 15.8	23.3 ± 12.5	2.0 ± 0.7	100%	138.5 ± 53.7	Type B dissection (n = 2) type C dissection (n = 1)
Aftanski 2023	Iliac (n = 8) CFA (n = 14) PFA (n = 4) SFA (n = 58) Popliteal (n = 19) BTK (n = 2)	102.5 ± 77.2	—	84.5 ± 11.0	42.4 ± 12	2.6 ± 0.9	100%	257.0 ± 71.0	Type A/B dissection (n = 6) Type C dissection (n = 4) Type D dissection (n = 1)
Armstrong et al 2020[31]	—	58.3 ± 57.6	—	83.1 ± 13.4	12.0 ± 12.1	—	100%	214.4 ± 136.5	None
Brodmann et al 2019[33]	—	76.9 ± 34.8	98.1 ± 41.7	78.2 ± 13.5	24.2 ± 5.7	3.0 ± 0.8	100%	136.0 ± 75.0	Type B dissection (n = 4) Type C dissection (n = 4) Type D dissection (n = 1)
Brodmann et al 2018[32]	ATA (n = 8) PTA (n = 8) Peroneal (n = 2) TPT (n = 2) Popliteal (n = 1)	52.2 ± 35.8	72.1 ± 37.6	72.60 ± 12.8[$$$]	26.2 ± 10.7[$$$]	1.5 ± 0.5	95%	77.8 ± 58.0[$$$]	Grade B dissection (n = 1)
Brodmann et al 2019[34]	—	37.8 ± 16.7	61.6 ± 30.7	72.3 ± 12.8	21.3 ± 10.7	3.1 ± 1.3	100%	140.0 ± 58.0	Grade B dissection (n = 5)
Colacchio et al 2022[40]	CFA (n = 15)	28.36*	—	82.18[$] ± 12.22[$$]	37.8[$] ± 8.07[$$]	—	100%	150.0*	None
Ciccone et al 2012[35]	—	—	—	93.0 ± 9.0	84.0 ± 13.0	—	100%	—	—

Table 2 (Continued)

Study	Arteries treated[a]	Preprocedure lesion length (mm)[b]	Preprocedure calcified length (mm)[b]	Preprocedure diameter stenosis (%)[b]	Postprocedure diameter stenosis (%)[b]	Acute gin (mm)[b]	Procedural success rate	Average pulses[b]	Complications
Nardi et al 2021[36]	Common iliac (n = 35) External iliac (n = 17) Common and external iliac (n = 47) CFA (n = 7)	20.0 ± 71.9$$$	50.5 ± 89.6$$$	50.0 ± 10.7	25.0 ± 9.7$$$	—	100%	300.0 ± 122.4$$	A-C (minor) dissection (n = 4) Type D-F (major) dissection (n = 3) Perforation (n = 1)
Radaideh 2021	Common Iliac (n = 2) CFA (n = 3) SFA and popliteal (n = 5) SFA (n = 12) Popliteal (n = 2)	84.5 ± 37.1	—	57.6 ± 19.0	20.7 ± 3.4	1.9 ± 0.2	100%	118.6 ± 51.9	Grade C or higher dissection (n = 2)
Radaideh 2019	Left iliac (n = 3) Right iliac (n = 4)	90.71*	—	95.0 ± 6.45	0	—	100%	72.14 ± 23.07	Grade C dissection (n = 3)
Stavroulakis et al 2023[41]	Popliteal (n = 26) Femoral (n = 45)	95.0$ ± 30.62$$	—	—	—	—	97%	—	Perforation (n = 1) Peripheral embolization (n = 1) Any dissection (n = 5)
Tepe et al 2021[39]	—	100.9 ± 41.0	129.4 ± 50.7	85.0 ± 12.0	27.3 ± 11.5	—	65.7%	228.0 ± 11.5	Any dissection (n = 24)

[a]Artery treated: ATA, anterior tibial artery; BTK, BTK = below the knee; CFA, common femoral artery; PTA, posterior tibial artery; SFA, superficial femoral artery; TPT, tibioperoneal trunk.
[b]Mean calculated using Hozo's formula, using range and median ($), Standard deviation calculated using Hozo's formula, utilizing range and median ($$), Standard deviation borrowed from study of similar sample size ($$$).

Table 3 Pre- and postprocedure pain-free walking distance and quality-of-life factors

Study	Preprocedure pain-free walking distance (m)	Postprocedure pain-free walking distance (m)	Time at which postprocedure distance was measured	Improvement in quality-of-life factors
Harwood et al 2018[25]	58.1 ± 32.5	218.8 ± 162.3	12 weeks	Yes
Serizawa et al 2012[26]	—	$171 \pm 75\%$ increase	12 weeks	Yes[a]

[a]Walking impairment questionnaire was utilized for this study.

outcome 12 weeks after the treatment,[25,26] which is shown in ►**Table 3**. Both studies reported a significant increase in the pain-free walking distance following the IVL procedure, and both reported that there was a significant improvement in QoL factors following IVL treatment based on patients' survey responses. Serizawa et al specifically measured the patients' quality of life using the Walking Impairment Questionnaire instead of the QoL assessment.[26]

Effect of IVL on Blood Flow to Ischemic Limb

Tara et al's study was the one study that reported the efficacy of IVL in the form of reporting pre- and postprocedure variables pertaining to blood flow in the ischemic limb (table not included).[27] The study measured $TcPO_2$, SPP and ^{99m}Tc-TF Perfusion Index, and performed IVL treatment on the calf, dorsum of foot, plantar surface of the foot, and anterior tibia. There was a significant increase in postprocedure $TcPO_2$ in the calf and dorsum of the foot following IVL; however, there was no significant increase in the postprocedure $TcPO_2$ in the anterior tibia following IVL. There was no significant increase in post-procedure SPP following IVL in the dorsum of foot or plantar surface of the foot. There was a significant increase in the ^{99m}Tc-TF Perfusion Index in the foot following IVL treatment.

Discussion

This systematic review aimed to analyze the safety and efficacy of intravascular lithotripsy in the management of calcified plaques in PAD patients. The overall findings of this review identified that all but three studies reported a 100% procedural success rate following an IVL procedure, with notable improvement in the vessel diameter, significant improvement in pain-free walking distance, significant increase in $TcPO_2$ in the calf, and increased perfusion index in the foot. Two of the studies reported a 95[32] and 97%[41] technical success rate; however, Tepe et al[39] reported a 65.7% technical success rate. The lower technical success rate in this particular study may be due to nuances in the methodology compared to other studies. For example, 83% of patients in this study were treated for severe calcifications, which was a much higher proportion of severe calcifications than in other included studies. Additionally, the initial device generator used in Tepe et al was only able to deliverer a maximum of 180 pulses, and only 13 patients received pulse delivery from an updated generator software that could

deliver up to 300 pulses, which may have prohibited the ability to attain technical success by defined parameters in the methodology.

In addition, the compilation of these studies has shown that IVL can successfully be used in a diverse array of vasculature in the lower extremities, including iliac, femoropopliteal, and infrapopliteal disease. This systematic review is the second known review that compiles existing literature regarding the usage of shock wave lithotripsy (Shockwave Medical, Fremont, California, United States) to treat lower extremity calcifications in patients with moderate to severe PAD. Conducted by Wong et al, the first systematic review included nine studies that supported the usage of IVL as a safe and effective approach for the treatment of calcified plaques in lower extremity PAD.[43] Our review included an additional 11 studies. Moreover, our review corroborated their results with a larger population size. Wong et al reported an average 80.76% pre-IVL diameter stenosis and 20.2% post-IVL diameter stenosis, while this study reported an average $77.70 \pm 11.56\%$ pre-IVL diameter stenosis and $24.72 \pm 9.86\%$ post-IVL diameter stenosis. A previous patient-level pooled data analysis was conducted, which showed that there was a significant reduction in the postprocedure percent diameter stenosis following IVL, from 78.8% pre-IVL to 28.6% post-IVL.[44] The current systematic review includes the largest population size to date and the greatest number of lesions, with 976 patients and 1,162 lesions.

One of the highlighted features that has supported IVL as an effective and safe treatment for plaque removal is the substantially low reported risk of postprocedural complication. There were 75 total patients (7.78%) who had a reported complication following IVL. About 3.52% of patients had a postprocedural Grade A to C (minor) dissection, 0.93% had a Grade D to F (major) dissection, two reported cases of perforation and one reported case of distal embolization. Additionally, there were no thrombus formation, no-reflow, or abrupt closure of the vessel reported. In contrast to these reported values, there have been several RCT studies showing outcomes following PTA procedures, reporting anywhere from a 45.2 to 72% rate of Grade A to C dissection[45–47] and a 29 to 30% rate of Grade C or higher dissection.[47,48] One RCT study also reported that distal embolization occurred in 1.1% of patients who underwent PTA.[49] Additionally, a study directly comparing efficacy of IVL versus PTA showed that flow-limiting dissections occurred more frequently in the PTA group.[39] The disrupt PAD III randomized trial also

reported higher procedural success following IVL in comparison to PTA after 30 days,[39] supporting the notion that IVL is more efficacious than PTA for the treatment of calcified plaques. Recently published mid-term outcomes reporting from the disrupt PAD III trial have also confirmed that primary patency at 1 year was significantly greater in the IVL arm than in the PTA arm, confirming the consistent efficacy of IVL.[50] Several RCT studies reported between a 63.8 and 74% rate of Grade A to C dissection following DCB, and between a 32.4 and 42% rate of Grade C or higher dissection.[45,46,51] One study also reported three cases of distal embolization and two cases of perforations following DCB therapy.[52] Additionally, several studies have identified a particularly high rate of postprocedural distal embolization following atherectomy procedures.[49,53–55] These reported complication rates are substantially higher than the complication rates reported in our review for IVL treatment, highlighting a clear implication that IVL may provide equally effective clinical outcomes, while also minimizing complications in patients.

There were several limitations in this study that were predominantly inherent to the systematic review process. Despite the studies in this review reporting procedural success, the technical success was not defined and reported in most studies; therefore, there was no analysis conducted on these aspects of each study. In addition, this review included papers that were of various study types, resulting in clinical heterogeneity. However, it does provide a safety and efficacy data from a large cohort of patients.

Conclusion

Overall, this review supports the utilization of intravascular lithotripsy as a safe and effective treatment modality in removing arterial calcifications in patients with PAD. The existing literature has shown that IVL successfully decreases residual diameter stenosis, increases luminal gain, increases pain-free walking distance, and improves blood flow to ischemic limbs, with minimal to no postprocedural complications. Additional high-quality prospective studies with larger patient populations are warranted to better support the effectiveness of this technique and to directly compare intravascular lithotripsy to other treatment modalities, so that we can enhance our understanding of the versatility and efficacy of this device.

Note
This manuscript data was presented as an oral presentation at the 2022 Society of Interventional Radiology Annual Scientific Meeting. This work has not been previously published and is not under review elsewhere for publication.

Ethical Approval Statement
This study is a systematic review of previously published data and did not require the approval of an IRB.

Conflict of Interest
None declared.

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