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PROTOCOL

Use of Shockwave® intravascular lithotripsy in the treatment of calcific peripheral vascular disease of the crural vessels: a protocol for a systematic review

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Plain English Summary

Why we are undertaking this work: Intravascular lithotripsy is a new technology that helps open blocked or narrowed arteries. It can aid in the treatment of limb-threatening ischaemia by opening arteries that take blood to the leg and foot. We currently do not know how this technology can be best deployed when treating patients with blocked or narrowed arteries. However, recent evidence suggests that this device is safe and effective.

What we will do: We aim to identify all the studies that used this device to treat patients with blocked or narrowed arteries below the knee. We will then independently assess the reported safety and efficacy where the device was used.

What this means: The information we gather from this review will help us confirm the safety of the device and measure the benefit it adds to the treatment of patients with arterial blockage below the knee. We will then be able to direct future research to identify how this technology can be best used to maximise its benefit to patients.

Key words: intravascular lithotripsy, chronic limb-threatening ischaemia, peripheral artery disease, arterial calcification, crural

Abstract

Background: The prevalence of chronic limb-threatening ischaemia due to crural peripheral arterial disease is increasing. Crural disease can be challenging to treat with angioplasty and is associated with poorer patient outcomes. Intravascular lithotripsy (IVL) is a novel technique that uses acoustic waves to target arterial wall calcification, causing microfractures and increasing lumen gain. It has shown promising results in early clinical trials. This is a protocol for a systematic review of the studies on the use of IVL in the treatment of calcified crural vessels.

Methods: A systematic review will be conducted on the use of IVL in patients with calcified crural lesions in accordance with PRISMA guidelines. A search of OVID Medline and EMBASE databases will be carried out for studies of patients with crural peripheral arterial disease undergoing endovascular revascularisation, where IVL was part of the procedure. The primary endpoint of the review will be the safety of IVL, defined as the rate of Major Adverse Limb Events (MALE) and Major Adverse Cardiac Events (MACE). The efficacy of IVL will be the secondary outcome and will be evaluated in terms of technical and clinical outcomes. The Rayyan web tool for systematic reviews will be used for study screening and selection. Data extraction will be performed using a dedicated Excel spreadsheet. The risk of bias of included studies will be assessed using tools recommended by Cochrane for randomised and non-randomised studies. The assessment of evidence quality and strength of recommendation will be performed using the GRADE approach.

Ethics and dissemination: This is a systematic review and meta-analysis of published literature data and does not require prior ethical approval. Requests for unpublished data from authors of included studies will comply with the UK General Data Protection Regulation (GDPR). We aim to disseminate the results of this study in peer-reviewed journals and conferences.

Introduction

Peripheral artery disease (PAD) is a systemic atherosclerotic disease with an increasing prevalence currently estimated at over 230 million adults globally.[1,2] PAD prevalence in the infrapopliteal/crural arterial bed is increasing, influenced by the ageing population, as well as the increasing prevalence of diabetes and chronic kidney disease.[1–3]

Chronic limb-threatening ischaemia (CLTI), the most severe form of lower limb PAD, presents with rest pain, non-healing ulcers and gangrene.[4] Registry data estimate that CLTI accounts for one in 10 patients diagnosed with PAD and can have devastating consequences for patients, with a 25% risk of mortality and a 30% risk of major limb amputation in the first year of diagnosis.[5,6] These risks are significantly higher in the presence of arterial calcification.[7,8]

Endovascular revascularisation is an established treatment strategy in patients with CLTI; however, treatment is challenging in calcified infrapopliteal/crural vessels due to higher rates of restenosis, poor vessel compliance and dissection.[9–11] Vessel preparation using adjunctive calcium debulking tools such as atherectomy has shown some improvement compared with percutaneous transluminal angioplasty (PTA) alone.[12] However, atherectomy has not shown a significant benefit as an adjunctive tool before drug-coated balloon in crural vessels and still has significant risks of vessel perforation and distal embolisation.[13,14]

Intravascular lithotripsy (IVL) is a novel technology that preferentially targets arterial calcium. The use of IVL in calcified lower limb lesions was first described in 2016, with the first feasibility study on crural arteries published in 2018.[5,15]

IVL leverages similar principles to urological lithotripsy, which is an accepted, safe and effective treatment of renal tract calculi. Electrohydraulic-generated sonic pressure waves pass through soft tissue and interact strongly with high-density calcium, producing significant shear stresses that fracture calcium. IVL is designed to modify both intimal and medial calcium across peripheral vessel beds and is proposed to increase vessel compliance and minimise vessel wall trauma.[5,16,17]

The Peripheral Lithoplasty System developed by Shockwave Medical® (Santa Clara, California, USA) consists of a generator, connector cable and a proprietary single-use sterile catheter that contains multiple lithotripsy emitters enclosed in an integrated balloon. The emitters positioned along the length of the balloon create a localised field effect via sonic pressure waves that selectively disrupt and fracture calcium.[16,18]

The use of IVL in patients with calcified coronary artery disease and other peripheral arterial beds has shown promising efficacy and safety data.[19–22] The DISRUPT CAD III trial, a study of IVL in calcified coronary arteries, showed a procedural success rate of 92.4%, with acceptable 30-day and 1-year Major Adverse Cardiovascular Events (MACE) of 7.8% and 13.8%.[22] The DISRUPT PAD III randomised controlled trial (RCT) compared the safety and efficacy of IVL versus PTA prior to drug-coated balloon or stenting in symptomatic femoropopliteal disease. The procedure success rate was superior in the IVL group (65.8% vs 50.4%; p=0.01). The periprocedural complications such as flow-limiting dissections (1.4% vs 6.8%; p=0.03) and stent placement (4.6% vs 18.3%; p<0.001) were greater in the PTA group, although rates of major adverse events and clinically driven target lesion revascularisation were similar in both groups at 30 days and 1-year follow-up.[20,21]

So far, there are limited data on the safety and efficacy of the Shockwave Peripheral IVL system and its newer catheter in the treatment of calcified crural vessels. Early data have suggested improvement in diameter stenosis and low complications following the use of IVL in lower limb arteries. However, most studies were not on lesions in the crural arteries, which have different histomorphological disease characteristics and calcification patterns compared with lesions in other lower limb arterial beds.[23,24] Therefore, the aim of this study is to review the available safety and efficacy data, specifically on the use of IVL in patients with crural arterial disease and, where possible, compare outcomes against other treatment strategies.

Methodology

This review is registered on the International Prospective Register of Systematic Reviews (PROSPERO) database (CRD42022330337).[25] The methods used in this review are in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses Protocols (PRISMA-P) guidelines.[26] The PRISMA-P checklist is shown in Appendix 1 (online at www.jvsgbi.com).

Study eligibility

Randomised controlled trials (RCTs), prospective and retrospective studies of adult patients with diagnosed symptomatic PAD having endovascular revascularisation involving the crural vessels will form the study population. Study intervention must include crural vessel preparation using IVL by Shockwave Medical® as part of the procedure. Studies of the use of IVL in other arterial beds such as coronary, aortoiliac and femoropopliteal beds, vascular access interventions, asymptomatic PAD or PAD not involving the crural vessels, single case reports or case series of fewer than 10 patients will be excluded. If studies showing comparative data are available, eligible comparators include optimal medical therapy, supervised exercise, other endovascular approaches or surgical bypass.

Search strategy

A preliminary scoping search with pre-defined search terms will be conducted in consultation with a qualified medical librarian. EMBASE and OVID Medline databases will be reviewed from inception to April 2022 for studies reporting the use of intravascular lithotripsy in the treatment of calcific PAD using keywords, equivalent words, and Medical Subject Headings terms to maximise search sensitivity. Search terms will include “angioplasty”, “lithoplasty”, “lithotripsy” and “shockwave”. A final search will be

performed before data extraction and analysis to include recent data if available. A review of the Shockwave Medical® website and trial registries such as clinicaltrials.gov will be performed to identify conference papers, ongoing clinical trials or unpublished data that meet the inclusion criteria. A draft search strategy is shown in Appendix 2 (online at www.jvsgbi.com). References will be managed using Mendeley version 2.74.0 (Elsevier, 2022).

Study selection and data extraction

The Rayyan© web tool for systematic reviews will be used for study screening and selection.[27] The search results will be uploaded to the web tool, followed by automatic duplicate identification and manual removal of duplicates. Two authors will review the literature search results and independently select studies that meet the inclusion criteria based on title, abstract and, if required, full paper review. A consensus will be sought on study inclusion; if this is not possible, a third reviewer will provide arbitration. Additional relevant literature that meets the inclusion criteria will be sought from full text and reference search of selected studies. Following this, independent data extraction will commence using a dedicated Microsoft Excel spreadsheet (Microsoft® Corporation, 2022). Again, discrepancies will be resolved through consensus and, where necessary, study authors will be contacted for further data or clarification.

Data will be collected on study characteristics, patient demographics, stage, level and laterality of PAD, procedure data, vessel diameter pre- and post-IVL, use of stents, types of intervention, complications and comparators (where available). Detailed results of each study will be included in the spreadsheet. Where eligible studies include data on patients with crural PAD mixed with those without, study authors will be contacted to provide data for patients with crural disease separately to be eligible for meta-analysis. In addition, conflict of interest, study funding and other sources of bias will be reported if deemed relevant.

Outcome

The safety of IVL will be the primary outcome. IVL safety will be measured by the rate of Major Adverse Limb Events (MALE) and Major Adverse Cardiac Events (MACE). MALE will be evaluated by the rate of postprocedural complications such as vessel dissection, acute thrombosis, distal embolisation and the need for emergency surgical revascularisation of the target limb or amputation. MACE will be defined as death, myocardial infarction, or stroke. Amputation above the ankle is classed as major amputation, whereas minor amputation is below the ankle.

The efficacy of IVL will be the secondary outcome and will be evaluated in terms of technical and clinical outcomes. Technical outcomes include primary patency, the need for re-intervention, assisted patency, the severity of stenosis and luminal gain, which will be assessed using digital subtraction angiography (DSA). Re-intervention is classified as any vascular procedure outwith the study protocol. Clinical outcomes are amputation-free survival, improvement in PAD severity, and patient-reported quality of life measures. Acceptable measures of PAD severity include improvement in walking distance, Rutherford disease classification, ulcer healing or measured pressures.

Assessment of methodological quality

The risk of bias in selected studies will be assessed using the revised Cochrane's risk-of-bias tool for randomised trials (RoB 2) or the ROBINS-I (Risk Of Bias In Non-randomised Studies - of Interventions) tool.[28,29] If included studies are non-RCTs, the ROBINS-I tool will be used. Studies judged as having a critical risk of bias will be excluded from data analysis and synthesis.

The certainty of the evidence for each outcome will be assessed according to the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) system.[30] The outcome will be rated as "very low", "low", "moderate" or "high" as per the guideline. Evidence from an observational study which is categorised as low risk of bias using the ROBINS-I tool may be upgraded using the GRADE system following a consensus by the authors.

Data analysis

Analysis of data will be carried out using Review Manager (version 5.4, The Cochrane Collaboration, 2020) and SPSS® Statistics (version 27, IBM®, 2020). Continuous outcomes will be analysed using mean or standardised mean difference (SMD) with a 95% confidence interval (CI). For observational studies without a comparative arm, means and 95% CI will be reported. Dichotomous outcomes will be reported as risk ratios with 95% CI where a comparative study is available. The incidence rate with 95% CI will be reported where there are no comparators. Data from RCTs will be presented separately from observational studies. Meta-analysis of outcome data will be performed for studies that are deemed clinically homogenous. Clinical heterogeneity concerning patient demographics, disease severity, location of disease, type of interventions and outcomes will be assessed first. If clinical homogeneity criteria are satisfied, statistical heterogeneity will be assessed using the χ^2 and I^2 tests. In the presence of significant statistical heterogeneity, a random effects model will be used in the meta-analysis.

Dichotomous outcomes will be presented in a forest plot with risk ratios (RR) and 95% CI, whereas continuous outcomes will be presented as mean difference (MD) or SMD with 95% CI. Data from homogenous single-arm cohort studies will be combined and presented as a mean with a 95% CI for continuous outcomes or proportion with a 95% CI for categorical outcomes, or a hazard ratio with a 95% CI for time-to-event data. In addition, we will provide a narrative review for outcomes that cannot be quantified or analysed in a meta-analysis.

Discussion

Infrapopliteal/crural lesions are technically challenging to treat due

KEY MESSAGES

- Symptomatic crural PAD is associated with poor patient outcomes.
- Intravascular lithotripsy (IVL) is a promising technology with good safety and efficacy profile in various arterial beds.
- A systematic review of IVL in crural PAD will be carried out accordance to PRISMA guidelines.

to the presence of vessel calcification, limited flow, long lesion length and small vessel diameter.[9] Histopathological and radiological analysis have demonstrated that the pattern of disease in crural arteries is different from that in other arterial beds.[31] An annular calcification pattern has been described in the crural arteries of patients with CLTI, and it is thought to be related to medial arterial calcification.[32] This pattern of calcification is seen in most patients with CLTI and is associated with a poorer prognosis.[24] This contrasts with dot-like or patchy calcification related to intimal atherosclerosis seen predominantly in other arterial beds.[24] IVL targets both intimal and medial wall calcification and has shown promising results in arterial beds above the crural level, but data on patients with crural disease are limited.[20,21]

Patients with CLTI and crural disease stand to benefit significantly from IVL technology if results in other arterial beds carry over to this group of patients. There are currently no systematic reviews that synthesise data on the use of IVL in this patient group. Moreover, the available data from original studies are largely industry-sponsored and focused on technical results, which may not reflect clinical priorities from a patient perspective. This systematic review will independently assess and synthesise the current data on the use of IVL in treating patients with CLTI and crural arterial disease. It will also help inform future research in this area in terms of identifying the presence of a signal of improvement in key safety and efficacy outcomes.

Conclusion

IVL is emerging as an adjunctive and definitive tool in treating calcified PAD. Overall, the aim of this review is to ascertain the available evidence on the safety and efficacy of this novel technology in crural arteries.

Conflict of Interest: RL has lectured for Shockwave Medical® in Industry Symposia.

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References

1. Aday AW, Matsushita K. Epidemiology of peripheral artery disease and polyvascular disease. *Circ Res* 2021;**128**(12):1818–32. https://doi.org/10.1161/CIRCRESAHA.121.318535
2. Criqui MH, Aboyans V. Epidemiology of peripheral artery disease. *Circ Res* 2015;**116**(9):1509–26. https://doi.org/10.1161/CIRCRESAHA.116.303849
3. Hamburg NM, Creager MA. Pathophysiology of intermittent claudication in peripheral artery disease. *Circ J* 2017;**81**(3):281–9. https://doi.org/10.1253/circj.CJ-16-1286
4. Criqui MH, Matsushita K, Aboyans V, *et al*. Lower extremity peripheral artery disease: contemporary epidemiology, management gaps, and future directions: a scientific statement from the American Heart Association. *Circulation* 2021;**144**(9):e171–91. https://doi.org/10.1161/CIR.0000000000001005
5. Brodmann M, Holden A, Zeller T. Safety and feasibility of intravascular lithotripsy for treatment of below-the-knee arterial stenoses. *J Endovasc Ther* 2018;**25**(4):499–503. https://doi.org/10.1177/1526602818783989
6. Gaisset R, Lin F, Borry O, *et al*. Incident cardiovascular events and early mortality in patients with revascularized critical limb ischemia. *J Med Vasc* 2022;**47**(1):19–26. https://doi.org/10.1016/j.jdmv.2022.02.001
7. Guzman RJ, Brinkley DM, Schumacher PM, Donahue RMJ, Beavers H, Qin X. Tibial artery calcification as a marker of amputation risk in patients with peripheral arterial disease. *J Am Coll Cardiol* 2008;**51**(20):1967–74. https://doi.org/10.1016/j.jacc.2007.12.058
8. Conte MS, Bradbury AW, Kolh P, *et al*. Global vascular guidelines on the management of chronic limb-threatening ischemia. *Eur J Vasc Endovasc Surg* 2019;**58**(1):S1–S109.e33. https://doi.org/10.1016/j.ejvs.2019.05.006
9. Schamp KBC, Meerwaldt R, Reijnen MMPJ, Geelkerken RH, Zeebregts CJ. The ongoing battle between infrapopliteal angioplasty and bypass surgery for critical limb ischemia. *Ann Vasc Surg* 2012;**26**(8):1145–53. https://doi.org/10.1016/j.avsg.2012.02.006
10. Rocha-Singh KJ, Zeller T, Jaff MR. Peripheral arterial calcification: prevalence, mechanism, detection, and clinical implications. *Catheter Cardiovasc Interv* 2014;**83**(6):E212–20. https://doi.org/10.1002/ccd.25387
11. Norgren L, Hiatt WR, Bell K, *et al*. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). *Eur J Vasc Endovasc Surg* 2007; **33**(Suppl 1):S1–75. https://doi.org/10.1016/j.ejvs.2006.09.024
12. Zeller T, Rastan A, Schwarzwälder U, *et al*. Midterm results after atherectomy-assisted angioplasty of below-knee arteries with use of the Silverhawk device. *J Vasc Interv Radiol* 2004;**15**(12):1391–7. https://doi.org/10.1097/01.RVI.0000138060.05915.9D
13. Rastan A, Brodmann M, Böhme T, *et al*. Atherectomy and drug-coated balloon angioplasty for the treatment of long infrapopliteal lesions: a randomized controlled trial. *Circ Cardiovasc Interv* 2021;**14**(6):e010280. https://doi.org/10.1161/CIRCINTERVENTIONS.120.010280
14. Thukkani AK, Kinlay S. Endovascular intervention for peripheral artery disease. *Circ Res* 2015;**116**(9):1599–613. https://doi.org/10.1161/CIRCRESAHA.116.303503
15. Brodmann M, Werner M, Brinton TJ, *et al*. Safety and performance of lithoplasty for treatment of calcified peripheral artery lesions. *J Am Coll Cardiol* 2017;**70**(7):908–10. https://doi.org/10.1016/j.jacc.2017.06.022
16. Kereiakes DJ, Virmani R, Hokama JY, *et al*. Principles of intravascular lithotripsy for calcific plaque modification. *JACC Cardiovasc Interv* 2021;**14**(12): 1275–92. https://doi.org/10.1016/j.jcin.2021.03.036
17. Khan S, Li B, Salata K, *et al*. The current status of lithoplasty in vascular calcifications: a systematic review. *Surg Innov* 2019;**26**(5):588–98. https://doi.org/10.1177/1553350619848557
18. Holden A. The use of intravascular lithotripsy for the treatment of severely calcified lower limb arterial CTOs. *J Cardiovasc Surg* 2019;**60**(1):3–7. https://doi.org/10.23736/S0021-9509
19. Brodmann M, Werner M, Holden A, *et al.* Primary outcomes and mechanism of action of intravascular lithotripsy in calcified, femoropopliteal lesions: results of Disrupt PAD II. *Catheter Cardiovasc Interv* 2019;**93**(2):335–42. https://doi.org/10.1002/ccd.27943
20. Tepe G, Brodmann M, Bachinsky W, *et al*. Intravascular lithotripsy for peripheral artery calcification: mid-term outcomes from the randomized Disrupt PAD III Trial. *J Soc Cardiovasc Angiogr Interv* 2022;**1**(4):100369. https://doi.org/10.1016/j.jscai.2022.100341

21. Tepe G, Brodmann M, Werner M, *et al*. Intravascular lithotripsy for peripheral artery calcification: 30-day outcomes from the randomized Disrupt PAD III Trial. *JACC Cardiovasc Interv* 2021;**14**(12):1352–61. https://doi.org/10.1016/j.jcin.2021.04.010
22. Kereiakes DJ, Hill JM, Shlofmitz RA, *et al*. Intravascular lithotripsy for treatment of severely calcified coronary lesions: 1-year results from the Disrupt CAD III Study. *J Soc Cardiovasc Angiogr Interv* 2022;**1**(1):100001. https://doi.org/10.1016/j.jscai.2021.100001
23. Soor GS, Vukin I, Leong SW, Oreopoulos G, Butany J. Peripheral vascular disease: who gets it and why? A histomorphological analysis of 261 arterial segments from 58 cases. *Pathology* 2008;**40**(4):385–91. https://doi.org/10.1080/00313020802036764
24. Konijn LCD, Takx RAP, Mali WPTM, Veger HTC, van Overhagen H. Different lower extremity arterial calcification patterns in patients with chronic limb-threatening ischemia compared with asymptomatic controls. *J Pers Med* 2021; **11**(6):493. https://doi.org/10.3390/jpm11060493
25. Igwe C, Abduraheem M, Shahani N, Raghuram L, Daniel C, George S. Shock-wave intravascular lithotripsy in the treatment of calcific peripheral vascular disease of the crural vessels: a systematic review. 2022. Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022330337
26. Page MJ, McKenzie JE, Bossuyt PM, *et al*. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;**372**:n71. https://doi.org/10.1136/bmj.n71
27. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev* 2016;**5**(1):210. https://doi.org/10.1186/s13643-016-0384-4
28. Sterne JAC, Savović J, Page MJ, *et al*. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* (Online) 2019;**366**:l4898. https://doi.org/10.1136/bmj.l4898
29. Sterne JA, Hernán MA, Reeves BC, *et al*. ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* (Online) 2016; **355**:i4919. https://doi.org/10.1136/bmj.i4919
30. Granholm A, Alhazzani W, Møller MH. Use of the GRADE approach in systematic reviews and guidelines. *Br J Anaesth* 2019;**123**(5):554–9. https://doi.org/10.1016/j.bja.2019.08.015
31. Konijn LC, Takx RA, de Jong PA, *et al*. Arterial calcification and long-term outcome in chronic limb-threatening ischemia patients. *Eur J Radiol* 2020;**132**:109305. https://doi.org/10.1016/j.ejrad.2020.109305
32. Narula N, Dannenberg AJ, Olin JW, *et al*. Pathology of peripheral artery disease in patients with critical limb ischemia. *J Am Coll Cardiol* 2018; **72**(18):2152–63. https://doi.org/10.1016/j.jacc.2018.08.002

Appendix 1 PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol*

Section and topic	Item No	Checklist item
ADMINISTRATIVE INFORMATION		
Title:		
Identification	1a	Identify the report as a protocol of a systematic review
Update	1b	If the protocol is for an update of a previous systematic review, identify as such
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number
Authors:		
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments
Support:		
Sources	5a	Indicate sources of financial or other support for the review
Sponsor	5b	Provide name for the review funder and/or sponsor
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol
INTRODUCTION		
Rationale	6	Describe the rationale for the review in the context of what is already known
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)
METHODS		
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated
Study records:		
Data	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review

Appendix 2 Draft systematic review search strategy

Embase <1974 to 2022 April 25>

1	exp angioplasty/ or angioplasty.mp.	114618
2	(shockwave or shock-wave or shock wave).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	18104
3	1 and 2	177
4	lithotripsy.mp.or exp lithotripsy/	26516
5	lithoplasty.mp.	84
6	coronary.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device tradename, keyword heading word, floating subheading word, candidate term word]	781852
7	3 not 6	69
8	4 not 6	25929
9	5 not 6	27
10	1 not 6	49769
11	8 and 10	90
12	7 or 11	125
13	9 or 12	141

Ovid MEDLINE(R) ALL <1946 to April 25, 2022>

1	exp angioplasty/ or angioplasty.mp.	80970
2	(shockwave or shock-wave or shock wave).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]	11676
3	1 and 2	73
4	lithotripsy.mp.or exp lithotripsy/	15048
5	lithoplasty.mp.	60
6	coronary.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device tradename, keyword heading word, floating subheading word, candidate term word]	538026
7	3 not 6	21
8	4 not 6	14774
9	5 not 6	19
10	1 not 6	29702
11	8 and 10	52
12	7 or 11	59
13	9 or 12	74