Volume 2 Issue 2 February 2023

Journal of VASCULAR SOCIETIES

GREAT BRITAIN & IRELAND

ISSN 2754-0030

The journal is owned by the Vascular Society for Great Britain and Ireland (VSGBI)

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ADDRESS FOR CORRESPONDENCE:
Journal of Vascular Societies GB&I
c/o Executive Business Support
Davidson Rd
Lichfield
WS14 9DZ

ARTICLE SUBMISSIONS AND GENERAL ENQUIRIES PLEASE EMAIL:
Editorialoffice@jvsgbi.com

ADVERTISING AND SALES ENQUIRIES PLEASE EMAIL:
info@jvsgbi.com

The *JVSGBI* is published online quarterly in Feb, May, August and November on the *JVSGBI* website. Articles, when finalised for publishing, will be published online, and then at the discretion of the Editor in Chief, included in the online issue and/or printed issue.

ISSN 2754-0022 (print)
ISSN 2754 0030 (online)

Produced by: Executive Business Support and Production 10 Limited

Printed on 100% recycled paper

JOURNAL OWNED AND PUBLISHED BY

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The Vascular Society for Great Britain and Ireland

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The Vascular Society of Great Britain and Ireland (VSGBI) is the pre-eminent organisation in the country promoting vascular health by supporting and furthering excellence in education, training and scientific research.

The Society represents and provides professional support for over 600 members, including vascular surgeons, vascular radiologists and others involved in independent vascular practices in Great Britain and Ireland.

The Society focuses on non-cardiac vascular disease, including diseases of peripheral arteries, veins and lymphatic. Vascular specialists are trained in the diagnosis and management of conditions affecting all parts of the vascular system.

The VSGBI is a charity organisation funded principally by Members who are vascular specialists in the UK and Ireland who treat non-cardiac vascular diseases. It has a professional structure including a permanent Secretariat, Executive Officers and Council elected by Members. The aim of the VSGBI is to have an interest in the provision of diagnosis and treatment of non-cardiac vascular diseases in the UK and Ireland.

Benefits of Membership

The Society represents and provides professional support for over 600 members, including vascular surgeons, vascular radiologists and others involved in independent vascular practices in Great Britain and Ireland. Membership of the Society is widely recognised in the vascular community as a mark of professional achievement.

The advantages of membership of the Vascular Society include:

- The VSGBI **represents vascular specialists nationally** and helps drive policy through its relations with Royal Colleges, other related professional Societies (e.g. BSIR) and the Department of Health. Members have access to the Executive and Council who prepare and enable these policies.
- The VSGBI **promotes vascular training**, runs training courses and has lobbied for positions such as the post CCT Fellowships, and the Endovascular Fellowships.
- The VSGBI **organises specialist courses and meetings** delivered locally, together with an annual meeting with scientific and political updates.
- The VSGBI **publishes virtual educational resources** which are available to members.
- The VSGBI **publishes a quarterly journal,** the *Journal of the Vascular Societies Great Britain and Ireland*, which is available to its members.
- The VSGBI **publishes policy documents** and quality improvement resources which are available on its website.
- ESVS Membership. VS members can enjoy **ESVS membership at a discounted rate**, and benefit from ESVS membership benefits.
- The VSGBI together with HQIP and the clinical effectiveness unit (CEU) at the RCS London **maintains the National Vascular Registry**, the principal outcomes database for vascular interventions in the UK and Ireland (and for the NHS AAA Screening Programme).
- The Society's **Professional Standards Committee, (PSC) offers support to individuals and hospitals**. For further information visit **www.vascularsociety.org.uk** Council and Committees page. Details of the support and advice scheme are given in the Professional Standards Committee section.
- The Society is an associate partner of the BJS. This entitles VS members to a **reduced BJS subscription**
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and is available to Specialists in vascular practice in non-consultant career grades, living and working in Great Britain and Ireland. Prospective associate members should be proposed by two ordinary members. Nominations will be considered by the Council. Applications satisfying the above criteria may be admitted to membership.

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Journal of
VASCULAR SOCIETIES
GREAT BRITAIN & IRELAND

J.Vasc.Soc.G.B.Irel. 2023;2(2):61
http://doi.org/10.54522/jvsgbi.2023.066

www.jvsgbi.com

Editor's foreword

Welcome to this latest bumper edition of the *Journal of Vascular Societies Great Britain and Ireland (JVSGBI)*. It contains 11 brilliant articles and two excellent supplements!

The first article is an editorial outlining the extensive but perhaps underappreciated work undertaken by the excellent vascular CRG. This is followed by three original research articles addressing CLTI and frailty; a review of vascular Ehlers Danlos syndrome which includes a novel, in depth presentation of the patient's perspective; four research protocols and two interesting case reports.

We also present the prize-winning abstracts from the recent Annual Scientific Meetings of the VSGBI and its affiliated societies.

Finally we include two supplements - firstly the Scottish Physiotherapy Amputee Research Group (SPARG) guidelines regarding the management of intermittent claudication and secondly all the abstracts presented at the VSGBI ASM in Brighton in November 2022.

I would like to thank the journal reviewers and editorial board who continue to provide fantastic support for which I am really grateful. Please continue to submit your articles for consideration of publication.

Ian Chetter
Editor in Chief JVSGBI
VSGBI Research Committee Chair

Journal of
VASCULAR SOCIETIES
GREAT BRITAIN & IRELAND

J.Vasc.Soc.G.B.Irel. 2023;2(2):62-64
http://doi.org/10.54522/jvsgbi.2023.063

www.jvsgbi.com

EDITORIAL

The CRG for Vascular Services

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Received: 30th January 2023
Accepted: 21st February 2023
Online: 26th February 2023

The last decade has witnessed a number of changes in the delivery of vascular services nationwide. Vascular surgery attained speciality status in 2012, and is well recognised as an urgent and emergent speciality delivering time-dependent care for patients with aortic aneurysms, carotid surgery for stroke prevention and lower limb revascularisation for critical limb-threatening ischaemia. The National Vascular Registry (NVR), established in 2013, provides effective monitoring and reports on outcomes whilst also delivering a robust programme of quality improvement.[1] The National Abdominal Aortic Aneurysm Screening Programme was fully implemented in 2014,[2] and this coincided with a move towards centralisation of vascular services to a network model of care with elective and emergency arterial surgery concentrated in arterial hubs. In 2013, NHS England took full responsibility for all specialised commissioning which included all arterial surgery. Over the years, major vascular policy decisions make reference to the Vascular Clinical Reference Group (CRG), yet few clinicians are aware of who these groups are, who they are accountable to and how they are involved in organising, reconfiguring, delivering and monitoring of vascular services in England.

The Vascular Services CRG was first established in 2013 and currently sits in its fourth iteration as part of the Internal Medicine National Programme of Care (NPoC), one of six national programmes as part of Specialised Services commissioned by NHS England.[3] It is a 'lead and inform' CRG that covers the spectrum of arterial and deep venous interventions and aims to deliver the products of commissioning to contract services based on the Vascular Service Specification of NHS England.[4] The CRG advises Specialised Commissioning on achieving high quality care and aims to reduce health inequalities by championing the delivery of evidence-based, data-driven, patient-centred effective interventions and care pathways and promotes 'joined up' health services to avoid patients falling through gaps and reduces the risk of harm.[5]

The Vascular CRGs are appointed to a three-yearly term with a Chair, currently a vascular surgeon, and representatives from stakeholders that include clinicians from vascular surgery and interventional radiology, vascular nurses and allied specialties, a patient and public representative and a lead commissioner. The membership of the CRG, for the duration of the term, is aligned to a clear patient-focused work plan characterised by collaborative working, supporting patients, clinicians, vascular networks and commissioners.

During times of transformational change towards a hub-and-spoke networked model of care, the CRG helped with two reports. The first formed the basis of the service specification of the 'non-arterial' centres of vascular networks which outlined the models of patient services and care provided by 'spoke' hospitals based on the successful experience of vascular reconfiguration in Merseyside, Staffordshire and South Cheshire. This service specification was adopted in the Provision of Vascular Services (POVS) 2015 document from the Vascular Society for Great Britain and Ireland.[6] This was followed by the very well received 'Top Tips for reconfiguring vascular services', a multi-disciplinary document outlining the key lessons from well led reconfiguration that has been a singular reference to help difficult vascular reconfigurations and included in POVS 2018.[7]

The Vascular CRG has made contributions to

Key words: CRG, NHS England, Vascular Surgery

the monitoring of transformation and the performance of vascular networks working with the Vascular Society of Great Britain & Ireland (VSGBI) and the Vascular Getting it Right First Time (GIRFT) programme, building on the recommendations in the 2018 GIRFT Vascular report.[8]

This partnership between GIRFT and NHS England & Improvement led to the establishment of the Joint Programme Board (jointly chaired by the two parties) and the Action on Vascular Programme. The aims were to reach a consensus on the implementation of the Vascular GIRFT recommendations. It facilitated visits to networks where the process of reconfiguration was challenging. It worked closely with clinicians, managers and regional teams tackling difficult issues and sometimes uncompromising views in a mediatorial and supportive rather than a mandatory and dictatorial manner.

The Vascular CRG realised the importance of NHS England tariff and reimbursement to vascular providers, and has kept abreast with changes to the digital currency of the NHS with the Healthcare Resource Group (HRG) structure from payment by results (PBR) to block contracts and blended payments and produced an overview of the changes in national tariff and their relevance to vascular networks in 2017.[9]

From little acorns grow big oaks; this was brought home by a major collaborative effort between the CRG, the NVR, the NHS England and NHS Digital teams responsible for Hospital Episode Statistics (HES) coding and High Cost Tariff Excluded devices working group from NHS Supply chain which concluded the NHS England spend on vascular surgery alone was close to half a billion pounds per year when accurate coding and reconciliation of HES with NVR data allowed all arterial procedures to be included along with device costs such as endovascular stent grafts – a far cry from the original rather conservative and erroneous figure of circa £47 million per year. This put Vascular Surgery and Vascular Services firmly in focus when it came to NHS England's national commissioning strategies and future planning, maintaining visibility with a high profile.

During this decade we have also witnessed an endovascular revolution with the explosion of endovascular techniques, interventions and devices for an ever-increasing range of conditions. Some have proven revolutionary for patient care, however not all have fulfilled early promise; some have led to patient harm and have contributed to considerable soul searching. The NICE abdominal aortic aneurysm (AAA) draft guidelines, in particular the role of endovascular aneurysm repair,[10] led to considerable controversy in the vascular community. The measured and statesman-like response from the VSGBI in collaboration with the CRG considerably enhanced our standing as a vascular community nationally and abroad.[11]

There was further evidence of clear, sensible, compassionate and collaborative leadership by the CRG as the world had to deal with the consequences of the COVID-19 pandemic prompting a national lockdown in March 2020. The CRG worked tirelessly and closely with the VSGBI Executive, NHS England Specialised Commissioning, GIRFT and allied societies such as the British Society for Interventional Radiology to issue guidelines regarding elective and emergency vascular surgery to keep patients safe whilst ensuring continued management of the most urgent vascular patients.[12] As the pandemic ebbed and flowed between further waves, weekly meetings ensured ongoing real-time regional and national perspective of the effects of the pandemic on patients, their families, staff and hospital services nationwide with subsequent timely guidance to allow for safe resumption of services, and in time the less urgent vascular services.[13]

Following the resumption of elective activity, the NHS England Specialised Commissioning Action on Vascular Programme advised by the CRG has continued to review vascular networks with diligence to current staffing and rotas, numbers of procedures undertaken as recommended in VSGBI POVS 2021,[14] enquiring on timely delivery of services and reporting of patient outcomes, both on the NVR, in order to keep vascular patients and vascular services firmly in the limelight and on par with other time-critical conditions such as cancer and cardiac surgery as the NHS struggles to deal with the demand on resources and waiting lists.

The VSGBI and its Audit and Quality Improvement Committee has an established track record of quality improvement programmes (QIP) to benefit patients such as the AAA QIP.[15] The VSGBI launched the Peripheral Arterial Disease Quality Improvement Framework (PAD QIF) in 2019, updated in 2022 to improve the timelines to care of patients with critical limb-threatening ischaemia.[16] The Vascular CRG strongly supported the VSGBI's well written clear NHS England incentivised payment Commissioning for Quality and Improvement (CQUIN) scheme for 2022–2023, rewarding excellence and supporting provider units to put measures in place to improve the quality of care for these patients, the subject of a previous editorial in this journal.[17]

The CQUIN which has been renewed for 2022–2023[18] is part of a package of measures put in by the VSGBI and our members, surgeons and interventional radiologists from the British Society for Interventional Radiology, supported by the Vascular CRG and many others that will ensure eventual success of the PAD QIF programme.

Similarly, the Vascular CRG has worked in collaboration with the Cardiac Surgical CRG to produce the Aortic Dissection toolkit, an excellent example of collaborative working between multidisciplinary teams to produce guidance on regional delivery of safe services for patients with potentially lethal aortic dissections.[19]

The Vascular CRG is currently developing advice and guidance on paediatric vascular surgical services, an area of current multidisciplinary interest, and novel drug treatments for arteriovenous malformations. The Vascular CRG has also had a few less successful endeavours. The Specialised Services Quality Dashboards were stymied by the lack of data support from provider units and fell by the wayside during the COVID-19 pandemic. The Vascular CRG engineered a collaborative plan with two national

audits, the NVR and the National Diabetic Foot Audit, aiming for a single commissioning strategy for the delivery of effective diabetic foot services between Clinical Commissioning Group (CCG)-led services in the community and tertiary care provided by vascular services with integration into preventative foot care protection services and postoperative rehabilitation in the community – a dream yet to be realised.

Vascular surgery continues to thrive. There are several reasons for this. We have a successful and effective national screening programme. As a specialty we are clinically led with evidence-based fully audited practices, particularly in the UK. We have demonstrated accountability and governance with the NVR as an exemplar national registry that closes the audit loop. Our patients and services were hard hit during the pandemic and vascular surgery became a protected specialty. We have demonstrated moral, ethical and compassionate leadership and have been open, honest and transparent with our failures. The Vascular CRG has always prioritised patients' interests. The CRG's collaboration with NHS Supply chain and Procurement, the Outcome Registries and Patient Safety programme board, and partnership with the VSGBI and the NVR allows a critical review of data on new procedures and devices to ensure vascular patients come to no harm and vascular services provide value for money. As we move into the era of integrated commissioning, the Vascular CRG will work with Integrated Care Boards to prioritise multidisciplinary diabetic foot care amongst other initiatives supporting integrated care across the spectrum of vascular disease management in order to make a real difference to these patients.

Conflict of Interest: RDS and ADP are members of the National CRG for Vascular Surgery. ADP is chair of the Audit & Quality Improvement Committee VSGBI, Clinical Lead for the NVR, Chair of SSDP and Co-Chair of NCIP Vascular Surgery. RDS is Chair of the CRG, NHS England Specialty Advisor for Vascular Services and VSGBI representative on RCS England Council.

Funding: None.

Acknowledgments: We would like to acknowledge the contribution of the other clinicians and members of the CRG. We would like to thank Mrs Kathy Blacker, Specialised Commissioning NHS England, Lead Commissioner for the CRG and Mr Michael Wilson, Programme Director for Action on Vascular Specialised Commissioning NHS England.

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Journal of
VASCULAR SOCIETIES
GREAT BRITAIN & IRELAND

J.Vasc.Soc.G.B.Irel. 2023;2(2):65-68
http://doi.org/10.54522/jvsgbi.2023.057

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ORIGINAL RESEARCH

Management of lower limb ischaemia using hybrid techniques: a single-centre experience

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Received: 22nd August 2022
Accepted: 18th October 2022
Online: 24th January 2023

Plain English Summary

Why we undertook the work: To provide outcomes of Hybrid procedures in a single vascular centre.

What we did: We undertook a retrospective review of the outcomes of patients undergoing hybrid procedures for lower limb ischaemia. This involves procedures combining traditional open surgery, in combination with an endovascular procedure.

What we found: Our results showed an acceptable rate of vessel patency and symptom resolution, and an acceptable rate of surgical complications.

What this means: The results of this study support the use of hybrid procedures in managing multilevel arterial disease causing lower limb ischaemia.

Abstract

Introduction: Modern vascular surgery combines procedures with both open and endovascular techniques, with these hybrid procedures becoming part of routine arterial surgery. Hybrid procedures have been established in this centre with access to a hybrid suite since 2014. The aim of this study was to characterise patients undergoing hybrid procedures including an open groin dissection plus an endovascular component.

Methods: A retrospective review of operation notes, electronic health records and radiology software for patients undergoing hybrid revascularisation for critical limb threatening ischaemia (CLTI) or intermittent claudication (IC) between January 2017 and December 2021 was performed. Any open groin surgical procedure including common femoral endarterectomy and/or lower limb bypass plus any endovascular procedure were recorded. Primary outcomes were recorded as stent patency, a composite of tissue healing or symptom resolution, and wound complications including surgical site infections. Secondary outcomes were length of stay, rate of readmission and mortality at 30 days.

Results: A total of 98 patients (77 men) of median age 73 years (IQR 68–78) underwent a hybrid procedure during this period. Treatment was for CLTI in 66% of the patients and for IC in 34%. The median length of stay was 5 days. Overall graft and stent patency was 85%. The overall rate of tissue healing and symptom resolution was 92%. The surgical site infection rate was 14% (14/98) and mortality at 30 days was 2%.

Conclusion: Hybrid revascularisation is safe and effective in treating CLTI and IC with an acceptable risk of surgical site infections. Our short-term results suggest that hybrid revascularisation should be considered in patients with multilevel disease.

Key words: hybrid vascular procedures, stent patency, surgical site infection

Introduction

Peripheral arterial disease (PAD) is recognised as an increasing global healthcare issue.[1] Chronic limb-threatening ischaemia (CLTI) resulting from PAD is the term adopted in the 2019 Global Vascular Guidelines. It is defined as 'a broader and more heterogeneous group of patients with varying degrees of ischemia that may delay wound healing and increase amputation risk'.[2] CLTI has been identified as the leading cause of limb loss and a significant cause of premature mortality worldwide.[3] Surgeons treating vascular

disease must be skilled in both open and endovascular techniques, with hybrid surgery becoming a routine part of arterial surgery to treat CLTI.[4] These strategies can be used to treat multiple levels of disease and have been shown to be feasible in patients with complex disease in whom less invasive procedures are beneficial.[5–7] Access for these procedures is commonly gained at the femoral vessels in the groin. This is a common site for surgical site infection (SSI), which is associated with preventable morbidity and mortality as well as increased healthcare cost.[8]

Gloucestershire Hospitals NHS Foundation Trust provides Vascular Surgery services as an arterial hub for the regional Vascular network. Access to a hybrid suite in this centre was established in 2014. This has permitted the burgeoning development of hybrid revascularisation strategies to treat multilevel arterial disease. The patient population undergoing these procedures and the outcomes of this practice have not yet been described.

The aim of this retrospective cohort study was to characterise the population of patients undergoing hybrid procedures including an open groin dissection for common femoral endarterectomy plus an endovascular component; to describe the therapeutic effect; to describe the stent patency rate; to describe the rate of SSI; and to describe mortality rates.

Methods

A retrospective review of consecutive patients undergoing hybrid revascularisation of the lower limbs for either CLTI or disabling short distance intermittent claudication (IC) at our centre between January 2017 and December 2021 was performed. Data were collected by case notes review, electronic health records and radiology software on patient demographics, procedure performed, operative procedure time, length of stay, clinical outcomes, groin complications and mortality at 30 days.

Operative procedures performed

Open groin surgical procedure included common femoral endarterectomy and/or lower limb bypass. This was performed in conjunction with an endovascular procedure including either an iliac or femoropopliteal angioplasty and/or stent or both inflow and runoff procedures.

Follow-up and outcomes

Patients are usually followed up 6 weeks after discharge from the hospital. All patients undergoing a stent and/or a bypass procedure have a 6-week stent and/or graft surveillance duplex scan as a routine in out Trust. Further surveillance is organised based on the individual case. Primary outcomes were recorded as stent patency at follow-up, a composite of tissue healing or symptom resolution, and wound infection or complication. Secondary outcomes were length of stay, rate of readmission and mortality at 30 days.

Statistical analysis

Descriptive analysis was performed using Microsoft Excel (Microsoft, USA). Median + interquartile range (IQR) was used for continuous data (length of stay in days, procedure time in minutes, follow-up time in weeks). Percentage (%) was used for continuous data (index pathology, procedure performed, outcomes and complications).

Results

A total of 98 patients underwent a hybrid procedure during the study period, of which 79% were male (n=77) with a median age of 73 years (IQR 68–78). Treatment was indicated for CLTI in 66% (n=65) and short distance IC in 34% (n=33) of cases. These demographics are shown in Table 1.

Table 1 Demographics of patients undergoing hybrid lower limb revascularisation procedures.

Age, median (IQR)	73 (68–78)
Gender, n (%)	
Male	77 (79%)
Female	21 (21%)
Indication for treatment, n (%)	
Critical limb-threatening ischaemia (CLTI)	65 (66%)
Short distance intermittent claudication (IC)	33 (34%)

Operative procedures

The most commonly performed groin procedure was common femoral endarterectomy (n= 79; 81%). Femoral–femoral crossover was performed in 7% (n=7) and lower limb bypass was performed in 7% (n=7). Femoral exposure for other reasons was recorded in 5% (n=5). These data are shown in Figure 1.

Endovascular procedures

The most commonly performed endovascular procedure was iliac angioplasty/stent (83%, n=81). Run-off vessel angioplasty/stent was performed in 13% (n=13), combined inflow and run-off angioplasty/stent were performed in 3% (n=3) and angioplasty to proximal anastomosis of aortobifemoral graft in 1% (n=1). These data are shown in Figure 2.

Primary outcomes

The median operative procedural time was 300 min (IQR 254–352). The median time to first outpatient follow-up was 7 weeks (IQR 5–9), at which point stent/vessel patency was present in 85% of patients (n=83). Tissue healing or symptom resolution was documented in 92% of patients (n=90). Wound infection was reported in 14% (n=14), seroma in 6% (n=6), haematoma in 2% (n=2) and pseudoaneurysm was reported in 1% (n=1). Seromas were managed conservatively and resolved on further follow-up. The patient with pseudoaneurysm was also managed conservatively with follow-up scans and it eventually occluded without intervention. All patients with documented wound infection (n=14) required antibiotic treatment and in 11 patients no further

Figure 1 Open surgical groin components performed as part of hybrid lower limb revascularisation procedures. CFEA, common femoral endarterectomy; FFXO, femoral–femoral crossover.

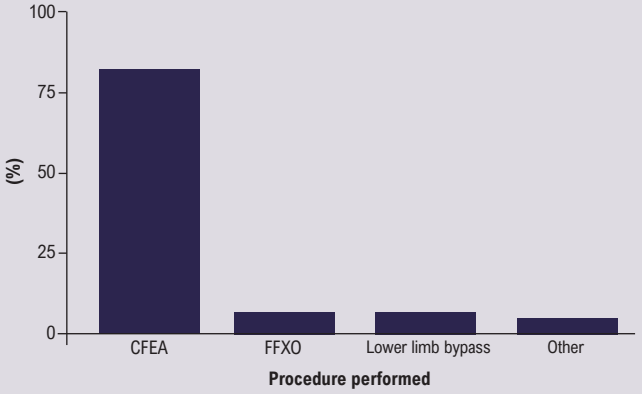
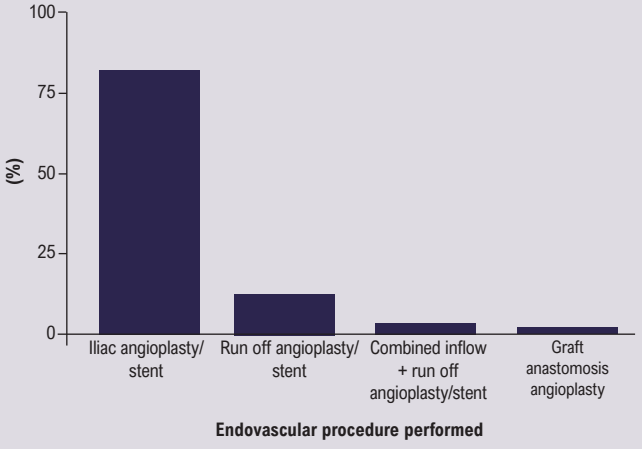


Figure 2 Endovascular components performed as part of hybrid lower limb revascularisation procedures.



intervention was required. In the remaining three patients, one required negative pressure dressing therapy for dehiscence, one required wound washout and one required removal of an infected graft and subsequent above-knee amputation. Both patients with haematomas required washout and a sartorius flap.

Secondary outcomes

Median length of stay was 5 days (IQR 3–9). The rate of unplanned readmission for wound-related complications was 13% (n=12). Mortality at 30 days was 2% (n=2); these deaths were from unrelated causes. These data are shown in Table 2.

Discussion

PAD resulting in CLTI and short distance IC is prevalent in both elective and emergency vascular practice. It has a significant cost to patients in terms of quality of life, to healthcare systems and society.[9] It is multifactorial, and by the time of presentation in increasingly comorbid patients its treatment may often be complex. Hybrid strategies to treat complex multilevel arterial disease are becoming more common and have been shown to be beneficial in high-risk patients.[7] As such, the modern vascular surgeon is trained in the UK in both open surgical and endovascular techniques. These procedures often require open surgical access to the femoral vessels and are multistep, often requiring a multitude of equipment, resulting in a longer surgical time. The outcomes of hybrid procedures performed in this unit have not previously been described.

Table 2 Outcomes of patients undergoing hybrid lower limb revascularisation procedures.

Operative time (min), median (IQR)	300 (254–352)
Stent/vessel patency, n (%)	83 (85%)
Time to follow-up (weeks), median (IQR)	7 (5–9)
Tissue healing or symptom relief, n (%)	90 (92%)
Wound complications, n (%)	
Wound infection	14 (14%)
Seroma	6 (6%)
Haematoma	2 (2%)
Pseudoaneurysm	1 (1%)
Length of stay (days), median (IQR)	5 (3–9)
Unplanned readmission, n (%)	12 (13%)
Mortality, n (%)	
30-day	2 (2%)

Based on the results of this single-centre retrospective cohort study, it appears that hybrid revascularisation in selected groups of patients with CLTI and IC is both safe and feasible. Vessel/stent patency was seen in the majority of patients at first outpatient follow-up. This correlated in favourable rates of tissue healing and symptom resolution, seen in 92% of patients. Although the procedure time was relatively long, length of stay was as expected at a median of 5 days with a low 30-day mortality in this high-risk group of patients undergoing complex procedures.

The implementation and continued use of hybrid strategies in this single UK centre is similar to that published internationally, with data from the Vascular Quality Initiative (USA) reporting up to one-third of lower extremity revascularisations being performed with a hybrid strategy.[6] Its use has been shown to have favourable perioperative outcomes and should be considered in high-risk patients.[6] Another large study examining perioperative outcomes in patients undergoing bypass surgery and hybrid procedures found higher rates of systemic complications, infection, postoperative transfusion and readmission in patients undergoing bypass procedures compared with hybrid procedures for femoropopliteal disease.[10] A smaller study examining hybrid strategies for aorto-iliac segment disease reported shorter operative times, less blood loss

and better surgical morbidity, with favourable primary patency rates at follow-up.[11] The results of our study corroborate these findings and support the use of hybrid strategies as feasible and effective.

Surgical site infection was seen in 14% of the patients in this study. This is comparable to the recently published GIVE study, which is a multicentre study examining groin wound infections following femoral exposure for any non-infective cause.[8] The authors reported a rate of surgical site infection of 8.6% in all patients. However, when looking specifically at procedures with 'groin access (±groin intervention) for endovascular aorto-iliac/infra-inguinal occlusive disease', the rate of surgical site infection was 12.1%. This is comparable, albeit lower, than the 14% rate of wound infection in our cohort. The development of surgical site infection in the GIVE study was reported to be frequent and carries significant sequelae. They recognised increased surgical time as a risk factor for developing surgical site infection. The group developing surgical site infection had a median operating time of 3.3 hours (198 min), which was significantly longer than the SSI group without surgical site infection (p=0.02). It is reasonable to suggest that hybrid strategies encounter more steps and can require more operative time. Our median operating time for hybrid procedures of 300 min is certainly in excess of the GIVE study and could be a contributing factor to the higher infection rate in our cohort. This increase in operative time is a result of combining two complex procedures together (open and endovascular), delaying the final completion.

All measures and efforts should be taken to reduce operative time and the risk of developing surgical site infection as far as possible. One possible strategy to reduce operative time would be to stage various levels of treatment, with an endovascular component happening separately from an open surgical procedure. Whilst this uncoupling of the hybrid procedure would reduce individual procedure time, it increases the number of intervention events and their associated risk for the patient, and has logistic and clinical service capacity implications. Furthermore, if a staged strategy were used to treat multilevel disease, there is a potential delay in achieving adequate treatment and clinical outcomes, with potential increased risk of limb loss. Therefore, we would advocate that, rather than stage treatment, modern practice should aim to optimise efficiency and theatre governance to reduce the time taken to complete hybrid procedures, ideally within a bespoke hybrid suite.

We acknowledge the methodological limitations of this study as a retrospective review, the small sample size and that cases may have been missed. Similarly, the outcome period studied was short and we cannot comment on longer term graft/stent patency or mortality. However, we have examined a common pathology seen in UK Vascular surgery practice, making our findings generalisable. Corollary work should include prospective evaluation and include more long-term follow-up, data regarding limb salvage and amputation rate, and could take the form of a registry-based collaborative study.

KEY MESSAGES

- Complex multilevel vascular disease can be safely and effectively managed with hybrid procedures.
- Comparable outcomes with stent patency and symptom resolution.
- Comparable SSIs.

Conclusion

This study aimed to describe a cohort of patients undergoing hybrid lower limb revascularisation for CLTI and short distance IC, and to examine the outcomes following these strategies. The results show that patients with complex multilevel arterial disease can be safely and effectively managed using these strategies, with an acceptable rate of complications.

Conflict of Interest: None.

Funding: None.

Reviewer acknowledgement: *JVSGBI* thanks Tristan Lane, Cambridge University Hospitals NHS Foundation Trust and Eddie Caldow, University of Salford, for their contribution to the peer review of this work.

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Journal of
VASCULAR SOCIETIES
GREAT BRITAIN & IRELAND

J.Vasc.Soc.G.B.Irel. 2023;2(2):69-75
http://doi.org/10.54522/jvsgbi.2023.055

www.jvsgbi.com

ORIGINAL RESEARCH

Frailty Assessment in UK Vascular Centres (FAVE): a survey to investigate data collection methods and impact on clinical practice

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Received: 5th September 2022
Accepted: 12th October 2022
Online: 9th January 2023

Plain English Summary

Why we undertook the work: Frailty is an important clinical syndrome. Frailty describes people who are more likely to have problems after a major health event, for example, an operation. The chance of being frail increases with age. Over 75% of people with circulation problems are over 65 years old. This means they have a higher chance of being frail and having problems after an operation. A patient's level of frailty can guide vascular surgeons in planning care before, during and after an operation to reduce the risk of problems. Frailty can also be used to help discussions with patients about the risks of having certain operations. In 2019 the National Vascular Registry (NVR), an anonymous database of vascular operations, started to include the patient's level of frailty on all operations entered onto their database. However, assessing frailty is only just becoming part of routine care in vascular surgery. To find out whether frailty is being measured in people with circulation problems, we conducted a survey of UK vascular surgeons.

What we did: We distributed an online questionnaire to vascular surgeons in the UK. The survey was advertised to vascular surgeons through Twitter and Vascular and Endovascular Research Network (VERN) and the Vascular Society of Great Britain and Ireland (VSGBI) email mailing lists and newsletters. The questionnaire was split into three parts. The first part asked where the surgeon was based. This was to ensure we gathered results from all over the UK. The second part asked questions about how frailty was assessed, which patients were assessed for frailty and how the surgeon used these assessments to guide patient care. The third part asked surgeons about their opinion about frailty. The survey ran from March 2022 to May 2022.

What we found: 48 surgeons who were based in 31 UK vascular centres completed the survey. Over half of the centres who responded assessed patients for frailty (61%, 19/31). Most centres use a scoring system to decide if someone is frail (68%; 13/19). The other centres use clinical judgement. The Clinical Frailty Scale was the most frequently used scoring system (77%; 10/13). Vascular surgeons perform frailty assessments in 47% (9/19) of centres and most assessments take place on the ward (68%;13/19). People are re-assessed for frailty following optimisation or an operation in 21% (4/19) of centres. The patient's level of frailty was used to guide their care in 63% (12/19) of vascular centres. In the vascular centres that did not assess frailty more than half plan to start in the future (58%; 7/12). Vascular surgeons do not assess frailty because they are unfamiliar with the best way to do it and because they did not think the current ways of assessing frailty are applicable to some people with circulation problems.

What this means: There is a lot of variation in how patients with circulation problems are assessed for frailty in the UK. The top reasons vascular surgeons did not assess frailty are uncertainty in the best way to measure frailty and applicability of current frailty scoring systems for patients with circulation problems. Future research should address these reasons.

Abstract

Background: Frailty is an important clinical syndrome that is associated with adverse postoperative outcomes. The assessment of frailty provides an opportunity to enhance patient care. The National Vascular Registry (NVR) introduced frailty categories on all vascular procedure proformas in 2019. The aim of this survey was to capture the current practice of frailty assessment in vascular centres in the UK.

Methods: A nationwide survey was carried out of all UK vascular centres who enter procedural data onto the NVR database. The Qualtrics online survey tool was used to distribute the survey through mailing lists and social media. The survey captured data on location of centres who responded, how frailty data are collected and vascular surgeons' opinions of frailty assessments. The survey was live from 29 March 2022 to 29 May 2022.

Results: The survey received responses from 48 UK vascular surgeons based in 31 UK vascular centres. Frailty assessment was undertaken in 61% (19/31) of centres that responded, of which 68% (13/19) used a frailty assessment tool. The Clinical Frailty Scale was the most frequently used tool (77%; 10/13). Vascular consultants personally perform frailty assessments in 47% (9/19) of centres and most assessments take place in the ward setting (68%; 13/19). Frailty was re-evaluated in 21% (4/19) of centres. Frailty status influenced clinical practice in 63% (12/19) of vascular centres. 58% (7/12) of responders plan to assess frailty in the future. Clinician-perceived barriers to assessing frailty was unfamiliarly with the tools and concerns over validity.

Conclusion: There is variation in how frailty is measured in UK vascular centres. Uncertainty and concerns over validation of tools are perceived barriers to assessing frailty. Further research should target validation of frailty tools and their role in guiding patient care in vascular surgery.

Key words: frailty, vascular surgery, risk assessment

Introduction

The importance of frailty as a clinical syndrome is gaining momentum in surgical specialties. Frailty is defined as 'a state of vulnerability to a stressor event, triggering disproportionate changes in health status'.[1] Increasing age may lead to the clinical condition of frailty.[1] In the UK, three quarters of patients presenting with vascular disease are over 65 years old, putting them at an increasing risk of being frail.[2] Frailty has already been identified as a risk factor for morbidity and mortality at 30 days and one year post surgery in patients undergoing vascular procedures.[3] Identifying preoperative frailty provides an opportunity for surgeons to work in multidisciplinary teams to optimise a patient's preoperative state, plan admission to higher dependency units and organise appropriate rehabilitation.

There is no consensus on the gold standard tool for capturing frailty status in vascular patients. The National Vascular Registry (NVR) included frailty on all vascular surgical proformas from 2019 to help explore the influence of frailty on clinical outcomes.[4,5] In order to accommodate centres using different tools, the NVR created frailty categories to enable centres to map their frailty score to the NVR categories if they were using either the Clinical Frailty Scale (CFS), Edmonton Frail Scale or the Electronic Frailty Index.[4] Currently, other validated tools used for screening for frailty are not easily – or not at all – transferable to the NVR categories.

This survey aims to evaluate whether frailty assessments are being undertaken, how the frailty data are collected, and how frailty assessments inform clinical care in vascular centres in the UK.

Methods

This survey is reported with reference to the Checklist for Reporting of Survey Studies (CROSS).[6]

Design

A nationwide cross-sectional survey of frailty assessments was conducted in vascular centres in the UK. The survey was designed by a vascular speciality trainee and a research fellow with a PhD in frailty in vascular surgery. The survey was internally piloted in four vascular consultant surgeons, in line with the target population, until no further changes were necessary. The survey was then revised based on consensus opinion before being re-piloted. Major changes included removing details about the centre activity (as this is available through the annual NVR reports). Minor changes included removing questions on mechanisms of undertaking frailty assessments, such as length of time taken to perform an assessment and where the outcome was reported, as this was felt to be irrelevant. The survey was then shared with the Vascular and Endovascular Research Network (VERN) Executive Committee, which includes six consultant vascular surgeons, who externally piloted the survey. The survey was then amended based on consensus opinion until no further changes were necessary before distribution.

Eligibility

The survey was aimed at vascular consultant surgeons based in UK vascular centres. A UK vascular centre was defined as an NHS Trust who provides arterial services and submits data to the NVR. This includes the 101 NHS Trusts.[7]

Outcomes

The primary outcome of this survey was to establish how clinicians in UK vascular centres assess frailty in patients presenting to vascular services. The outcome measures were: name of the frailty assessment tool, type of patient screened for frailty, timing of frailty assessment and healthcare professional assessing for frailty. Secondary outcomes were: coverage of UK and Irish vascular centres in the survey, judged by response rate and geographical location of responders, impact of frailty assessment and clinician opinions of frailty assessment in vascular patients.

Data collection

The Qualtrics online survey tool (London, UK) was used to collect data. The survey was split into three sections. The first part captured the geographical spread of respondents to ensure the

sample was representative of UK vascular centres. The second part explored frailty assessment. The third part investigated clinicians' perceptions around frailty assessment. The survey items are included in Appendix 1 (online at www.jvsgbi.com). Multiple choices responses were permitted for questions Q7, Q8, Q10, Q12, Q17, Q22, Q29 and Q34. Results of these questions are presented as the total number of responders who selected each option in the question. The remaining questions were single response answers.

The survey was distributed in collaboration with the VERN and Vascular Society of Great Britain and Ireland via social media platforms and mailing lists. Convenience sampling was used to identify respondents. Responses from clinicians outside the UK were excluded from the analysis. The survey was re-distributed every month via Twitter and newsletters and collected responses between 29 March 2022 and 29 May 2022. Only responses during this window were included in the analysis, and after a lockout was enabled, preventing further responses. The QualtricsXM 'prevent multiple responders' function was used to prevent multiple participation of participants.

Analysis of data

Only responders who had completed the survey were included in the analysis. Data submitted by responders from the same centre were checked for similarity before being entered into Microsoft Excel (Excel for Microsoft 365, Microsoft Corporation, Washington, USA). Descriptive statistics, including counts and frequencies, are reported where appropriate. Free-text responses of clinicians' opinions were collated and described. Figure 1 was created using MapChart (https://www.mapchart.net/).[8]

Ethics and governance

The study did not require ethical approval as it was a survey of healthcare professionals and did not involve patients. Consent was indicated by completion of the survey. Responders could decide whether to provide their name and the centre at which they worked. Any identifiable responder information collected was kept confidential and destroyed at the end of the survey.

Results

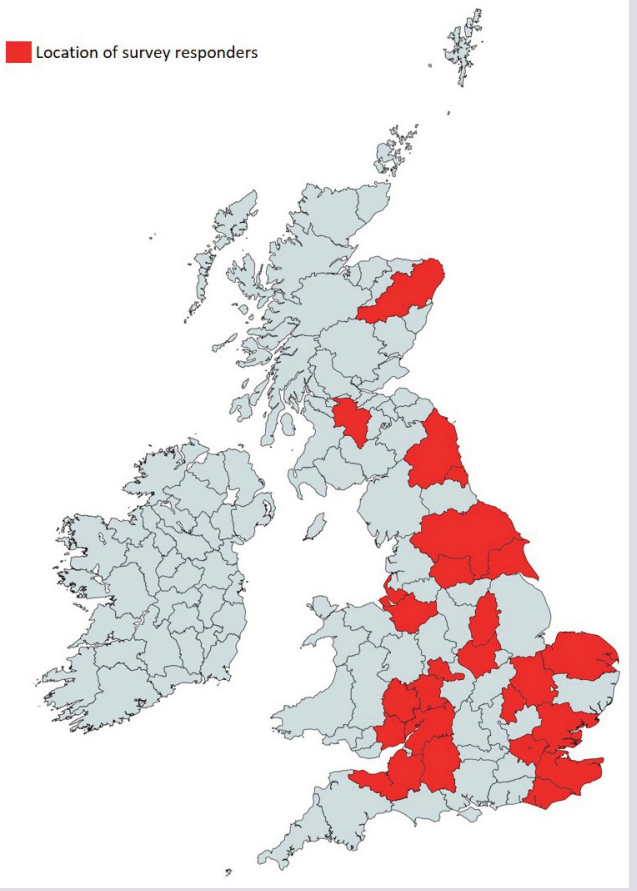
Reach

The survey received responses from 31 (31%) vascular centres in the UK (Figure 1). Forty-eight consultant vascular surgeons completed the survey fully. There were responses from 28 centres in England, two centres in Wales and one centre in Scotland.

Frailty assessment

Frailty was assessed in 61% (19/31) of centres that responded. Nine units use a frailty assessment tool alone (47%; 9/19), four units rely on clinical judgement (21%; 4/19) and a further four use a combination of both (21%; 4/19). Two centres did not give details on how frailty was assessed. Responders from the same centre agreed on how frailty assessments were undertaken.

Figure 1 Location of survey responders.

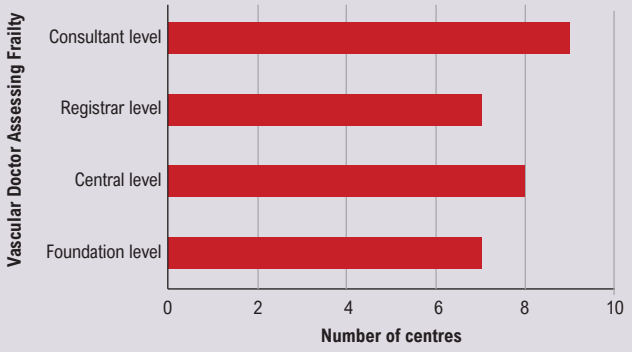


In the centres using a frailty assessment tool, the CFS was the most frequently used (77%; 10/13). Other tools included the Electronic Frailty Index and the Comprehensive Geriatric Assessment Toolkit. Clinical judgement of frailty, not using a frailty assessment tool, was undertaken by either a vascular medical physician, vascular perioperative physician, anaesthetist or care of the elderly physician.

Common reasons cited for selecting a frailty assessment tool were ease and speed of use (32%; 6/19), validated tool (37%; 7/19), fit to the local population (21%; 4/19), fulfilling NVR criteria (21%; 4/19) and prior experience using the tool (21%; 4/19). Other reasons included current use of the tool for research purposes at the NHS Trust, local NHS Trust policy, integration in electronic record systems, 'national guidance' and inclusion in other specialty clerking booklets.

Healthcare professionals completing the frailty assessment tool were mostly consultant vascular surgeons (47%; 9/19), followed by vascular junior doctors (42%; 8/19), consultant vascular physicians (21%; 4/19), vascular specialist nurses (11%; 2/19) and physician associates (16%; 3/19). Other healthcare professionals were research nurses, advanced nurse practitioners, physiotherapists and occupational therapists. The seniority of the vascular junior

Figure 2 Level of doctor performing frailty assessments in UK vascular centres.



doctor assessing frailty is shown in Figure 2. One-fifth of centres provide training for frailty assessment (21%; 4/19).

The location of frailty assessments included vascular outpatient clinics including pre-assessment clinics (74%; 14/19), hospital wards (68%; 13/19) and the emergency department (32%; 6/19).

One-fifth of responders reported frailty status was re-evaluated (21%; 4/19). This was undertaken prior to any operative intervention (25%; 1/4), after the patient's clinical status was deemed to have changed (50%; 2/4) and after optimisation interventions (25%; 1/4).

Frailty status influenced clinical practice in most vascular units that assessed patient frailty state (63%; 12/19). Patient care was adapted according to frailty status in multiple ways. The most common ways were through prehabilitation planning (67%; 8/12), involving other specialists (67%; 8/12), earlier initiation of physiotherapy (58%; 7/12), rehabilitation (58%; 7/12), admission planning (25%; 3/12) and follow-up planning (42%; 5/12). Five centres used the degree of frailty to guide decisions to offer invasive interventions (42%; 5/12).

Patients screened for frailty

Thirty percent of responders screen all patients admitted to a vascular ward for frailty (32%; 6/19), 21% screen patients over 65 years old under the care of vascular services (4/19) and 21% screen all patients under the care of the vascular service (inpatients and outpatient) (4/19). Three (15%) centres screen all patients prior to aortic interventions. Other responders reported an ad hoc approach where patients are assessed depending on clinician judgement, depending on (poor) results from cardiopulmonary exercise testing and all patients presenting with chronic limb-threatening ischaemia.

Centres that do not assess frailty

Reasons responders cited for not assessing frailty at their vascular unit (38%; 12/31) included frailty assessments not being part of routine clinical practice (83%; 10/12), unfamiliarity with assessing for frailty (42%; 5/12), frailty status not impacting clinical management (8%; 1/12) and lack of evidence on the impact of frailty status on clinical management and outcomes (8%; 1/12).

In centres that did not assess frailty, two-thirds (67%; 8/12) reported that they planned to assess frailty in the future. The CFS (38%; 3/8) and the NVR categories (38%; 3/8) were the commonest choices. The Fried Frailty Phenotype Criteria (12%; 1/8) was proposed to be used by one centre and the other centre was undecided (12%; 1/8).

Reasons for the choice of tool were ease and speed of use (50%; 4/8), tool validation (50%; 4/8), fulfilling NVR criteria (50%; 4/8) and prior experience using the frailty tool (38%; 3/8).

Clinician opinions of frailty assessments

Clinician-reported barriers to carrying out frailty assessments in routine practice were uncertainty in how to assess frailty (53%; 8/15), concerns over validity of frailty tools in vascular patients (27%; 4/15), need for research into the benefit of assessing for frailty (13%; 2/15), requirement for input from care of the elderly specialists (7%; 1/15) and no perceived benefit of frailty assessment over end-of-the-bed review (7%; 1/15).

Themes arising in the free-text responses included the view that frailty assessment had a positive impact on patient care. Clinicians reported frailty assessments result in additional support by both the care of the elderly ward and the perioperative care for older people undergoing surgery (POPS) teams, who specifically tailor the care of older patients (but not necessarily frailer) to support any additional needs.

However, other responders felt assessing frailty is a 'tick-box' exercise and has little clinical value over end-of-the-bed assessment. Others felt the application of current tools are not appropriate in certain patient groups – for example, those with chronic limb-threatening ischaemia. Some clinicians felt frailty assessments should be undertaken by care of the elderly specialists as surgeons are 'incentivised' to operate, whereas care of the elderly clinicians are able to optimise patients based on findings from frailty assessments. "Knowing the degree of frailty alone is of no benefit", noted another respondent.

Some responders felt assessment of frailty in vascular patients could have an important role in patient care, but that further research was required to guide the use of frailty status in decisions around offering high-risk surgical interventions.

Discussion

This survey found frailty is assessed in over half of the centres that responded, with a further quarter planning to introduce frailty assessments, signifying a growing role of frailty assessment in vascular practice. However, uncertainty in undertaking frailty assessment, along with queries about validation of existing tools in vascular patients and variable input from care of the elderly specialists, has resulted in some vascular surgeons questioning the value of frailty assessments until future research is available.

There are currently a plethora of tools that measure frailty, which can be considered in two main types – the cumulative deficit[9] and the phenotype frailty models.[10] A cumulative model quantifies frailty through an increasing number of co-morbidities, whereas a phenotype model describes frailty as a group of characteristics. There is some overlap between these models[11] – for example, functional decline as measured in the deficit-driven model will encompass cumulative factors identified in the phenotype model such as physical activity, muscle strength and walking speed.

A range of frailty assessment tools has been used to predict the risk of adverse outcomes in patients undergoing vascular procedures.[12] Studies of patients undergoing vascular procedures report the Hospital Frailty Risk Score, FRAIL (Fatigue, Resistance, Aerobic capacity, Illness and Loss of weight) screening tool, Groningen Frail Indicator, Addenbrookes Vascular Frailty Score, modified Frailty Index and Risk Analysis Index can all predict 30-day mortality, postoperative complications and requirement for a higher level of care on discharge.[13–20] Critics of these tools argue that they describe cumulating co-morbidities rather than detecting the phenotypical characteristics of frailty, and therefore contest their validity as tools to identify frailty. In addition, these studies often exclude patients who did not undergo an intervention which introduces selection bias and limits generalisability. The responders of this survey felt a major role of frailty assessment tools is to predict the risk of surgical morbidity and mortality. While frailty may be associated with increased surgical risk, the relationship is complex and the ultimate aim of frailty assessment tools is to reliably diagnose frailty and improve care. The NVR has stated that the CFS, Edmonton Frail Scale and Electronic Frailty Index can all map onto the four categories of frailty recorded in the NVR[4] but, again, validation of these scales to diagnose frailty in vascular patients is still awaited.[9,21–23]

In this survey, some surgeons reported that the assessment of frailty results in reduced postoperative complications in their vascular centre. This finding is likely confounded by those who have a positive experience also having resources to optimise individuals identified as frail. Nonetheless, similar findings are reported in the literature; collaboration between the vascular team and specialist perioperative care of the elderly team results in fewer complications, shorter length of stay and fewer 30-day readmissions.[24] This likely drives the reported cost effectiveness of assessing frailty.[25,26] These findings should be considered by vascular centres when allocating resources.

Another application of frailty assessment is to inform decision making around 'high-risk' interventions. This area is more contentious, as risk is subjective and comprised of many components, of which patient related risk is only one aspect.[27] Frailty screening must not increase harm to older frail persons by denying a patient a surgical intervention based on the score alone. The British Geriatrics Society (BSG) and Centre for Perioperative Care (CPOC) provide extensive guidance on how frailty assessment can complement care throughout the surgical pathway to complement shared decision making, rather than dictate it.[28,29]

Time, ease of use and prior experience were all listed reasons why units chose to adopt certain frailty tools. A combination of patient-reported outcomes and surgeon-performed frailty assessment using the CFS could provide a reliable and efficient method of assessing frailty in the outpatient clinic setting.[30,31] Some vascular surgeons in this survey felt they performed just as well as frailty assessment tools; while the end-of-the-bed assessments could be a useful screening tool to trigger a more in-depth frailty assessment, further validation work is needed.[32]

The CFS was the preferred frailty assessment tool in this survey. It is a user-friendly tool that describes the sequential degrees of frailty in text and pictorial form. The BSG/CPOC guidelines recommend using the CFS to assess frailty in all those over 65 years old and those under 65 years old at risk of frailty prior to surgery.[29] While the CFS is a validated, easy to use and recommended tool to use in patients prior to surgery, there are concerns about its applicability in certain vascular patient groups. For example, those with claudication and progressive limb ischaemia due to peripheral arterial disease report similar symptoms to those described in the CFS of limited walking ability and being 'slowed up'. The differentiation between declining function due to frailty versus symptoms of lower limb ischaemia is difficult to untangle and may affect the validity of the CFS in these patients. Curiously, few centres reported using the Electronic Frailty Index, despite it being a validated tool recommended by NHS England to GPs to assess those over 65 years old for frailty that is often included on the patient's GP record,[33] that can also be mapped on the NVR's frailty categories.

The major limitation of this survey was engagement. The survey gained responses from vascular centres spread throughout the England; however, engagement from the devolved nations was limited, with only two responses from Wales, one response from Scotland and no responses from Northern Ireland. While the survey does give an indication of the current state of frailty assessments in England, it cannot reliably report on practice in Scotland, Wales or Northern Ireland. The survey is also subject to selection bias, where those in support of frailty assessments are more likely to have completed the survey compared with those who do not assess frailty and those more sceptical of frailty assessments. This could have skewed the results and potentially mean most vascular units in the UK actually do not routinely assess for frailty. Other implications of the low response rate include those surgeons who did respond could not represent the practice of that unit and skew the reported methods on how frailty is assessed and the impact it has on patient care. Other limitations include the views surgeons have on frailty in vascular surgery may not be represented by the 48 surgeons who provided responses. Nonetheless, the results of this survey support the NVR Annual Report 2021, which reported that an insufficient amount of frailty data is submitted, potentially due to frailty assessment not being undertaken, which prevents exploration of the relationship between frailty and mortality.[5]

KEY MESSAGES

- Frailty in vascular patients is often assessed using a frailty assessment tool and the Clinical Frailty Scale is the most frequently used.
- Two-thirds of vascular surgeons reported frailty status influenced their clinical practice.
- Surgeon-reported barriers to assessing frailty include unfamiliarity with the frailty assessment tools and concerns over the validity of frailty assessment tools in vascular patients.

Conclusion

This survey has demonstrated the variation in frailty assessment in vascular centres in England and Wales, although generalisability of the results are limited by lack of engagement. The preferred method to assess frailty is with a tool such as the CFS. Vascular surgeons believe frailty assessment could play an important role in shared decision making, especially in high-risk cases. However, barriers to implementation of frailty assessment include concerns of validity of frailty assessment methods in vascular patients, uncertainty in how to perform frailty assessments by vascular surgeons and insufficient resources to optimise the care of those identified as frail. Ongoing studies should target validation of the frailty tools recommended by the NVR to guide the role of frailty assessments in vascular surgery.

Conflict of Interest: None.

Funding: This work is supported by the Bayer Prize awarded at the Vascular and Endovascular Research Network (VERN) Dragon's Den at the Annual Vascular Societies Scientific Meeting 2019. Bayer have not been involved in the concept, research questions, survey design, data analysis or interpretation, the drafting of the manuscript or decision to publish.

Acknowledgements: Academic Vascular Surgical team Claire Acey, Bankole Akomolafe, Lynne Andrews, Anna Firth, Josie Hatfield, Caroline Jennison, Brian Johnson, Rakesh Kapur, Judith Long, Robert Lonsdale, Anthony Mekako, Louise McLean, Paul Renwick and Tracey Roe and Junaid Sultan.

Reviewer acknowledgement: *JVSGBI* thanks Andrew Nickinson, University Hospitals of Southampton NHS Foundation Trust, for the contribution to the peer review of this work.

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Journal of
VASCULAR SOCIETIES
GREAT BRITAIN & IRELAND

J.Vasc.Soc.G.B.Irel. 2023;2(2):76-82
http://doi.org/10.54522/jvsgbi.2023.059

www.jvsgbi.com

ORIGINAL RESEARCH

The role of Braden scores in predicting outcomes following revascularisation for chronic limb-threatening ischaemia and their association with frailty

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Received: 23rd September 2022
Accepted: 18th January 2023
Online: 7th February 2023

Plain English Summary

Why we undertook the work: Peripheral arterial disease is a medical condition where, due to disease of the blood vessels, not enough blood reaches the leg or foot. In its most severe form, this is called chronic limb-threatening ischaemia (CLTI), which is associated with a high risk of amputation and death. Tests to measure for patients' frailty may help predict who will do well and who will do badly after undergoing major surgery to improve blood flow to the leg, but these are not routinely used at the moment. We wanted to know if a different test such as the Braden score (a scoring system to see how at risk someone is of getting a bed sore from not moving enough in bed) could help to predict who will do better or worse after major surgery to improve the blood flow to their leg.

What we did: Patients who underwent an operation for CLTI over a 2-year period (2016–2018) in the Northern Vascular Centre, Freeman Hospital, Newcastle upon Tyne, UK were studied. The accuracy of the Braden scores and electronic Frailty Index (eFI) calculated using General Practice (GP) notes in predicting outcomes and complications of surgery were assessed.

What we found: The Braden scale was able to predict rates of amputation and complications after the operation such as infections and heart attacks. The Braden scale was also able to predict the likelihood of death following the operations. The eFI scoring system was able to predict rates of amputation, re-blockage of circulation and the need for more operations. The Braden score was found to be related to the eFI, meaning that if a patient had a worse score on the Braden scale, they were more likely to be frail on the eFI.

What this means: The Braden scale could be used as a tool to help predict outcomes of surgery for CLTI. Because the Braden scale was also found to have a link to the eFI, it could also be used as a marker for frailty on its own. However, more studies and research with larger groups of patients are needed to prove this.

Abstract

Introduction: Chronic limb-threatening ischaemia (CLTI) is a substantial healthcare burden associated with high rates of amputation, morbidity and mortality. Frailty measures have proved to be an asset in risk prediction but are not routinely universally collated. This study aimed to identify the utility of Braden scores, an assessment tool for pressure ulceration, as a prognostic indicator for patients with CLTI undergoing revascularisation.

Methods: This is a retrospective study of a prospectively maintained database of all patients with CLTI who underwent lower limb revascularisation bypass surgery between 2016 and 2018 in the Northern Vascular Centre, Freeman Hospital, Newcastle upon Tyne, UK. Their Braden scores were obtained and their electronic Frailty Index (eFI) calculated. Patients were divided into subgroups for each scoring system and their post-revascularisation outcomes were compared. This allowed us to identify the ability of these scoring systems to predict outcomes.

Results: Eighty-seven of 124 CLTI patients undergoing lower limb revascularisation bypass surgery had their Braden scores calculated. Nineteen patients (22%) had Braden scores $\leq$18 (high risk for ulceration) with a higher risk of baseline sarcopenia (32% vs 12%, p=0.04, OR 1.4, CI 0.48 to 4.53), major amputation (53% vs 28%, p=0.04, OR 1.2, CI 0.48 to 3.02), longer hospital stay (median 33 vs 14 days, p=0.04) and overall complications of pneumonia, myocardial ischaemia and wound infection (58% vs 31%, p=0.035, OR 1.8, CI 0.59 to 5.53) considered as composite factors. These patients also had worse overall survival according to Kaplan–Meier analysis (p<0.001), and the Braden scores were independently associated with death (hazard risk 1.157, CI 0.67 to 1.92; p=0.01). Braden scores were negatively correlated with an increasing eFI (p=0.016).

Conclusion: Braden scores appear to be a promising prognostic indicator of adverse outcomes in patients with CLTI undergoing revascularisation surgery. Additionally, Braden scores may also be a surrogate marker of frailty. Further larger studies are required for the validation of Braden scores and their roles in improving outcomes of CLTI intervention.

Key words: Braden score, frailty, chronic limb-threatening ischaemia, lower limb revascularisation

Introduction

Peripheral artery disease (PAD) poses a substantial healthcare burden worldwide as the third leading cause of atherosclerotic vascular morbidity.[1] Chronic limb-threatening ischaemia (CLTI) induces rest pain and/or tissue loss and encompasses the end stage of PAD, developing in approximately 11% of PAD patients, and is associated with debilitating pain, poor quality of life, one-year limb loss (15–20%) and mortality (15–40%).[2,3]

Lower limb revascularisation aims to improve tissue perfusion in order to avert major adverse limb and cardiovascular events.[4] The most vital index for evaluating lower limb revascularisation in CLTI is the long-term symptoms improvement and preservation of the affected limb.[5] However, as evidenced by the aforementioned poor prognostic figures,[2,3] this is not always possible and it is currently difficult to reliably quantify the risks and benefits of revascularisation on an individual level. Therefore, in order to aid both patients and clinicians in their clinical decision making, the development of valid risk prediction models is vital. However, concurrent models provide limited efficacy in predicting amputation and mortality.[4]

Several risk factors for poor postoperative outcomes have been identified, such as age and biochemical markers (including abnormalities in serum sodium, haemoglobin and low albumin).[6–10] However, lone predictors have been highlighted to fail in capturing the multifactorial nature of risk in critically ischaemic vascular patients undergoing revascularisation suregry.[11] Contemporary research suggests that a principal factor in universal risk determination is the frailty syndrome.[11,12] Frailty has been defined as a state of vulnerability to adverse stressors due to an ageing-associated cumulative decline in physiology and homeostatic reserve.[13–15] As vascular pathologies, especially CLTI, are primarily a disease of the elderly,[16] the consequences of frailty are essential to consider when calculating the postoperative risks associated with lower limb revascularisation surgery. Indeed, frailty in vascular surgery patients has been shown to predict a multiplicity of poorer outcomes.[17–19]

Despite its recognised significance in the literature, frailty remains difficult to measure due to the absence of a gold standard index, resulting in the development of multiple assessment tools and therefore a lack of consistency.[20,21] Although a variety of these models are able to identify patients at high risk of adverse events,[22–24] their use in clinical practice is often limited by the need for time-consuming performance measures which are not routinely measured (gait speed, grip strength, sit-to-stand tests) or access to up-to-date primary care electronic health records (EHR).[11,13,24] Furthermore, the majority of frailty measures, such as the Clinical Frailty Scale, although shown to be able to assess frailty retrospectively, are required to be measured prospectively.[25]

The electronic Frailty Index (eFI) for frailty assessment based on data from EHRs is the most widely used tool, particularly in primary care, and appears to be a promising predictor of adverse postoperative outcomes.[24,26–28] The eFI was chosen specifically as a validated retrospective measure for our patient cohort: eFI scores are calculated using pre-diagnosed deficits that are given equal weight when categorising an individual into different frailty brackets. The eFI showed a robust predictive value for outcomes of mortality, hospitalisation and nursing home admission.[24]

The Braden scale is a risk assessment tool routinely collected by nursing staff for the determination of pressure ulcer risk.[29] Several studies have shown that the Braden scale predicted postoperative complication rates, length of hospital stay and institutionalisation upon discharge after abdominal and pelvic surgery.[11,30–34] The utility of the Braden scale in patients undergoing surgery for CLTI has not been assessed to date. This study therefore aimed to establish if preoperative Braden scores independently predict outcomes following lower limb bypass for CLTI, and whether it would be able to provide a similar predictive potential to frailty measures.

Methods

Study design and population

This retrospective analysis of a prospectively maintained database included all patients with CLTI who had rest pain and/or tissue loss for more than 2 weeks and underwent lower limb revascularisation bypass surgery only between 2016 and 2018 in the Northern Vascular Centre, Freeman Hospital, Newcastle upon Tyne. Patients' PAD severity was classified according to the Rutherford classification. Their Braden scores were obtained prospectively by the nursing staff as described by Bergstrom *et al*,[29] and the eFI scores were calculated retrospectively by our research team as described by Clegg *et al*,[24] using a total of 36 variables available from primary care EHRs. The score is calculated by expressing the cumulative deficits present as an equally weighted proportion of the total.

Preoperative baseline characteristics were collected, including demographics and co-morbidities including diabetes mellitus, ischaemic heart disease, hypertension, cardiac failure, renal failure, and chronic obstructive pulmonary disease. Preoperative patients' sarcopenia was defined through the routine preoperative CT angiogram images of each patient as a skeletal muscle area at the 3rd lumbar vertebra level of <114 cm^2.[35] Patients' preoperative biochemical markers were collected including haemoglobin,

leukocyte count, serum sodium, potassium, albumin, creatinine and total protein. The study was approved by the Newcastle upon Tyne Hospital Research Department and the Newcastle University Review Board.

For analysis of the Braden scale, the patients were divided into two groups: (1) scores ≥19 and (2) scores ≤18. The aforementioned values were chosen in previous studies as patients scoring >18 are deemed to be at low risk of pressure ulcers.[11,31] For eFI, we followed the documented categories by the developing team: fit (0–0.12), mild (>0.12–0.24), moderate (>0.24–0.36) and severe frailty (>0.36).[24]

Patients were divided into subgroups for each scoring system and their post-revascularisation outcomes were compared. This allowed us to identify the ability of these scoring systems to predict outcomes. Outcomes examined were major lower limb amputation (MLLA), defined as either a below-knee, above-knee or through-knee amputation; length of stay; a composite of postoperative complications (pneumonia, myocardial ischaemia, wound infection) obtained retrospectively from clinical notes; all-cause mortality; re-intervention rates; and bypass graft occlusion. Each subgroup within the two indices was used as individual comparators.

Study outcomes

The primary outcome was the association between Braden scale and post-lower limb revascularisation outcomes (major lower limb amputation, composite of postoperative complications, all-cause mortality; re-intervention rates bypass graft occlusion and operative time as higher risk patients are likely to undergo more straightforward surgery) in CLTI patients. The secondary outcomes were the variation between different demographics and operative measures and different eFI and Braden groups, and the association between eFI and the aforementioned post-lower limb revascularisation outcomes in CLTI patients, and to study the relation between Braden score and eFI.

Statistical analysis

Patients were grouped depending on their category of frailty and Braden score. Continuous variables were tested for normality and when data were not normally distributed a non-parametric analysis and median values with interquartile range were reported. Descriptive analysis was used to calculate the mean and standard deviation of the demographic information and length of stay, and binary regression analyses were used to assess for significant correlation between the abovementioned outcomes. Kaplan–Meier survival plots were used to compare survival using a log-rank test, and multivariate analysis was performed to adjust for the key variables and risk factors. Statistical analyses were carried out using SPSS version 27 (SPSS, IBM, Chicago, Illinois, USA), and statistical significance was defined with a p value <0.05.

Results

A total of 124 patients with CLTI were included in the study (100 men (80.65%), median age 67.5 years (IQR 59–75)) with a median follow-up of 4.8 years (IQR 4.05–5.77). Their demographic characteristics, co-morbidities, biochemistry laboratory investigations, severity of peripheral arterial disease and operative time are shown as per their eFI and Braden scores in Table 1.

All patients underwent lower limb revascularisation bypass surgery; 66 were elective operations, 47 were urgent (within 1–5 days from admission) and 11 were emergency (<24 hours). The median operative time was 210 min (IQR 170–284). Lower limb revascularisation operations were as follows: seven aorto-bifemoral bypasses with prosthetic graft, two ileo-femoral bypasses with prosthetic graft, five femoro-femoral crossover bypasses with prosthetic graft, 16 femoral-above knee popliteal bypasses with vein graft, 67 femoral-below knee popliteal bypasses (65 with vein and 2 with prosthetic graft), 27 femoral-distal bypasses (26 with vein and one with prosthetic graft). A total of 122 patients had available information for the calculation of their respective eFIs (30 fit; 65 mild frailty; 21 moderate frailty; 6 severe frailty). Eighty-seven patients had their preoperative Braden scores documented (68 low-risk patients (score ≥19) and 19 high-risk patients (score ≤18)). The patients with a high-risk Braden score (13 men (68.42%), median age 68 years (IQR 60–76)) underwent six elective, 12 urgent and one emergency operations of one femoro-femoral crossover bypass with prosthetic graft, three femoral-above knee popliteal bypasses with vein graft, 12 femoral-above knee popliteal bypasses with vein graft and three femoral-distal bypasses with vein graft. Their median operative time was 210 min (IQR 180–300). Twelve patients (63%) required re-intervention and eight patients (42%) suffered from graft occlusion (Table 2). The principal reason for such a discrepancy in the availability of Braden scores was primarily due to the coinciding electronic uploading of inpatient notes, rendering them unavailable for the study period.

Higher risk patients with Braden scores of ≤18 were more highly associated with baseline sarcopenia (p=0.04, OR 1.4, CI 0.48 to 4.53) (Table 1) and stayed in hospital for a longer duration by 19 days compared with lower risk patients with Braden scores ≥19 (p=0.04; Table 2). Braden scores were not associated with bypass graft occlusion or re-intervention rates, but patients in the higher risk group developed a significantly higher rate of postoperative complications (p=0.04; Table 2).

Following lower limb bypass surgery, patients with severe frailty were found to be more likely to experience longer operative time (p=0.02), while moderately frail patients had a higher graft occlusion rate (p=0.001, OR 2.8, CI 1.09 to 7.35) and the merged frail patient cohort required further re-intervention compared with the non-frail group (p=0.03, OR 1.05, CI 0.52 to 2.13). However, there was no significant association between eFI status and postoperative complications or length of hospital stay (Table 2).

Both lower Braden scores and higher eFI were associated with major lower limb amputation rates (OR 1.2, CI 0.48 to 3.02 (p=0.04) and OR 1.56, CI 0.72 to 3.36 (p=0.008), respectively).

Table 1 Demographic information subdivided by electronic Frailty Index (eFI) and Braden scores.

Demographics	electronic Frailty Index							Braden score		
	Fit (n=30)	Mild Frailty (n=65)	P value	Moderate Frailty (n=21)	P value	Severe Frailty (n=6)	P value	≥19 (n=68)	≤18 (n=19)	P value
Median Age (IQR in years)	60 (55-69)	68 (60-70)	0.01*	68 (61-75)	0.04*	76 (65-78)	0.02*	64.5	68.4	0.43
Males (%)	25 (83%)	53 (81%)	>0.9	17 (81%)	>0.9	3 (50%)	0.11	56 (82%)	13 (68%)	0.57
Diabetes	3 (10%)	24 (36.9%)	0.007	14 (66.7%)	<0.0001*	2 (33.3%)	0.18	34%	29%	0.18
Ischaemic Heart Disease (IHD)	5 (16.6%)	21 (32.3%)	0.14	13 (61.9%)	0.001*	2 (33.3%)	0.57	28%	47%	0.82
Hypertension	16 (53.33%)	50 (76.9%)	0.03*	17 (80.9%)	0.09	6 (100%)	0.06	72%	76%	0.26
Cardiac Failure	1 (3.3%)	2 (3.07%)	>0.9	2 (9.5%)	0.56	1 (16.66%)	<0.0001	5%	12%	0.64
Renal Failure	1 (3.3%)	3 (4.62%)	>0.9	1 (4.76%)	>0.9	0 (0%)	>0.9	5%	0%	0.26
COPD	7 (23.33%)	12 (18.46%)	0.59	10 (47.62%)	0.13	1 (16.66%)	>0.9	22%	24%	0.83
Haemoglobin (g/L)	137 (127.8-149.5)	123 (108-145.5)	0.04*	122.5 (114.5-138.5)	0.03*	111 (100-122)	0.02	134 (122-152)	114 (98-134)	0.91
Leukocytes count (10^9/L)	8.85 (6.65-11.45)	8.87 (7.85-10.76)	0.96	8.44 (7.40-10.35	0.95	10.43 (7.26 -13.75)	0.43	8.6 (7.2-11.31)	10.86 (7.09-14.70)	0.30
Serum Sodium (mEq/L)	139 (134.5-140)	139 (135 -140)	0.81	138 (135-139)	0.20	141 (135.5 -142.5)	0.16	139 (136-141)	136.5 (132.5-139)	0.45
Serum Potassium (mEq/L)	4.55 (4.20-4.85)	4.4 (4.17-4.80)	0.69	4.6 (4.4-5.1)	0.22	4.65 (4.30-4.83)	0.65	4.4 (4.2-4.9)	4.8 (4.43-5.13)	0.45
Serum Albumin (g/L)	43 (39.50-46)	42 (38-44)	0.33	39 (36-42)	0.02*	39.5 (35.25-43.25)	0.12	42 (39-45.75)	39 (38-45)	0.31
Creatinine (µmol/L)	78 (64.5-86.5)	77 (66.5-89.5)	0.74	81 (66-113)	0.47	87 (72.75-108.50)	0.19	81 (67.75-96.25)	80 (65.75-98.50)	0.28
Total Protein (g/dL)	70 (68.0-74.5)	70 (66-74)	0.73	66 (62-74)	0.005*	65 (61.25-67.50)	0.01*	69 (66-73)	69 (64-73)	0.91
Sarcopenia	5 (16.6%)	11 (16.9%)	>0.9	4 (19.04%)	>0.9	0 (0%)	0.56	12%	32%	0.04*
Rutherford Grade	4	6	0.15	5	0.14	5	0.55	4	5	0.13
Operative time (mins)	187.5 (162.5-243.3)	202 (157.5-265.0)	0.54	270 (210.0-322.5)	0.02*	247.5 (207-330)	0.11	202.5 (151.3-275.0)	210 (180- 300)	0.64

All continuous variables are presented by their median and interquartile range (IQR).* = p<0.05.

The patients' Braden scores were negatively correlated with their eFI (correlation coefficient 0.26, p=0.016).

Cox regression analysis showed that lower Braden scores were associated with a higher risk of all-cause mortality, with a hazard risk of 1.157 (CI 0.67 to 1.92; p=0.01), while the eFI was unable to accurately predict mortality (Figures 1 and 2).

Discussion

Our study results highlighted that higher risk Braden scores were associated with a higher rate of MLLA, longer duration of stay in hospital, overall complication rates and all-cause mortality. Braden scores also significantly correlated with mortality.

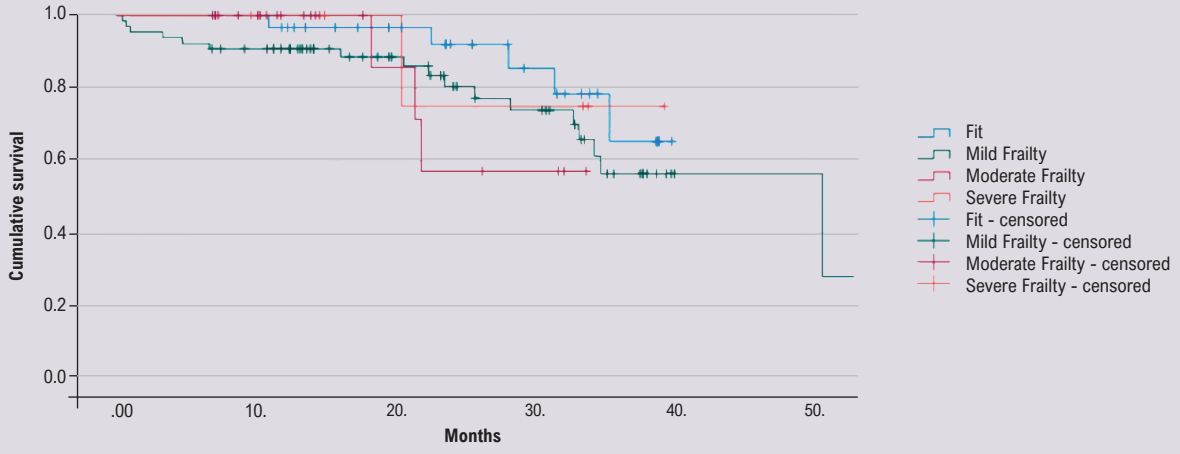
CLTI itself is associated with high morbidity and mortality.[2,3] This

Table 2 Outcomes subdivided by Braden scores eFI and Braden scores.

Outcomes	electronic Frailty Index							Braden score		
	Fit (n=30)	Mild Frailty (n=65)	P value	Moderate Frailty (n=21)	P value	Severe Frailty (n=6)	P value	≥19	≤18	P value
Length of stay (days)	9	16	0.11	14	0.09	35	0.02*	14	13	0.04*
Postoperative complications	9 (30%)	27 (41.54%)	0.36	7 (33.33%)	>0.9	3 (50%)	0.38	20 (31%)	11 (58%)	0.04*
Re-intervention	11 (36.66%)	30 (46.88%)	0.50	12 (57.14%)	0.17	5 (83.33%)	0.07	28 (41%)	12 (63%)	0.09
Graft occlusion (by 3 months)	7 (23.33%)	19 (29.23%)	>0.9	9 (42.86%)	0.001*	4 (66.67%)	0.06	21 (31%)	8 (42%)	0.17
MLLA	7 (23.33%)	17 (26.15%)	>0.9	9 (42.86%)	0.002*	5 (83.33%)	0.01*	19 (28%)	10 (53%)	0.04*

MLLA, Major Lower Limb Amputation. All continuous variables are presented by their median and interquartile range (IQR). * = p<0.05.

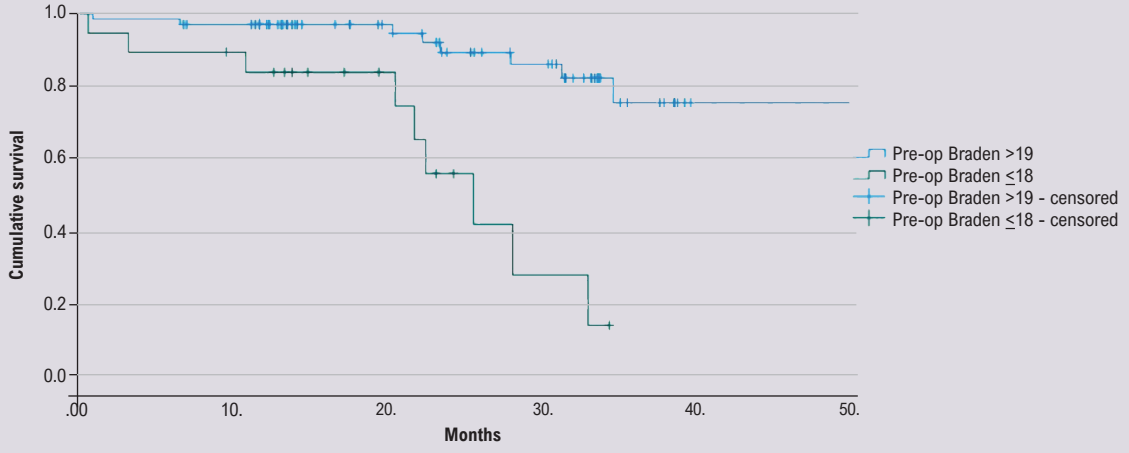
Figure 1 Kaplan-Meier estimates for survival as per eFI.



Time	0	10	20	30	40	50
Number at risk	122	112	71	45	6	2

A Kaplan-Meier Curve representing the patient cohort subdivided into the four eFI categories. The significance of mortality between the subgroups was p=0.65

Figure 2 Kaplan-Meier estimates for survival as per Braden scores



Time	0	10	20	30	40	50
Number at risk	87	82	51	30	3	1

A Kaplan-Meier Curve representing the patient cohort subdivided into the two Braden scores categories. The significance of mortality between the high and low risk groups was p=0.001.

is more pronounced in frail patients with CLTI as they are more likely to be managed conservatively, and are associated with even higher hospital costs, mortality and amputation rates.[34–38] The James Lind Alliance Vascular Research Priority Setting Partnership suggested that the foremost priority in PAD research is to identify what can be done to improve outcomes in patients with severe circulation problems to their legs.[39]

Our study results, in keeping with previous research,[36,37] demonstrate that frailty plays a crucial role in surgical outcomes of lower limb revascularisation bypass operations. However, to our knowledge, this is the first study to examine the role of Braden scores on CLTI patients and its relation to the outcomes of revascularisation.

Our patients with Braden scale of ≤18 had a two-fold increased risk of limb loss and a seven-fold increase in overall mortality. This patient group demonstrated worse sarcopenia compared with their peers, which put them at a higher risk of postoperative outcomes, particularly as sarcopenia has been previously reported as an independent factor for MLLA rates and overall mortality following lower limb bypass operations.[35] However, higher risk Braden scores

were not statistically associated with more frequent bypass graft occlusion or re-intervention.

On the other hand, the greater rates of limb loss present among the more frail subgroups is underpinned by the presence of similarly increasing rates of bypass graft occlusion and re-intervention rates. This phenomenon is likely highly conducive of graft failure, leading to the more frequent need for MLLA. However, the underlying principle behind the failure of the grafts is not completely evident as it is likely a multifactorial cause. Severely frail patients underwent the second shortest operations, so one might assume that they underwent more straightforward arterial reconstruction that suited their frailty.

It is important to acknowledge, however, that frailty and co-morbidity are interrelated but distinct entities, meaning that frailty is independent of disease.[45,46] The Braden scale, in contrast, provides a more accurate snapshot of each individual patient at a given moment in time, and may provide further invaluable information in relation to the non-descript factors of frailty.

This notion is further emphasised by the finding that patients in the higher risk subdivision of the Braden groups were more likely to suffer from postoperative complications (Table 2). In addition, their average length of stay as an inpatient was over twice as long, which puts them at a higher risk of hospital-acquired infections.[47] The finding that the eFI score was not associated with complication rates, length of stay and mortality in our patient cohort while the Braden score was efficacious in doing so, suggests that the multifactorial and temporal nature of frailty may not be fully captured by eFI, and it may be prudent to use the Braden scale as a supplementary marker for frailty in this patient population.

eFI and Braden scores were weakly negatively correlated (correlation coefficient 0.26), which could suggest that the two scales might be interconnected. However, further research is required to evaluate whether the Braden scale may be used not only as an adjunct but also as a surrogate measure of frailty, which would prove to be vital for future research due to its ease of measurement.

Several individual factors play a vital role in eventual poor surgical outcome, and therefore a risk prediction model consisting of a combination of tools would be an invaluable asset to guide decision-making. This study presents frailty as a key contributing factor to poorer surgical outcomes following primary lower limb revascularisation surgery for the treatment of CLTI. Furthermore, it highlights the potential clinical use of the Braden scale as a prediction tool for risk assessment in lower limb revascularisation, especially with regard to MLLA rates. This suggests that frailty and Braden scores may both hold a place in the aforementioned risk prediction model. However, as the current results also suggest that Braden scores may be interchangeable with frailty scores, only one of these tools would be needed in the model. Due to its accessibility, Braden scores may be best placed in this model. The use of such models should not prevent patients from receiving lower limb bypass operations, but aid in the risk evaluation process on an individual patient level. This will allow for joint decision making with regard to whether primary revascularisation or primary MLLA is appropriate, to ultimately improve outcomes.

KEY MESSAGES

- Braden scores showed great potential as a risk-stratification tool in predicting outcomes following lower limb revascularisation in patients with chronic limb-threatening ischaemia.
- Higher risk patients with poor Braden scores suffered from higher major lower limb amputation and postoperative complication rates, overall mortality and length of hospital stay.
- The Braden scale is correlated with the frailty index (eFI) and can be considered as a surrogate marker for frailty.

Study limitations

The limitations of this study include the relatively small sample size from a single centre with a relatively homogenous study population, all of whom are based in the North-East of England.

Conclusion

This UK Vascular Surgery tertiary centre study shows that the Braden scale is associated with MLLA and complication rates, overall mortality and length of hospital stay following lower limb revascularisation in patients with CLTI. Braden scores have the potential to be used as risk stratification tools in the context of CLTI. Furthermore, as the Braden scale has been independently linked to surgical outcomes and correlated with the eFI, it may be a surrogate marker for frailty. Further studies in a patient cohort are recommended for the validation of Braden scores and their role in improving outcomes of CLTI intervention.

Conflict of Interest: None.

Funding: None.

Reviewer acknowledgement: *JVSGBI* thanks Andrew Nickinson, University Hospitals of Southampton NHS Foundation Trust and Sean Pymer, Hull York Medical School for their contribution to the peer review of this work.

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GREAT BRITAIN & IRELAND

J.Vasc.Soc.G.B.Irel. 2023;2(2):83-90
http://doi.org/10.54522/jvsgbi.2023.064

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REVIEW

A contemporary review of the diagnosis and management of vascular Ehlers–Danlos syndrome

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Received: 1st October 2022
Accepted: 17th January 2023
Online: 28th February 2023

Plain English Summary

Why we undertook the work: Vascular Ehlers–Danlos syndrome (vEDS) is a rare genetic condition (ie, that you are born with) that affects the strength of major blood vessels (arteries). This means that arteries are fragile and, as such, are prone to damage with even minimal or no trauma.

What we did: We reviewed the literature searching for papers which focused on how we may diagnose and manage patients with vEDS.

What we found: Diagnosis is still based on recognised clinical features, but there is some hope that objective tests could help with the diagnosis. The major aim of treatment is to prevent blood vessel complications, and the evidence would point to the use of a drug that affects the pressure of blood as it passes through the blood vessels. When complications do happen they are difficult to treat, so the aim should be to reduce the chance of such complications occurring.

What this means: Early diagnosis and active prevention of complications are key in the management of patients with vEDS.

Abstract

Introduction: Vascular Ehlers–Danlos syndrome (vEDS) is a connective tissue disorder weakening the vasculature. There is a perceived lack of awareness within the medical fraternity on this condition. This paper reviews contemporary evidence to enhance the understanding of this complex condition.

Methods: A systematic review was performed. Inclusion criteria were studies in humans with a minimum of five patients. Exclusion criteria were laboratory or animal-based studies, reviews and studies not in English. A total of 115 papers were assessed with articles grouped into four categories: diagnosis, natural history, medical and surgery therapy.

Results: The Villefranche criteria have a high sensitivity/negative predictive value for diagnosing EDS. Assessment of skin architecture/radiological investigation of large vessels can facilitate diagnosis. Genetic testing is available for the pathogenic COL3A1 variant. With regard to natural history, an overall review of 1,400 patients showed that age at diagnosis ranged from 4 to 40 years, age of death ranged from 28 to 54 years and vascular complications were frequent. The key medical therapy is celiprolol, which is associated with a reduction in arterial events three times greater with treatment than without. Non-operative therapy/non-invasive imaging techniques are suggested to be used when possible. Vessel reconstruction is possible but fragile tissue makes this challenging and endovascular interventions are ideally suited for the treatment of false aneurysms. There is a high rate of procedure-related complications (early and late).

Conclusions: The poor natural history of vEDS means that accurate diagnosis is key to allow extension of complication-free periods. Vascular interventions are associated with high complication rates.

Key words: vascular Ehlers–Danlos syndrome, vEDS

Introduction

Ehlers–Danlos syndrome (EDS) is a recognised connective tissue disorder that affects collagen and extracellular matrix function. EDS is a cluster of 13 inherited conditions/types (19 different causal genes) which vary in incidence, clinical presentation and natural history.[1]

The most common of these is that of hypermobile EDS which has an incidence of approximately 1:10,000 of the population.[2] Vascular EDS (vEDS) or – as it was previously called – type IV is less common but is of interest to vascular surgeons due to the effect it has on the extracellular matrix of both the vasculature and also within hollow visceral organs. vEDS is dominantly inherited and is caused by a mutation in the gene COL3A1 which encodes the alpha 1 chain of type III collagen.[1]

Because of a clinical overlap with some forms of Loeys–Dietz syndrome, Marfan syndrome and familial arterial aneurysm and dissection syndromes, the diagnosis should be confirmed by identification of pathogenic variants in COL3A1 to allow for appropriate surveillance, treatment and family studies.[3]

Over the last four decades there has been progress in the understanding of vEDS. This has been driven in part by some understanding of the underlying pathological and molecular processes that underpin vEDS.[1] Yet there is still a lack of awareness around the condition in the medical fraternity in general and in vascular surgeons specifically.

The aim of this review is to explore the current available information for the diagnosis, medical and surgery therapy and natural history for patients with vEDS to highlight this condition to vascular surgeons and allied healthcare professionals. This paper also provides a patient's perspective on the condition to highlight barriers experienced in accessing appropriate care.

Methods

A systematic review of published material relating to vEDS was undertaken. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (http://www.prisma-statement.org/) were adhered to throughout. Figure 1 shows the study flow chart.

PubMed and Embase databases were queried, taking into account the different notations for the EDS subtypes using the following keywords: vascular, type 4, type IV. Based on these keywords, we queried the PubMed database with the following search string: (vascular OR "type 4" OR "type IV") AND (Ehlers Danlos OR Ehlers-Danlos). The Embase database was also queried for additional results with the following search string: (vascular OR type 4 OR type IV) AND (Ehlers Danlos OR Ehlers-Danlos). All material published before 17 April 2021 were eligible for inclusion in this review.

After removing duplicate results, studies were included if they involved five or more patients with the vEDS subtype. Studies that did not include the vEDS subtype or did not differentiate between EDS subtypes were excluded. The following types of studies were considered: clinical trials, case–control studies, cross-sectional studies, cohort studies, case series and case reports. We excluded cell culture laboratory studies, animal studies, reviews and studies that were not published in English. A bibliography was created using Zotero (https://www.zotero.org/). Using these criteria, two authors (AC and PC) screened the titles and abstracts of the remaining papers and removed those that did not meet the inclusion criteria. Further papers from the bibliography were reviewed when appropriate.

Results

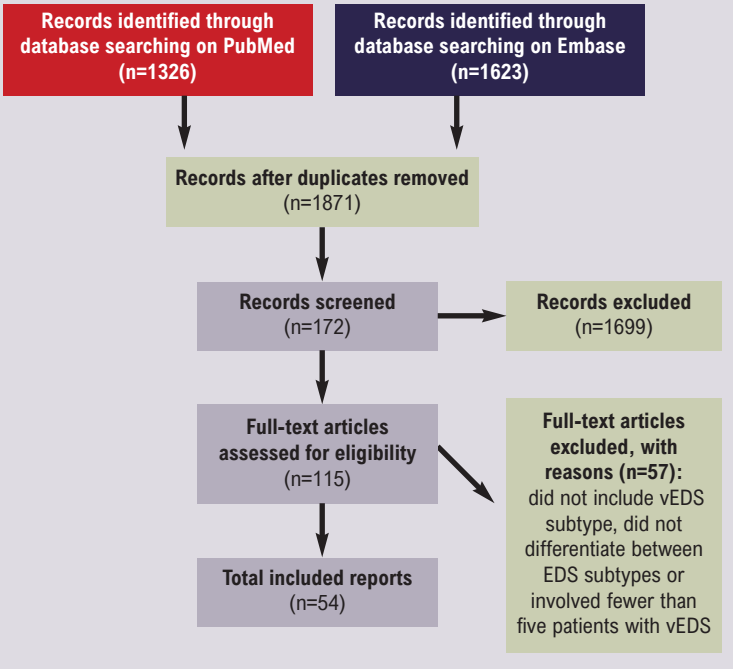
A total of 115 papers were assessed for eligibility and, after analysis, a total of 54 papers were assessed to formulate this review. Due to the nature of this narrative and clinical focused synthesis, we grouped the articles into diagnosis of vEDS, medical and surgery management and the natural history of vEDS. Papers that focused on the genetics of vEDS were not included in this review.

Diagnosis

The diagnosis of vEDS is challenging and patients often arrive at a diagnosis after a long and protracted path of misdiagnosis or uncertainty.

Initial diagnostic criteria for EDS overall were initially proposed in 1986. The progress in our understanding and the specific

Figure 1 PRISMA flow chart.



identification of a vascular specific EDS led to the development of the Villefranche criteria in 1997, which was put forward to improve patient selection for genetic testing.[4] The Villefranche criteria consist of four major diagnostic criteria – arterial/intestinal/uterine fragility or rupture, extensive bruising, thin/translucent skin and characteristic facial appearance – with the presence of two or more criteria identifying those patients who would benefit from genetic testing.

Minor criteria include acrogeria (a skin condition characterised by premature aging with unusually fragile, thin skin on the hands and feet), small joint hypermobility, tendon/muscle rupture, clubfoot, early onset varicose veins, arteriovenous or carotid-cavernous sinus fistula, pneumothorax, gingival recession and a positive family history, sudden death in a close relative. The diagnostic relevance of these has been untested.

A study by Henneton *et al* retrospectively looked at a consecutive series of patients (384 probands, defined as the first person in a family to receive genetic counselling and/or testing for suspected hereditary risk and 135 relatives) with a possible diagnosis of vEDS in a tertiary referral unit who were scored using the major and minor diagnostic criteria of the Villefranche classification and also went on to be genetically tested.[5] Of these patients, a specific pathogenic COL3A1 variant was confirmed in 165 patients but the Villefranche criteria for diagnosis was met in 248 patients (sensitivity 79%, negative predictive value (NPV) 87%). Diagnostic accuracy was highest for symptomatic probands (sensitivity 92%, NPV 95%). The sensitivity and NPV of the Villefranche criteria were lower for relatives yet, in practice, this group of patients is likely to undergo mandatory genetic testing and thus it could be argued that diagnostic criteria are of less importance.

The Villefranche criteria evolved in 2017, keeping most of the same clinical criteria but with the addition of some further clinical criteria (Table 1).[6] The accuracy of the 2017 criteria was assessed retrospectively in 50 patients with genetic confirmation of vEDS. Within this cohort, 32 were female with 24% having died at the time of the retrospective review. The mean age at death was 29 years. Forty percent of patients had had an acute arterial event (rupture/dissection) before the age of 40 years and 22% an unexplained sigmoid colon rupture. Two Villefranche major criteria were evident in 94% of patients, whereas only 28% of patients had all the major criteria. The frequencies of the other major and minor criteria are shown in Table 1.

There has been increasing diagnostic focus on both skin architecture and radiological investigation of large vessels. Ong *et al* used an ultrastructure scoring procedure following skin biopsy made up of abnormal fibroblast shape, presence of lysosomes in the fibroblast and abnormal basal lamina and showed it performed well with an AUC of 0.9.[7] An older study which used immunofluorescence of cultured skin fibroblasts showed abnormal amounts of cytoplasm type III collagen.[8] This result has been corroborated by abnormally low levels of serum procollagen type II aminopropeptide (P-III-NP), released during conversion of type III procollagen to collagen, in vEDS.[9]

Table 1 Frequencies of vEDS major and minor criteria of the Villefranche nosology. Adapted from Ritelli *et al*.[6]

	Patients		
	N	Total	%
Major			
Thin translucent skin	44	49	89.9
Arterial/intestinal/uterine fragility or rupture	35	50	70.0
Extensive bruising	39	50	78.0
Characteristic facial appearance	29	50	58.0
Minor			
Acrogeria	10	49	20.4
Hypermobility of small joints	27	45	60.0
Tendon and muscle rupture	5	46	10.9
Talipes equinovarus	8	50	16.0
Early-onset varicose veins	11	47	23.4
Arteriovenous, carotid-cavernous sinus fistula	6	42	14.3
Pneumo(haemo)thorax	5	48	10.4
Gingival recession/fragility	15	41	36.6
Positive family history, sudden death in (a) close relative(s)	29	50	58.0

Some groups have focused on haemodynamic and arterial wall properties. Arterial wall stress (both steady and pulsatile) in vEDS patients was found to be higher than in controls.[10] Further, carotid intima-media thickness was 32% lower in patients with vEDS. An abnormally low intima-media thickness generates a higher wall stress which may increase the risk of arterial dissection and rupture in vEDS patients. Patients with vEDS have been shown to have a reduction in the relative increase in carotid pulse wave velocity between early and end systole, which could reflect a less adaptative arterial wall stiffening during the cardiac cycle.[11] It was postulated that this may explain the higher susceptibility to arterial rupture in vEDS patients.

Novel imaging techniques have allowed for a detailed analysis of patients with vEDS. Using MRI of both the aorta and carotid arteries, Kerwin *et al* compared 17 patients with vEDS with eight age/sex-matched controls and analysed a number of artery-specific variables.[12] They found that, in those patients with vEDS, there was a significant negative correlation ($r=-0.82$, $p=0.02$) between age-adjusted pulse propagation velocity and familial longevity, suggesting that elevated pulse propagation velocity (an indicator of vessel distensibility) may be a risk factor for complications of EDS IV. Ultrasound has also been used to examine the biomechanical properties of arteries in vEDS.[13] Examination of the carotid artery has shown that common carotid artery distension and compliance tended to be lower in vEDS subjects.

Table 2 Celiprolol therapy

Study	Therapy	Patients	Median age (years)	Follow-up period	Arterial complications	Other complications	Other findings
Baderkhan *et al*[14]	Celiprolol	31		44 months	5 (4 fatal) • Ascending aorta rupture • Type B dissection with rupture • Cerebral vessel rupture • Pulmonary artery rupture • Splenic artery rupture (coiled)		
	No therapy	2			2 (1 fatal) • Type B dissection	• Bowel perforation (fatal)	
Hoang *et al*[15]	Celiprolol	46	35	5 years 6±3 visits			• Increased systolic BP, Di, IMT and Einc • Decreased distensibility
	No therapy	17					• No change in blood pressure • Increased Di, IMT, Einc • Decreased distensibility
Ong *et al*[16]	Celiprolol	25		47±5 months	5*		
	No therapy	28			14		

*Primary end point was arterial events (rupture or dissection, fatal or not). Hazard ratio 0.36, 95% CI 0.15 to 0.88; p=0.040).
BP, blood pressure; Di, diastolic diameter; IMT, intima-media thickness; Einc, Young's elastic modulus.

Medical management

A key medical therapy in patients with vEDS is celiprolol (Table 2). Celiprolol is a β-blocker with a unique pharmacologic profile; it is a β1-adrenoceptor antagonist with partial β2 agonist activity.[17] While it has antihypertensive and antianginal actions, reducing heart rate and pulsatile pressure, it lacks the commonly seen side effects of more mainstream β-blockers (namely bronchoconstriction, left ventricular function depression and peripheral vasoconstriction) due to the allied β2 agonist effect. This β2 agonist effect also influences vascular tone and directly affects smooth muscle and, as such, it is unique in being recognised as a therapeutic intervention for patients with vEDS. The reduction in heart rate and pulsatile pressure also reduces the mechanical stress on collagen fibres within the arterial wall.

The Beta-Blockers in Ehlers-Danlos Syndrome (BBEST) study is a prospective, multicentre, randomised, open trial which reported in 2010.[16] The study compared patients with vEDS randomised to either celiprolol or no treatment and the assessment of clinical events was blinded. Fifty-three patients were randomly assigned to celiprolol (25 patients) or control groups (28). The mean duration of follow-up was 47 (SD 5) months, with the trial stopped early for treatment benefit. The primary endpoints (arterial events – rupture or dissection, fatal or not) were reached by five (20%) in the celiprolol group and by 14 (50%) controls (hazard ratio 0.36; 95% CI 0.15 to 0.88; p=0.040). The beneficial results have been supported by more recent observational studies and, as such, celiprolol holds promise for the management of patients with vEDS.[14]

Surgical management

The fragile nature of the arterial system in patients with vEDS makes surgical management challenging. A study by Freeman *et al* reviewed their experience of managing vEDS in an era prior to the routine use of endovascular therapies.[18] Within their series there were 22 spontaneous haemorrhages, 17 aneurysms and five arterial dissections. Eleven of the vascular complications were treated with non-operative management, eight with vessel ligation, 20 with arterial reconstruction, and two with endovascular therapy. Eighteen patients underwent diagnostic angiography, with three (22%) major complications and one death (5.6%). Twelve (30%) patients died from vascular complications of vEDS, seven of whom had previously been treated with arterial reconstruction. They concluded that vascular complications should be treated wherever possible with non-operative therapy and non-invasive imaging techniques. If required, operative intervention ideally should focus on vessel ligation rather than reconstruction.

Okada *et al* reported their experience of endovascular therapies for vEDS patients presenting with arterial complications.[19] The interventions were predominantly for the development of false aneurysms, with the primary management being embolisation using a combination of coils and glue. While all procedures were ultimately successful, there were recognised complications both intra-procedurally and following the procedure both with access site issues and recurrence of the false aneurysm.

A more recent review of practice came from Oderich *et al* who reported their experience of managing 24 vEDS patients with

vascular-related issues.[20] In total, these 24 patients developed 132 vascular-specific complications (85 present before or at the time of the initial review and 47 occurring after the initial presentation). Fifteen patients underwent 30 operative interventions, of which 15 were reconstructive in nature. Three hospital deaths occurred due to uncontrollable haemorrhage. Procedure-related complications were high with one in three patients experiencing post-intervention bleeding and one in five patients requiring re-operation. The rate of late graft-related complications was also high, affecting 40% of arterial reconstructions and predominantly being due to anastomotic complications.

Natural history

This section focuses on the natural history of the condition with regard to vascular-specific complications as opposed to other complications including those affecting the gastrointestinal or genitourinary tracts. It is recognised that vEDS is associated with other non-vascular complications including gastrointestinal

Table 3 Gastrointestinal complications

Study	Patients	Women	Age (years)	Follow-up period (years)	Deaths	Age of death (years)	Gastro-intestinal rupture	Colonoscopies	Abdominal surgery
Adham *et al*[21]	5	2	24†		2	28.5†	1		1
Cisak *et al*[25]	59	27		19*			4		
Frank *et al*[27]	133	81		6.5†	17	44.2†	54		
Johansen *et al*[30]	18	11	31.5*				3		
Kilaru *et al*[39]	41							41	
Nelson *et al*[32]	57								9/27
Oderich *et al*[20]	31	16		30*	12	54†	7		
Shalhub *et al*[35]	67	38	40.9†				8		
Shalhub *et al*[34]	96	59	38.6†	12*			15		
Stephens *et al*[37]	26	4	9.9*						
Wang *et al*[38]	68	40						21	39

*Median. †Mean.

Table 4 Vascular complications

Study	Patients	Women	Age (years)	Follow-up period (years)	Deaths	Age of death (years)	Vascular-complications	Aneurysms	Dissections	Vascular surgery
Adham *et al*[21]	144		41.4†	17*		35.5†	82		82	
Adham *et al*[22]	133									10
Chu *et al*[23]	26			10*			19			
Cikrit *et al*[24]	5	2	24†		2	28.5†	3	1		1
Cisak *et al*[25]	59	27		19*			37			
Frank *et al*[26]	144		34*	5.8*	17		99			
Frank *et al*[27]	133	81		6.5†	17	44.2†	36/55			
Frank *et al*[28]	144	87		5.3*	17	35*	43			
Jaffe *et al*[29]	10									
Johansen *et al*[30]	18	11	31.5*					6	9	5
Leistritz *et al*[31]	19						18	4	12	
Nelson *et al*[32]	57									10/27
North *et al*[33]	202									
Oderich *et al*[20]	31	16		30*	12	54*	24			15
Shalhub *et al*[34]	96	59	38.6†	12*			65			
Shalhub *et al*[35]	67	38	40.9†				67	7	7	50
Smith *et al*[36]	14		9.9*							
Stephens *et al*[37]	26	4							2	
Wang *et al*[38]	68	40						41/67	37/67	20/67

*Median. †Mean.

perforation (Table 3), complications around pregnancy and cardiac-related complications. The management of other allied health problems is also more complex in such patients.

The natural history of vEDS with a focus on vascular complications shows that arterial complications are common, present as predominantly dissection or aneurysmal-related, and occur in a large proportion of patients (Table 4). Vascular complications can occur in any arterial bed, can develop at pace and the progression of asymptomatic aneurysmal disease as well as arterial dissections is uncertain. Life expectancy is shorter than that expected in patients without vEDS.

Discussion

vEDS is a rare condition and is associated with a significant risk of arterial complications. These provide significant challenges for vascular surgical teams to manage. The overall aim of this review was to highlight these complexities including offering a patient's perspective on pathways of care (see below). There are a number of take-home messages from this review and the accompanying patient experience for vascular surgeons and other medical staff who will see patients with vEDS.

vEDS is caused by pathological alteration in the sequence variants of COL3A1, which codes for procollagen III. This leads to abnormalities in the quantity and quality of type III collagen. We have purposely not focused on the associated genetic defects associated with vEDS as we want this review to focus on clinically relevant issues. That said, the diagnosis of vEDS needs to be confirmed by either genetic analysis of the COL3A1 gene or by analysis of a patient's collagen. vEDS is associated with a low intima-media thickness which, allied with high mechanical stress, leads to the high risk of arterial rupture and dissection. Close links with geneticists, dermatologists and other medical teams is essential in the longer-term management of such patients.

Within the UK, there are recognised centres of expertise. The EDS National Diagnostic Service is a highly specialised service commissioned by NHS England for individuals and families who are suspected to have complex EDS. These have been established since 2009 and are run out of the Sheffield Northern General Hospital and the Northwick Park & St Mark's Hospitals in London. These services aim to provide an accurate diagnosis in suspected cases, they develop guidelines and pathways of care for the different EDS subtypes and provide information for patients and carers. They also help lead research on EDS. Their teams are multifaceted with a strong emphasis on genetics and counselling. Current diagnostic techniques include clinical review, skin biopsy and genetic blood testing. Imaging parameters may hold promise about predicting progression to a vascular event, but coalescence of expertise and patient numbers are probably required to achieve appropriate larger scale natural history studies.

The EDS National Diagnostic Service does not provide a pathway for vascular surgery intervention. These centres do not act as a referring centre for the vascular complications, and it is possible that a patient with vEDS may present to any emergency department in the UK and the patient perspective in this paper reflecting the challenges they face is powerful. Indeed, this paper provides a unique view in as much as we have included a patient perspective on the current acute management of patients with vEDS. While this is a single patient's experience, it resonates with experiences of other patients and charities are actively engaging with numerous medical specialties (including emergency department staff) focusing on triage, the signs and symptoms of vascular emergencies and the need for a low threshold for imaging as patients can commonly present with relatively minor symptoms underlying a major arterial problem.

Currently there are no evidence-based guidelines for surveillance, and it is likely that an individualised approach is required. The lack of high-quality natural history data also make decision making regarding when to intervene in asymptomatic complications difficult. Again, more comprehensive natural history studies will help fill this gap in knowledge.

There is only one pharmacotherapy with a strong evidence base for reducing complication rates in patients with vEDS. The randomised controlled trial by Ong et al of the oral β-blocker celiprolol showed a significant reduction in arterial complications after a mean follow-up of 47 months (50% vs 20%).[16] Celiprolol is a cardioselective β1 blocker with a β2 agonist vasodilatory effect. This results in a reduction in both heart rate and pulse pressure leading to a reduction in mechanical stress on the collagen fibres within the arterial wall. All patients should be considered for celiprolol therapy administered twice daily and titrated up to a maximum dose of 400 mg daily.

With the focus of this review being on human studies, we have not addressed the ongoing research being conducted in animal models which investigate new therapies.

The fragility of the arteries in this cohort of patients makes any arterial intervention complex and challenging. This is reflected in the outcomes from the three cohorts highlighted in this review. The lack of other large cohort studies and the larger number of case reports reflects the uncommon nature of the condition. The take-home message from the studies appears to be to treat any vascular complication non-operatively where possible, simplify the operative technique if intervention is required, endovascular intervention is appropriate and can be first line to arrest haemorrhage and that intervention can fail early and this needs to be recognised within the early post-intervention period. Patients with vEDS can develop arterial complications within any vessel and not just the aorta and, as such, endovascular intervention can provide less risk than open surgical management of difficult to access/manage vessels. Arterial access complications affecting either the femoral or brachial arteries can be easier to manage than more challenging management of the primary arterial complication. In the UK, such patients should be managed wherever possible within centres with the range of skills that may be required throughout the patient's acute management.

KEY MESSAGES

- vEDS is uncommon but can be a devastating condition with high morbidity and early mortality
- Patients can have significant arterial pathology even when presenting with mild or minor symptoms. Have a low index of suspicion and low threshold for imaging.
- vEDS patients with arterial problems are complex and challenging to treat and should be managed in hospitals with appropriate skill sets.

The review has obvious limitations. The evidence base on vEDS is limited, which reflects the relatively rare nature of the condition, yet the overarching aim of this review is to draw attention and focus on the condition and to stimulate discussion within vascular surgical services and networks in the UK about how they would manage patients with vEDS and vascular complications.

Conclusion

vEDS is an uncommon condition often with a delayed diagnosis and life-threatening complications. Our understanding of vEDS is improving, but it is important that all vascular surgeons are aware of the condition, that it has a low threshold for investigation of minor symptoms and that they have access to the required facilities to treat such patients.

Conflict of Interest: None.

Funding: None.

Reviewer acknowledgement: *JVSGBI* thanks Dan Carradice, Hull York Medical School and the Editorial team for their contribution to the peer review of this work.

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Vascular EDS: A patient's perspective.

Although I wouldn't wish vascular Ehlers–Danlos Syndrome (vEDS) on my worst enemy, I consider myself very fortunate to have a confirmed diagnosis. Many people with vEDS are not diagnosed until after they have a major complication, or there is a sudden death in the family. My own mother died suddenly when I was 14 from acute mitral valve prolapse aged 49. Although never confirmed, it is possible that my mother had vEDS. But at the time her cause of death was attributed to Marfan's syndrome, and Von Willebrand disease was queried during her lifetime, as is sometimes the diagnostic journey for people with vEDS.

My parents raised concerns when they noticed easy bruising, skin tearing and blood in my stools in early childhood. I grew up with the understanding that I had vEDS, but my diagnosis was not 'rubber stamped' until later in life when genetic testing confirmed a mutation of the COL3A1 gene which is known to cause vEDS. Having a diagnosis has allowed me to alter my lifestyle, take medication, and benefit from regular scans and monitoring. All of which give me a better chance of improving my life expectancy. My diagnosis has also allowed me to make informed decisions on matters such as having a family.

This patient perspective will predominantly focus on access to care. It reflects what I have experienced, but also the experience of other patients with vEDS.

The absence of specialist out-of-hours support, the need for unplanned access to emergency medical care, and the rare nature of the condition means that I often rely on my ability to self-advocate to get the care I need. Experiencing multiple major vascular complications has led me to a better understanding of vEDS. I recognise the challenges facing doctors in the management of rare conditions, and feel strongly that collaboration between patient and doctor can improve health outcomes for vEDS patients. Unfortunately, despite a history of vascular complications, I have still experienced misdiagnosis within an emergency setting. The main barrier to appropriate medical care is awareness of the underlying disease process, specifically the fragility of vessels.

Living with vEDS and managing my health is a constant risk assessment. I don't feel safe in my own body because, at any time, without any warning, I could have a life-threatening problem. As unexplained symptoms occur, I have to consider where and when I access care, however minor the symptom, as even the most innocuous symptom can be serious. Some symptoms fall into a grey area between emergency and primary care services and require specialist time-sensitive medical assessment. vEDS patients fear being perceived as overanxious, and 'the boy that cried wolf' if they attend A&E for symptoms that turn out to be non-urgent. Due to the complex nature of my vascular history and the development of relationships with the local vascular team over many years, I now am comfortable contacting the vascular surgery team directly with any concerns. This is the exception, not the norm. I would champion all patients with vEDS having this sort of access to vascular services, as it would enhance the patient experience, health outcomes and understanding of the condition.

While I am more confident in my local healthcare providers due to my engagement with both the emergency department and the vascular surgery department, I have concerns when I am travelling to other parts of the country. I am uncertain whether the systems in place, and my ability to advocate for myself, will be enough for me to get the timely care I need. So, I continue to work to raise awareness in the hope that this will improve the outcomes for both patient and doctor.

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Journal of
VASCULAR SOCIETIES
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J.Vasc.Soc.G.B.Irel. 2023;2(2):91-96
http://doi.org/10.54522/jvsgbi.2022.053

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PROTOCOL

Assessment of the diagnostic accuracy of automated ankle brachial pressure index devices in patients with diagnosed or suspected peripheral arterial disease: protocol for a systematic review and meta-analysis

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Received: 3rd August 2022
Accepted: 18th October 2022
Online: 22nd November 2022

Plain English Summary

Why we are undertaking this work: Peripheral arterial disease is a common condition where narrowing of the blood vessels in the legs can reduce blood flow. This may cause symptoms that include calf, thigh and/or buttock pain when walking and this can progress to cause pain at rest and leg ulcers. The ankle brachial pressure index is a measurement that can be used to assess peripheral arterial disease. Currently, this is measured manually using a blood pressure cuff and ultrasound probe, though time constraints and staff training limit its widespread use. This causes difficulty in the assessment and diagnosis of peripheral arterial disease, particularly in primary care. There are automated ankle brachial pressure index devices available, which may alleviate some of this difficulty. However, there is limited evidence regarding their accuracy in diagnosing peripheral arterial disease.

What we aim to do: We plan to review the current evidence available for the accuracy of automated ankle brachial pressure index devices in people with known or suspected peripheral arterial disease. We will look at studies that have compared automated devices with the current methods used for diagnosing peripheral arterial disease including manual doppler ankle brachial pressure index measurements and vascular imaging.

What this means: We hope the results from this review will be used to inform clinical practice and guide future clinical trials.

Key words: ankle brachial pressure index (ABPI), oscillometry, doppler, peripheral arterial disease (PAD)

Review registration: Prospero ID CRD42022343920

Abstract

Background: The ankle brachial pressure index (ABPI) is a common diagnostic tool used in the assessment of peripheral arterial disease (PAD). The Doppler ultrasound technique is regarded as the gold-standard method for ABPI measurement; however, time constraints and operator experience limit widespread application in clinical practice, particularly in a primary care setting. Automated ABPI devices are not currently widely used due to a lack of evidence regarding their diagnostic accuracy. The aim of this proposed systematic review and meta-analysis is to explore the current evidence for the accuracy of automated ABPI devices in people with known or suspected PAD.

Methods: Systematic searches of electronic databases and grey literature will be performed. We plan to include studies of adult patients with diagnosed or suspected PAD that have compared automated ABPI device readings with manual Doppler ABPI measurements or confirmed the diagnosis of PAD using vascular imaging. Two independent reviewers will screen identified literature for inclusion and perform data extraction. Extracted data will include study and participant characteristics, a description of the index and reference tests, outcome measures and main findings. The methodological quality of selected studies will be assessed using QUADAS-2 and QUADAS-C. Meta-analysis will be performed for studies with paired designs using a bivariate random-effect model to provide pooled estimates of summary accuracy statistics. We intend to conduct subgroup analyses and meta-regression for suspected sources of heterogeneity.

Discussion: This review aims to assess the diagnostic accuracy of automated ABPI devices for detecting PAD in patients with known or suspected PAD compared with manual Doppler ABPI measurements or vascular imaging. These results will be used to inform clinical practice and guide future trials.

Background

Target condition being diagnosed

Peripheral arterial disease (PAD) is a prevalent cardiovascular disease, estimated to affect approximately 236 million people worldwide.[1] PAD is characterised by progressive narrowing of the arterial lumen, reducing blood flow to the distal extremities.[2] Classic symptoms include exertional calf, thigh and/or buttock pain known as intermittent claudication, and with disease progression patients may develop ischaemic rest pain, arterial ulceration and limb loss.[3] The presence of PAD is also associated with an increased risk of myocardial infarction, ischaemic stroke, and death.[4,5] However, more than 50% of patients with PAD are asymptomatic and are therefore commonly underdiagnosed and undertreated.[6] Detection of symptomatic or asymptomatic PAD is crucial to allow for the appropriate management to reduce disease progression and associated cardiovascular morbidities.

Index test and alternative tests

The ankle brachial pressure index (ABPI) is a non-invasive diagnostic tool widely used in the assessment of PAD and is a vital part of the clinical pathway. ABPI values of <0.9 are regarded as diagnostic for PAD, with lower values indicating increasing severity.[7,8] The manual Doppler ultrasound technique is considered the gold-standard method for ABPI measurements.[9] This technique uses a sphygmomanometer and Doppler ultrasound probe for accurate arterial flow readings in the brachial arteries of both arms, and usually the posterior tibial and dorsalis pedis arteries of both legs. The index is calculated for each leg by dividing the highest of the ankle pressures by the highest arm pressure.[10]

Imaging modalities can be used in the assessment of PAD, particularly when revascularisation procedures are being considered. These include duplex ultrasonography, contrast-enhanced magnetic resonance angiography (MRA) and computed tomography angiography (CTA). Duplex ultrasonography is the first-line imaging technique for patients being considered for revascularisation. It is easily accessible and inexpensive but is limited in the assessment of multi-level stenoses and heavily calcified vessels.[11] MRA has a high diagnostic accuracy for PAD and is used in patients who require further imaging following duplex ultrasonography prior to revascularisation. CTA can also be used as an alternative imaging method when MRA is contraindicated or not tolerated.[10]

Clinical pathway

In the UK, an initial PAD assessment should be performed in the primary care setting. A patient who presents with features of intermittent claudication, defined as reproducible calf, thigh and/or buttock pain on exertion, or with features of critical limb-threatening ischaemia, defined as the presence of chronic rest pain, skin changes such as ulceration, non-healing wounds and/or gangrene, should be assessed for possible PAD. Such an assessment is also indicated in patients with diabetes, unexplained leg pain, those who require compression hosiery and those being considered for interventions to the leg or foot. The assessment for PAD involves a clinical history, lower limb examination and ABPI measurement.[10]

An ABPI value of <0.9 is regarded as confirming the presence of PAD, though a resting ABPI value of ≥0.9 does not necessarily exclude the diagnosis of PAD, particularly in the presence of a positive history, risk factors, or if the value is >1.4.[12,13] Regardless, ABPI assessments performed in primary care facilitate earlier PAD diagnosis, therefore improving patient outcomes.[14,15] In addition, most PAD management can also be executed in the primary care setting with referral to secondary care only indicated in the case of non-responding or worsening symptoms of intermittent claudication or in the case of critical limb-threatening ischaemia.

An outline of the initial assessment and management pathway for patients presenting to primary care with varying degrees of suspected PAD is summarised in Figure 1, based on current guidelines from the National Institute for Health and Care Excellence (NICE).[10] To follow these guidelines on assessment and management, it is important that ABPI measurements are widely available in the primary care setting.

However, manual ABPI measurements can be time-consuming, as a period of supine rest is recommended prior to the measurement being taken and the blood pressure in each of the six arteries is measured separately.[16] This, in combination with the limited expertise available in the primary care setting, means that ABPI measurements are often not performed when indicated, resulting in secondary care referrals being made earlier than necessary to diagnose or exclude PAD.[17,18] These factors may also preclude the measurement of ABPI, when indicated, in other healthcare settings outside of a vascular centre.

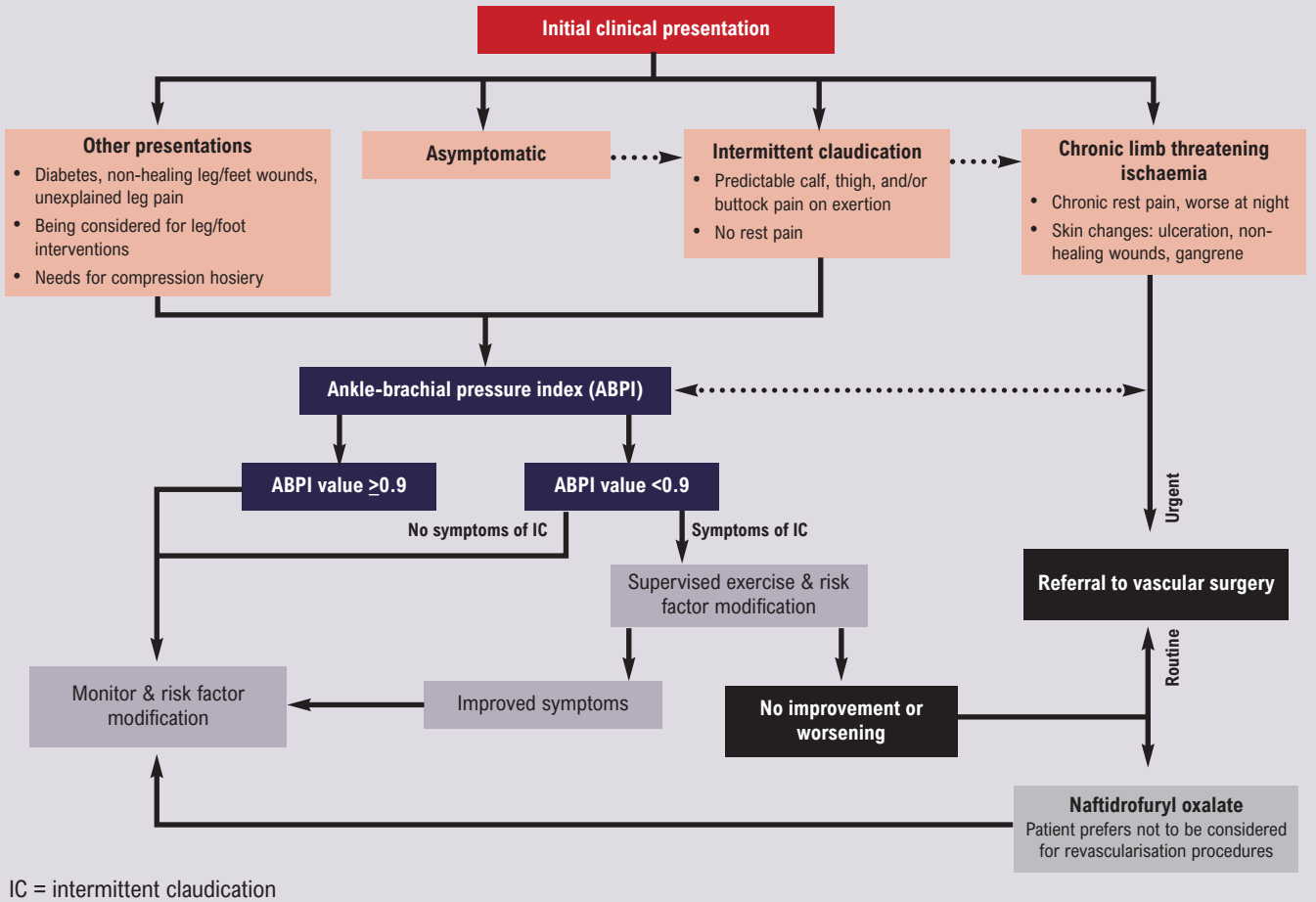
Rationale

Automated devices are becoming increasingly common for brachial blood pressure measurements in clinical practice, largely due to their simplicity and accuracy when compared to the traditional auscultation of Korotkoff sounds.[19] Such devices are also available for automated ABPI measurements. However, they are not currently widely accepted by the vascular, and wider, community due to limited evidence surrounding their accuracy and diagnostic performance in PAD. It is also not clear whether the diagnostic accuracy differs between device manufacturers.

Automated ABPI devices have the potential to replace manual ABPI measurements, which may negate the need for many secondary care referrals, particularly if PAD is not present, patients are asymptomatic or symptoms are mild.[10] Additionally, automated devices may improve accessibility to ABPI measurements in a variety of community and non-vascular settings. As such, these devices have the potential to improve patient care and alter the clinical pathway, better aligning it to what is recommended in the NICE guidelines (ie, diagnosis and management in primary care).

A previous systematic review was conducted in 2012, considering the reliability of automated ABPI devices. This review

Figure 1 Pathway for the initial assessment and management of patients with PAD.



IC = intermittent claudication

concluded that automated ABPI devices are valid and provide a practical alternative for the detection of PAD. However, sensitivity was low at 69%, prohibiting automated devices from replacing manual ABPI measurements due to their inferior test accuracy.[20] In the 10 years following this study, new automated devices have been developed which may have improved sensitivity and specificity for PAD diagnosis. Therefore, the aim of this study is to provide an updated review of the evidence considering the role of automated ABPI devices in the detection of PAD in patients with known or suspected PAD.

Objectives

Our primary objective is to determine the diagnostic accuracy of automated ABPI devices for detecting or excluding PAD in people with known or suspected PAD.

Our secondary objectives are to identify whether the accuracy of these measures is altered by differences between device manufacturers, study setting (ie, primary and secondary care) and participant characteristics.

Methods

Protocol development

This protocol has been developed using the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy and will be reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses of Diagnostic Test Accuracy (PRISMA-DTA).[21,22]

Eligibility criteria

Types of studies

We plan to include all cross-sectional comparative studies written in the English language which evaluate the accuracy of automated ABPI devices for diagnosing or excluding PAD. Only fully paired direct comparisons will be included whereby each patient was tested using an automated ABPI device and via the manual method or another reference standard. Patients may also be randomised to receive one (of multiple) automated device or randomised to be assessed via an automated ABPI device or via the manual method. Such studies will be included if an appropriate reference standard is

also used for each randomised patient. No exclusions will be made based on methodological quality or sample size.

Participants

Studies with adult participants (18 years of age and older), of any sex, in any clinical setting, who have suspected or previously diagnosed PAD will be eligible for inclusion. For those with suspected PAD, we will include all groups for whom an ABPI is indicated according to the NICE guidelines.[10] This includes patients who (i) have symptoms suggestive of peripheral arterial disease; or (ii) have diabetes, non-healing wounds on the lower limbs or unexplained leg pain; or (iii) are being considered for lower limb interventions; or (iv) need to use compression hosiery.

Index test

The index test to be reviewed is automated ABPI, captured by oscillometric or plethysmographic devices. Any automated ABPI device and method will be included, regardless of whether the device has been validated for use in PAD. An ABPI value of <0.9 is widely regarded as the cut-off value for diagnosing PAD; however, studies will not be excluded if they have used different threshold values and this will be accounted for during statistical analysis.

Target condition

PAD is the target condition for this systematic review, which the index and reference tests are intended to identify or exclude. Studies may categorise PAD into asymptomatic, intermittent claudication and critical limb-threatening ischaemia. No exclusions will be made based on categorisation.

Comparative test and reference standards

The comparative test considered to be the reference standard in this review will be the manual Doppler ABPI measurements. Manual Doppler ABPI measurements should be taken using a sphygmomanometer and Doppler ultrasound probe and any recognised method for calculating ABPI will be included. Additional reference standards used to confirm the presence or absence of PAD can include Doppler ultrasonography, MRA or CTA. Studies that include additional measures to assess vascular status, such as toe brachial pressure index, will be included; however, these data will not be included in the analysis.

Search strategy

Electronic searches

Systematic searches will be performed using the MEDLINE, EMBASE, CENTRAL, and CINAHL databases. MeSH terms with full text synonyms will be searched and include ("peripheral arterial disease" or "peripheral arter* disease") and ("ankle brachial index" or "ankle brachial pressure ind*") and ("oscillometr*" or "plethysmograph*"). A draft search is shown in Appendix 1 (online at www.jvsgbi.com). Searches will be restricted to articles written in the English language; no date restrictions will be applied.

Searching other sources

The reference lists of all included studies and screened full texts will be manually reviewed for additional relevant papers. Clinical trial registries including ClinicalTrials.gov and the Clarivate Web of Science: Conference Proceedings Citation Index will be searched for ongoing studies and authors will be contacted for results where possible.

Data collection and analysis

Selection of studies

Search results will be uploaded onto the Covidence systematic review software, which automatically removes duplicated articles.[23] The titles and abstracts will be screened for eligibility by two independent reviewers, and full texts of potentially relevant articles will then be independently reviewed for inclusion. Any disagreement between reviewers at either stage will be resolved by consensus or with a third reviewer. When full texts are not obtainable via conventional access methods, the authors and publishing journal will be approached to request the full article text. The number of search hits, number of duplicates removed, number of full texts reviewed, number of full texts excluded with reasons and the number of studies included will be reported using the PRISMA flow diagram.

Data extraction and management

Extraction of relevant data will be performed by two independent reviewers and recorded on two separate Microsoft Excel spreadsheets, using a bespoke data extraction form. Data extraction will be based on the Cochrane handbook.[24] The extracted data will include: (i) study characteristics including year of publication, country, study design, sample size, duration, setting, and inclusion and exclusion criteria; (ii) participant characteristics including age, sex and comorbidities; (iii) description of the index test including automated device name, operator and device validation; (iv) description of the reference test(s) including equipment, operator and method for calculating ABPI if appropriate; and (v) findings related to primary and secondary outcomes, including results to recreate 2x2 diagnostic tables for estimating test accuracy. Any discrepancies in the extracted data will be resolved by reviewing the original article.

Assessment of methodological quality

Studies that meet the eligibility criteria will be appraised for risk of bias and applicability by two independent assessors using the quality assessment of diagnostic accuracy studies (QUADAS-2) tool and the QUADAS-C extension for comparative diagnostic accuracy studies.[25,26] The QUADAS-C tool is shown in Appendix 2 (online at www.jvsgbi.com). Any disagreement between reviewers will be resolved by consensus or with a third reviewer. Each study will be assessed on patient selection, index test, reference standard, and flow and timing, with each domain being classified into one of three categories: (i) high risk of bias; (ii) unclear risk of

bias; and (iii) low risk of bias. The effect of methodological quality will be accounted for in subgroup analyses.

Statistical analysis and data synthesis

Statistical analysis will be performed using R package mada in R language version 4.1.[27] Initial data synthesis will include cross tabulation of the binary outcomes 'PAD' or 'no PAD' for automated ABPI against the reference standard, manual ABPI in diagnostic 2x2 tables (ie, true positives, true negatives, false positives and false negatives). If 2x2 tables are not provided directly, they will be back calculated from raw data where possible.[24] Where data are missing to allow construction of 2x2 tables, the study authors will be contacted.

Studies with fully paired designs will be entered into a meta-analysis. The patient will be the unit of analysis. Due to expected variations in the unit of analysis used by included studies, an analysis will be performed to evaluate the impact of the unit of analysis (ie, patient vs limb). Forest plots with 95% confidence intervals (CI) and summary receiver operator characteristic (SROC) curves with 95% prediction and 95% confidence regions will be produced as part of initial exploratory analyses. Given the anticipation of a common threshold (ABPI <0.9) and for substantial study heterogeneity, as is expected in a meta-analysis of diagnostic test accuracy, we will use a bivariate random-effect model to provide pooled estimates of summary accuracy statistics.[21] If there is evidence of a threshold effect, the hierarchical SROC model will be used.[28] All SROC curves will be plotted with studies as weighted data points.

We plan to perform subgroup analyses and meta-regression for: (i) study characteristics (eg, study design, study setting and study quality); (ii) participant characteristics (eg, age, sex, diabetes, hypertension, smoking status and PAD severity); and (iii) comparative index test characteristics (eg, unit of analysis, ABPI calculation method, automated device type, device validation status, reference standard and threshold effect, if appropriate). This will allow us to investigate the impact of these subgroups on automated ABPI diagnostic test accuracy.

Investigations of heterogeneity

Study heterogeneity will be assessed by visual inspection of coupled forest plots and SROC plots. We expect that included studies will use a common ABPI threshold of 0.9; however, there may be slight variation in the threshold used due to equipment calibration and differences between operators.

We intend to use Spearman's correlation coefficient to test for the presence of a threshold effect as a source of heterogeneity. For this, we will use the sensitivity and specificity of all studies and r $\geq$0.6 will indicate the presence a threshold effect.[29] The aforementioned subgroup analysis will also allow us to investigate the effect of these sources of heterogeneity on automated ABPI diagnostic test accuracy.

KEY MESSAGES

- ABPI is a common diagnostic tool used in the assessment of PAD.
- Automated ABPI devices are not currently widely used due to a lack of evidence regarding their diagnostic accuracy.
- We aim to summarise the current evidence for the accuracy of automated ABPI devices in people with known or suspected PAD.

Assessment of reporting bias

The presence of publication bias will be assessed visually using a funnel plot. If more than 10 studies are included in the analysis, funnel plot asymmetry will be examined using Deeks' test.[30]

Discussion

This protocol outlines a systematic review to assess the diagnostic accuracy of automated ABPI devices for detecting or excluding PAD in people with known or suspected PAD. The manual Doppler ABPI method is currently the recommended first-line investigation for PAD, though there are certain drawbacks such as the time and expertise required for measurement. These limitations also mean that ABPI measurements are rarely obtained in primary care, as is recommended in NICE guidelines. This leads to referrals to secondary care to diagnose or exclude PAD. In addition, it also means that ABPI measurements are rarely obtained in other settings including community healthcare services, prison healthcare services and non-vascular district general hospitals. Automated devices have the potential to overcome some of these drawbacks, making ABPI measurements more accessible in a variety of settings and reducing the need for some secondary care referrals. These devices are not currently widely accepted due to concerns surrounding their accuracy, particularly their sensitivity.[20] However, the contemporaneous evidence for such devices is yet to be fully evaluated, an evidence gap that this review aims to fill.

An anticipated limitation of this review is considerable heterogeneity amongst study characteristics and outcomes measured, making statistical comparison challenging. Such heterogeneity has been identified in a previous review, mostly due to differences in automated devices used and methods for manual ABPI measurements.[20] We plan to assess the impact of these sources of heterogeneity during our subgroup analyses.

Overall, this review aims to summarise the current evidence for the accuracy of automated ABPI devices. The results will be used to aid medical professionals in the diagnosis of PAD, altering the current clinical pathway and aligning it to what is recommended in NICE guidelines. The results may also assist in providing eligibility criteria framework for future trials designed to validate new automated ABPI devices.

Conflict of Interest: IC is the editor and chief of *JVSGBI*.

Funding: None.

Reviewer acknowledgement: *JVSGBI* thanks Colin Davies, Cheltenham General Hospital, and Fiona Miller, King's College Hospital NHS Foundation Trust, London, for their contribution to the peer review of this work.

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J.Vasc.Soc.G.B.Irel. 2023;2(2):97-102
http://doi.org/10.54522/jvsgbi.2023.054

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PROTOCOL

Dosing and efficacy of extracorporeal shockwave therapy for diabetic foot ulcer healing: a systematic review protocol

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Received: 23rd August 2022
Accepted: 12th October 2022
Online: 6th January 2023

Plain English Summary

Why we are undertaking this work: Diabetic foot ulcers are difficult to heal and are often resistant to treatment. Shockwave therapy is a type of treatment that delivers soundwaves onto the surface of ulcers with a gel paddle. Small studies have shown it may improve healing, but the data are not clear.

What we will do: To investigate the effect of shockwave therapy on diabetic foot ulcer healing, we are going to do a systematic review. A systematic review is a way of bringing together the results from existing studies to decide if a treatment is effective or not. This paper describes how we are going to bring all the existing studies on shockwave therapy together to decide if it should be used in routine practice to treat patients with a diabetic foot ulcer. We are going to search databases for published and unpublished studies that randomly allocate people with a diabetic foot ulcer to shockwave therapy or not. We will combine results on how fast ulcers healed in the different studies using a mathematical test. This will tell us if shockwave therapy was better than usual care in healing diabetic foot ulcers.

What this means: The results from the systematic review will tell us if shockwave therapy should be used in routine practice or if more research is needed. It will also allow other researchers to repeat the systematic review if they wish.

Key words: diabetic foot, wound healing, extracorporeal shockwave therapy

Abstract

Background: Effective interventions to improve diabetic foot ulcer (DFU) healing are urgently required. Extracorporeal shockwave therapy (ESWT) has the potential to transform DFU care, but is limited by uncertainties around clinical effectiveness and optimal dosing regimen. This protocol outlines the methodology of a systematic review that will address these unknowns.

Methods: Databases and the grey literature will be searched for randomised controlled trials (RCTs) comparing ESWT plus standard ulcer care to standard ulcer care ± sham ESWT in patients with a DFU. The primary outcome of the review is time to ulcer healing. Two independent reviewers will screen search results against pre-determined eligibility criteria and extract data onto a pre-piloted spreadsheet. A meta-analysis is planned to compare time to healing for ESWT versus standard care and different doses of ESWT. The Risk of Bias 2 and GRADE tool will be used to assess the quality of the evidence.

Outputs, dissemination, impact: The review will provide an estimate of the effect of ESWT on DFU healing and the impact of the ESWT dose on DFU healing. The systematic review will be submitted for publication in a peer-reviewed journal. A plain English summary will be produced. Outputs from the review will guide patient care and research.

Introduction

With the rapidly increasing prevalence of diabetes, effective interventions to tackle the complications are urgently needed. Diabetic foot ulcers (DFU) occur in 25–30% of patients with diabetes and are particularly challenging to heal in a timely manner.[1–4] Delays in ulcer healing increase the risks of localised infection, sepsis, major limb amputation and mortality.[5,6] Current therapies consist of simple dressings, offloading footwear, antibiotics for infection and anti-hyperglycaemic medications.[7,8] The introduction of advanced therapies to treat DFU has been challenging due to inconsistent evidence around

effectiveness. This has resulted in DFU care being left behind medical advances seen in other areas.

Extracorporeal shockwave therapy (ESWT) has been trialled in patients with DFU for over 10 years and previous systematic reviews have reported positive results.[9–11] Despite this, transition into routine care has not taken place. The International Working Group on the Diabetic Foot (IWGDF) guideline on wound healing interventions do not recommend the routine use of ESWT in preference to standard care due to uncertainties around treatment effect.[8]

Another area of consideration in developing ESWT for routine clinical practice is dosing. A previous systematic review highlighted the variation in dosing schedules used by different trialists.[10] Laboratory-based studies using murine and human skin wound models have demonstrated a dose-dependent relationship between number of shockwaves and speed of wound healing and expression of angiogenetic markers.[12,13]

This systematic review is designed to answer the following questions:

- Does ESWT reduce DFU healing time?
- Does the number of shockwaves delivered during ESWT affect DFU healing time?

Methods

This protocol is registered on PROSPERO (CRD42022312509) and reported with reference to the PRISMA-P guidance.[14]

Eligibility criteria

Participants

Inclusion criteria:

- Diagnosis of diabetes mellitus
- Diabetic foot ulcer (neuropathic or neuroischaemic)
- Assessment of lower limb perfusion
- Over 18 years of age

Exclusion criteria:

- Contraindications to ESWT: anticoagulation medication, malignancy in the treatment area, lymphoma, leukaemia, dissemination malignancy, breast feeding or pregnant

The review will include participants who have a diagnosis of diabetes mellitus and a non-healing foot ulcer below the medial malleolus. We will not specify how diabetes is diagnosed nor the minimum age of the ulcer. Method of assessing adequate limb perfusion must be detailed. There will be no limitation on DFU classification used. Additional information on patient factors known to impact healing will also be collected.[15]

If a study population includes all types of 'chronic wounds', it will be considered for inclusion if the study population with a DFU meets the above criteria and is reported separately in the trial. This population will be included in the narrative synthesis only due to biases arising from breaking the randomisation sequence by segregating this population. If this is not clear from the manuscript, the corresponding author will be contacted. The effect of including any studies like this will be explored in the analysis.

Intervention

The review will include all dosing schedules of ESWT. This includes how many shocks per cm^2 were delivered, the penetration of shockwaves, the shockwave energy used, how many pulses per second were used and how frequently the treatment was given. We will compare whether variations in schedules of ESWT impacts DFU healing. ESWT must be in addition to standard ulcer care (see below).

Control

The control arm must have either received standard ulcer care alone or standard care plus sham ESWT. Standard ulcer care should include information on types of dressing used, debridement, offloading footwear, glycaemic control and antibiotic use. If sham ESWT was not used, ideally the control would have undergone ulcer assessment at the same intervals as the intervention group during the ESWT treatment period. This is to counter any bias associated with increased frequency of ulcer care.

Outcomes

The primary outcome of the review is time to ulcer healing, measured in days. However, we will include any studies where an ulcer-related outcome is the primary outcome. If an otherwise eligible study does not report any ulcer-related outcomes, we will contact the corresponding author to ascertain whether the protocol was to collect data on ulcer healing and if there are unpublished data on ulcer healing. Secondary outcomes include:

- Proportion of ulcers healed at fixed time points.
- Quality of life: measured with a validated quality of life assessment tool that can either be generic or disease-specific.
- Economic analysis: quantified by cost of treatment, net health benefit, net monetary benefit or incremental cost effectiveness ratio.
- Infection rate: depth of infection will be reported as superficial or deep.
- Amputation rate: minor and major amputation will be reported separately. Minor amputation will be defined as a digital or forefoot amputation. Major amputation will be defined as below, through or above knee amputation.
- Diabetic foot ulcer-related hospitalisation rate.
- Ulcer-free days.

Study design

The review will only include randomised controlled trials (RCTs). A cross-over RCT will be eligible for inclusion in the narrative synthesis but not in the meta-analysis. This is because the length of treatment effect is currently unknown and even mitigating this by using only the first part of the trial data in a meta-analysis would result in a high risk of selection bias and reporting bias, and would

result in the exclusion of more than half of the trial data.

In the highly unlikely situation of a cluster RCT being identified, it will be included in the review but the results will not be used in the meta-analysis as it will not be possible to reliably carry out any individual level statistics.

There will be no restriction based on blinding. If the included trial is blinded, the review will report who was blinded (participant/outcome assessor) and how blinding was achieved. Treatment allocation must be randomised and we will not include any quasi-randomised trials.

Additional information gathered will be country(s) in which the trial took place, sector of care, funding sources, use of blinding and number of arms. We will include published and unpublished trials.

Information sources

Cochrane Wounds Group Specialised Register, Ovid MEDLINE®, PubMed®, EBSCO CINAHL Complete, Ovid EMBASE®, Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL), and Clinical Trials Registry will be searched. The reference lists of any included studies will be reviewed to identify any further studies. ESWT companies will be contacted for any unpublished data. If a trial is marked as ongoing or complete on a trial registry database, the chief investigator will be contacted for any available results. Existing systematic review reference lists will be searched for relevant studies.

The review will search the grey literature. This will include searching official publications (eg, NHS, NICE, UK government, Royal College and charity publications). The review will search pre-prints using medrxiv.org work and conference proceedings for unpublished work using OpenGrey. The review will also search for relevant PhD thesis and dissertation work using 'Open Access Thesis and Dissertations' and 'EThOS' databases.

Search strategy

Database searches will be restricted to English language only. This is because we do not have the resources to translate manuscripts. The search will also be limited to manuscripts published after 1 January 2000. ESWT is a relatively modern technique and articles older than 20 years are unlikely to be relevant. Box 1 outlines an example search strategy. Before the final analysis, the databases will be re-searched to identify any new studies. This will be an update of a previous systematic review.[10]

Box 1 Ovid®MEDLINE®ALL search strategy.

1. Diabetic Foot/
2. diabetic foot.mp.
3. DFU.mp
4. Wound Healing/
5. wound healing.mp.
6. High-Energy Shock Waves/ or Extracorporeal Shockwave Therapy/
7. wound heal*.mp.
8. re-epithelialis*.mp
9. ECSWT.mp.
10. extracorporeal shockwave*.mp.
11. ESWT.mp.
12. shockwave.mp.
13. shock wave.mp.
14. diabet*.mp.
15. Foot Ulcer/
16. heal.mp.
17. Ulcer/ or ulcer.mp.
18. wound.mp. or "Wounds and Injuries"/
19. 1 or 2 or 3 or 14 or 15 or 17 or 18
20. 4 or 5 or 7 or 8 or 16
21. 6 or 9 or 10 or 11 or 12 or 13
22. 19 and 20 and 21
23. limit 22 to (english language and yr="2000 -Current")

Study records

Study selection process

Two assessors will independently review the search results with reference to the study eligibility criteria for inclusion. The assessors will be blinded to each other's decision. Disagreements in studies will be discussed between assessors and, when a decision cannot be made, a senior researcher will make the final decision. The assessors will base their decision on article title, abstract or, if required, after reading the full article. Rayyan, a bespoke tool for conducting systematic reviews, will be used to enter search results and record decisions.[16]

Data extraction

Data will be extracted onto a specifically designed Microsoft Excel spreadsheet. The spreadsheet will be piloted prior to data extraction. Two reviewers will extract the data. Once extraction is completed, the reviewers will compare results. Any discrepancies will be checked and a third reviewer will be consulted if an agreement cannot be made.

Data items

- Study design: Only RCTs will be included. Information on method of randomisation, blinding, number of treatment arms and details of the power calculation will be collected.
- Participants: The number of participants in each study, number of participants in each arm and number of participants lost to follow-up/withdrawal will be collected. The following patient demographics will be collected: age, sex, ethnicity, diabetes type, HbA_{1c}, comorbidities and ambulatory status. The following ulcer demographics will be collected: number of active ulcers, site of index ulcer, duration of index ulcer, type or classification

of index ulcer, area and depth of ulcer and presence of infection.
- Intervention: The review will record the dosing schedule of ESWT. This includes type of ESWT (focused or radial), number of shocks per cm^2 delivered, the depth of shockwave penetration, shockwave energy density used, number of pulses per second and how frequently the treatment is delivered per week and total treatment course (in weeks). Standard wound care will be collected as below.
- Control: Standard wound care should be defined as per local, national or international guidelines. Details on type of dressing (as classified in the BNF wound management products), offloading footwear (as defined in the IWGDF guidance on footwear and offloading interventions), glycaemic control, antibiotic use and other adjuvant therapy will be collected.
- Measure of effect: All studies must report an ulcer-related outcome. This could be time to healing, proportion of ulcers healed at a time point or reduction in ulcer size. Secondary outcomes are quality of life, adverse events (amputation, infection, mortality) and economic outcomes. We will also record whether the analysis was an initiation to treat or per protocol analysis.
- Funding: The sources of trial funding will be recorded.
- Location/setting: The country in which the trial took place and healthcare setting (eg, outpatient clinic, community clinic, inpatient setting) will be recorded.

Where it is not possible to gain the above information from the full article, the corresponding author will be contacted.

Risk of bias

The Cochrane Risk of Bias 2 tool will be used to judge sources of bias in the included manuscripts.[17] Each manuscript will be judged for risk of bias for the primary outcome within the study. The risk of bias for outcomes across all the included studies will be summarised. Two reviewers will independently judge each study for bias and then compare results, coming to a decision if discrepancies arise. A third reviewer will be included if required to make the final decision.

The GRADE tool will then be used to judge the overall quality of the evidence in the review.[18]

Data synthesis[19]

The included trials' population, interventions, control and outcomes (PICO) will be tabulated and compared. ESWT, sham ESWT and standard ulcer care will be described and coded.

The trials will then be compared for similarity. The review will explore whether there are significant differences in the demographics of the trial populations, the dose of shockwaves and outcome measures.

The review will then determine whether the trial outcomes are suitable for synthesis. We wish to report time to healing; if the study does not report time to healing but reports the number of healed ulcers at certain time points, the corresponding author will be contacted for time to healing data. If the studies report reduction in ulcer size, we will derive the number of ulcers healed over the follow-up period. If the data are unclear, we will contact the study authors for further clarification.

Data analysis[20]

We plan to undertake a pairwise analysis to compare ESWT and standard wound therapy using a random effects model. We also plan to undertake a meta-regression to explore any effect of different doses of ESWT, comparing high-dose ESWT (500 shocks/cm^2 and above) and low-dose ESWT (250 shocks/cm^2 and below). Data will first be examined for skewness from the means and standard deviations by using the technique described by Altman and Bland.[21] If the data are skewed, they will be presented as medians and interquartile ranges in a table.

Time to event data will be analysed using the O-E and Variance method. We will convert the data into a log-rank scale and report the hazard ratio and standard error. Continuous ulcer-related outcomes (eg, reduction in ulcer size) will be reported as a mean difference with 95% confidence interval (CI). Dichotomous data (eg, healed/unhealed) will be reported as the risk ratio with 95% CI. The synthesis will be presented on a forest plot. The interpretation of mean differences will be: <0.2 is very small, 0.5 is moderate and 0.8 is a large effect.[22]

- Meta-regression: If there is a sufficient number of studies and data, we plan to undertake a subgroup analysis. There must be 10 studies for this to be undertaken.[20] We plan to undertake this because we are hypothesising that the more shockwaves delivered per cm^2, the quicker the time to DFU healing will be.
- Heterogeneity: Heterogeneity will be estimated and considered in the context of the studies and potential bias, as well as meaning on the meta-analysis overall result. We will consider the χ^2 and associated p-value as well as the I^2 statistic. If the inconsistency (I^2) is greater than 40% we will: check the data were entered correctly onto RevMan, consider whether the meta-analysis is appropriate (eg, if the direction of effect is in a uniform direction, if the interventions/populations are too different), consider whether the effect measure is appropriate and exclude studies.
- Missing data: In the first instance, missing data will be sought from the trial authors. If they are not available, they will be imputated from the dataset with replacement values from the mean.

Dissemination

The systematic review and meta-analysis will be submitted to a peer-reviewed journal for publication. We will also publicise our results on social media and will produce reports for the NIHR and Diabetes UK, including a Plain English Summary for patient groups.

KEY MESSAGES

- There is uncertainty about the role of ESWT in the promotion of DFU healing.
- Current clinical trials investigating ESWT in DFU report varying effectiveness.
- This protocol outlines a rigorous systematic review designed to evaluate whether ESWT reduces the time to DFU healing and whether the dose of ESWT has an impact on clinical outcomes.

Discussion

This protocol outlines the methods for systematically reviewing and summarising the evidence regarding ESWT for DFU healing to address uncertainties over the treatment effect and optimal dosing. The completed review is expected to guide clinicians, researchers and policy makers on the role of ESWT in DFU.

Previous systematic reviews on this topic, published by Omar *et al* in 2017, Hitchman *et al* in 2018 and Huang *et al* in 2020, report positive findings from the literature but call for further RCTs to increase confidence in the treatment effect.[9–11] The systematic review undertaken by Omar *et al* included all clinical trials (randomised, quasi-randomised, before-and-after and crossover) investigating ESWT in chronic ulcers of the lower limb. DFU contributed 39.6% of the combined population. The authors concluded there was 'mild-to-moderate' evidence for the use of ESWT in wound care.[9] High risk of bias and low certainty of evidence was highlighted in the review by Hitchman *et al* in 2018. The systematic review and meta-analysis of RCTs comparing ESWT to standard care reported ESWT was associated with improved DFU healing but called for further RCT evidence of ESWT before recommending it for routine care.[10] Huang *et al* repeated this review in 2020, but included two non-randomised trials (quasi-randomised[23] and a case-control study[24]) despite the inclusion criteria for only RCTs.[11] The review also did not include the large multicentre RCTs published by Snyder *et al* in 2018.[25] Huang *et al* concluded the same as the previous systematic review authors – more RCT evidence is needed.

The aim of this update is to synthesis data from the trials by Snyder *et al*[25] with existing data and to examine the effect of different doses of ESWT. For ESWT to translate into routine patient care, an evidence-based treatment protocol needs to be developed. Laboratory studies using wound models have found high-dose ESWT to be more efficacious than low-dose ESWT in augmenting healing.[12] Dosing in the current studies ranges from 100 shocks per cm^2 to 500 shocks per cm^2 and others give additional shocks over the anatomical location of arteries supplying the ulcer.[10] The impact of this needs to be further examined in humans to understand the mechanism of action of ESWT in DFU healing. This will guide treatment decisions and advance this potentially transformative therapy in the care of patients with DFU.

Conclusion

This protocol outlines how the evidence for the effectiveness of ESWT and optimal dosing of ESWT will be explored to answer key questions limiting the wider application of this potentially transformative therapy.

Conflict of Interest: None.

Funding: This study is funded by the NIHR Doctoral Research Fellowship NIHR301807. The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.

Reviewer acknowledgement: *JVSGBI* thanks Sophia Lewis, London North West University Healthcare NHS Trust, for the contribution to the peer review of this work.

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Journal of
VASCULAR SOCIETIES
GREAT BRITAIN & IRELAND

J.Vasc.Soc.G.B.Irel. 2023;2(2):103-108
http://doi.org/10.54522/jvsgbi.2023.056

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PROTOCOL

The DEFINITE Audit: a prospective audit of diabetic foot debridement in theatre – a protocol

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Received: 2nd September 2022
Accepted: 11th October 2022
Online: 17th January 2023

Plain English Summary

Why we are undertaking this work: Diabetes foot ulcers often become infected and require operations to treat the infection. The operation can either be to remove unhealthy tissue (debridement) or to remove infected toes (minor amputations). There are guidelines on the best way to perform these operations; however, there is variation in how these operations are performed.

What we will do: This is a worldwide study of patients with a diabetic foot complication who have a debridement or minor amputation. We will collect data on how surgeons treat patients before the operation, how surgeons perform the operation and the treatment patients receive after the operation. We will compare this to the guidelines. We will also collect data on how long wounds take to heal, the number of people who lose their leg (major amputation) and the number of people who died. This is to see if certain treatments result in better outcomes.

What this means: This study will help to identify areas for improvement in the care of diabetic foot complications and help to suggest which treatments result in better healing.

Key words: diabetic foot, wound healing, foot ulcer

Abstract

Background: People with diabetes are commonly affected by foot ulceration (DFU) and subsequent or concurrent infection (DFI). Surgical debridement is often needed to contain infection. Despite international guidelines, there remains significant variation in surgical practice of diabetic foot wound debridement in the operating theatre.

Methods: Diabetic Foot Ulcer Debridement in Theatre Audit (DEFINITE) is a global multicentre, prospective audit of consecutive patients undergoing a debridement or minor amputation in theatre for a diabetic foot complication. DEFINITE is led by the Vascular and Endovascular Research Network (VERN). The primary outcome is adherence to recommended practice as outlined in the International Working Group on the Diabetic Foot and Global Vascular Guidelines. Secondary outcomes are incidence of healing, re-admission, further amputation (minor and major) and mortality at 90 days. Anonymised data will be collected via REDCap. Eligibility and study registration at all hospital institutions performing in-theatre management of diabetic foot complications are eligible to participate after obtaining appropriate institutional level audit approvals. A lead clinician will be responsible for approvals and data management.

Pathway to impact: This audit addresses shared patient-clinician priorities and is supported by the UK Vascular Society multidisciplinary Special Interest Group on the Diabetic Foot. The results will be presented at international scientific meetings and submitted for publication in peer-reviewed publications. The results will also be used to initiate improvement in patient care.

Introduction

People with diabetes are at high risk of developing foot ulceration (DFU). Once established, diabetic foot ulcers are at risk of rapid deterioration and infection which can lead to bacteraemia and sepsis. Infected DFU is associated with high morbidity, limb loss and death.[1–3] The development of severe infection requires emergency hospital admission and surgery to remove necrotic and infected tissue, which is in turn associated with high levels of morbidity and mortality.[4,5] Often multiple episodes of wound debridement, with or without minor amputation, and intravenous antibiotics are required to

eradicate the infection. The economic impact is substantial with 0.9% of the UK National Health Service annual budget dedicated to the management of DFU.[6]

Patients and multidisciplinary clinicians recognise the scale and significance of this problem. Recently borne out in the Priority Setting Partnership led by the Vascular Society of Great Britain and Ireland (VSGBI) in collaboration with the James Lind Alliance (JLA),[7] 'improving outcomes in diabetic foot infections' is a top shared research priority.[8]

There are guidelines available to support practice, primarily aimed at improving healing rates following debridement and reducing the incidence of major lower limb amputation.[9–11] The International Working Group for Diabetic Foot (IWGDF) guidelines[10] and The Global Vascular Guidelines on the Management of Chronic Limb-Threatening Ischemia[11] outline critical recommendations on dealing with infected DFUs. In brief, these guidelines advise removal of all infected and necrotic tissue, drainage of sepsis, effective irrigation, sample collection for microbiological analysis, adequate dressing and sensitivity-driven antimicrobial use.

The Diabetic Foot Ulcer Debridement in Theatre Audit (DEFINITE) aims to assess the current pathways of care for patients with diabetes who undergo a digital amputation and/or foot wound debridement and compare surgical practice with the IWGDF and Global Vascular Guidelines. Secondary aims are to investigate if variations in practice are linked to wound healing rates, reoperation rates (further debridement or minor amputation), 3-month major lower limb amputation rates and 3-month readmission rates. It is hoped that the data gathered will support advances in diabetic foot care addressing a shared patient-clinician research priority.

Methods

Design

This is a multicentre, prospective service evaluation audit conducted in hospitals around the globe. It is delivered through the Vascular and Endovascular Research Network (VERN), a trainee-led national research collaborative that engages with research-active vascular trainees and allied healthcare professionals.

Eligibility criteria

All patients undergoing debridement of a foot wound or minor amputation in the operating theatre with a confirmed diagnosis of diabetes will be included in the audit. A separate record will be created if the patient undergoes debridement or minor amputation in the contralateral limb during the study period.

Patients will be excluded if they have foot wound debridement or minor amputation in a setting other than the operating theatre or if they are younger than 18 years. Patients who have undergone ipsilateral foot debridement or minor amputation in the preceding 6 weeks, and this index event is outside the study period, will also be excluded.

Outcomes measures

The primary outcome is adherence of current practice in debridement and minor amputation of diabetic foot disease to the recommendations outlined in the IWGDF[9] and Global Vascular Guidelines[10] (see Supplementary Information in Appendix 1 online at www.jvsgbi.com). Adherence is defined as the extent to which the procedure undertaken corresponds to the guidance. The audit will report adherence to each item in the guidance as well as overall adherence. Secondary outcomes are the incidence of healing at 3 months, the 3-month reoperation rate, readmission rate, minor and major lower limb amputation rates, the type of microorganisms isolated from diabetic foot tissue samples taken intraoperatively, and the duration and type of antibiotics administered after such procedures.

Recruitment

The DEFINITE audit is open to all centres which provide elective and/or emergency surgical management for diabetic foot infection. One team member acting as site lead clinician will be the point of contact between the DEFINITE audit team and the local audit team. They will register their hospital/site and team members for the audit by completing an online form found on the VERN website, that includes collection of information on existing diabetic foot services in the participating centres. The lead clinician will have overall responsibility for ensuring the audit is conducted according to the standards and methods described in this protocol at their hospital/site, and any instances of non-compliance will be reported by them to the DEFINITE audit team. The anticipated number of audit team members per centre is one lead clinician and five other team members, such as medical trainees, allied healthcare professionals and medical students. If centres include more than five additional team members, it is expected that allied healthcare professionals and/or medical students are included.

Prospective registration of the DEFINITE audit is required prior to data collection. It is the responsibility of the local audit lead to ensure this is complete.

Participant cases will be identified by a member of the DEFINITE team at each centre as per the inclusion/exclusion criteria, using acute admission lists, diabetic foot ward rounds and operating lists (as per local practice). Patient/disease registries will not be screened to identify potential participants. Queries regarding participant eligibility will be directed to the lead clinician, and non-resolution referred to the VERN team.

Data collection

The complete data collection form is available as Supplementary Information in Appendix 2 online at www.jvsgbi.com and at www.vascular-research.net/definite/.

Anonymised data collected will include baseline demographics (age, gender, smoking status), comorbidities, medications, American Society of Anaesthesiologists (ASA) physical status and previous re-vascularisation procedures.

Preoperative data will include COVID-19 status, use of variable rate insulin infusion, medications (regular insulin, steroids and anticoagulants), white cell count, and C-reactive protein, haemoglobin, creatinine and albumin levels. The audit will also collect the indication for the operative procedure, infection status of the contralateral limb, wound ischaemia foot infection (WIfI) stage,[1] whether osteomyelitis was suspected and preoperative antibiotic use. Preoperative antibiotic use will include length of antibiotic course prior to procedure, route of administration, type of antibiotic used and whether any preoperative topical antibiotics were used.

Intraoperatively, the audit will collect data on the speciality which the procedure was performed under, the type of procedure (debridement, digit amputation, both), urgency of the procedure, operative time, skin preparation solution used, irrigation fluid used, packing material choice, local antibiotic use, use of a drain and dressing choice. The audit will also collect data on whether soft tissue and bone samples were sent for microbiology and histology and the method of tissue sample collection.

Postoperative data includes organisms grown from the microbiology samples, antibiotic use (route, length, type, sensitivity to organisms cultured), total length of hospital stay, postoperative morbidity grade (Clavien–Dindo), postoperative mobilisation status, length of drain use (if used), vascular imaging and revascularisation procedures. The audit will also collect data on return to theatre for further debridement or amputation and in-hospital mortality.

The 3-month data collection items are duration of antibiotic therapy, COVID infection status, complete wound healing at 90 days, readmission, further debridement, further amputation (minor/major) and mortality.

Data will be prospectively collected from paper or electronic hospital records. Preoperative data will be collected prior to the procedure, intraoperative data will be collected immediately after the procedure has taken place, postoperative data will be collected when the patient is discharged from hospital and 3-month data will be collected 3 months after the patient underwent the procedure. Data will be entered onto a purpose-built electronic database on the Research Electronic Data Capture (REDCap) platform, hosted by Newcastle Joint Research Office. Data will be collected and uploaded by a member of the audit team with appropriate REDCap training from VERN.

Data management

All audit data will be preferably uploaded directly to REDCap with printable case report forms (CRFs) available if required to facilitate data capture. Oversight of paper CRFs used at centres will be the responsibility of each centre's lead clinician. All CRFs used will be securely stored in an appropriate location onsite until data are uploaded to REDCap, at which point the centre's lead clinician will be responsible for ensuring they are appropriately destroyed.

Through the audit's REDCap database design, no identifiable data can be uploaded. A specific audit identification number will be assigned to each patient to allow anonymised data to be collected. Patients may be enrolled twice if undergoing a procedure for both feet during the study period, and in these cases a unique study ID will be assigned to each procedure. Each centre's lead clinician will be responsible for ensuring a database containing each participant's local hospital ID and corresponding audit ID is maintained to ensure accurate follow-up data and stored securely on an appropriate hospital computer. Data will be kept for two years to allow a possible follow-up audit and will be destroyed thereafter. Data will be available to others. The minimum dataset will be included in the DEFINITE results paper as a supporting information file with fully anonymised patient data.

Data analysis

Descriptive analyses will be performed to describe variations in practice and examine secondary outcomes. Secondary outcomes will be compared between adherent and non-adherent groups. Continuous data will be tested for normality and parametric or non-parametric tests will be used as appropriate. The χ^2 test will be used to analyse for differences in categorical variables.

Missing data will be analysed to determine the pattern of missingness and, if appropriate, multiple imputation will be used using the Markov chain Monte Carlo method. Sensitivity analyses will be conducted to compare the results of imputed data analysis with complete-case analysis.

Univariable and multivariable regression analyses will be used to identify independent predictors of further debridement/minor amputation, major lower limb amputation, and complete wound healing at 3 months following the index procedure. A p value of <0.05 will be used to define statistical significance.

Data quality

Following the initial data collection period, data completeness will be quantified. Patient records with less than 95% completeness of mandatory data points will be returned to the centre for completion and, if not possible, the record will be excluded from analysis. All centres will be required to validate data accuracy. Each centre will identify an additional team member (not involved in initial data collection) to recapture 25% of the data points (at random) for 20% of the cases (at random) for their centre. Any centre reporting less than 95% accuracy will be required to validate a further 20% of their cases, and the lead clinician to investigate and report back to the DEFINITE management team. All centres will be required to assess case ascertainment. The lead at each centre (or delegate of) will be required to review theatre records or registry data (eg, National Vascular Registry) and report the total number of eligible procedures performed during the study period to the DEFINITE management team for comparison with cases submitted to REDCap.

Regulatory approval and research governance

The audit will be conducted in compliance with the principles of Good Clinical Practice (GCP) guidelines and in accordance with all

applicable regulatory guidance, including, but not limited to, the UK Policy Framework for Health and Social Care Research. Ethical approval is not required in the UK as this study is a service evaluation, which does not include any change in routine patient care, and no patient identifiable data will be collected. The lead clinician will be responsible for local audit governance approvals as per their hospital/site policy. Non-UK centres will be required to show evidence of appropriate approvals in accordance with local regulations; this may require institutional review board approval.

The audit departments at the following NHS trusts have approved the project locally: Hull University Teaching Hospital NHS Trust, Leeds Teaching Hospitals NHS Trust, Barts Health NHS Trust, St George's NHS Foundation Trust, Worcester Acute Hospitals NHS Trust, NHS Tayside, Oxford University Hospitals NHS Trust, Manchester University Foundation Trust, London North West University Healthcare NHS Trust, South Tyneside and Sunderland NHS Foundation Trust, NHS Lothian, NHS Greater Glasgow and Clyde, South Tees Hospitals NHS Foundation Trust, Mid and South Essex NHS Foundation Trust, Manchester University NHS Foundation Trust, Nottingham University Hospitals NHS Trust, North Bristol NHS Trust, Shrewsbury and Telford Hospital NHS Trust, Frimley Health NHS Foundation Trust, Imperial College Healthcare NHS Trust, University Hospitals Sussex NHS Foundation Trust, NHS Grampian, Aneurin Bevan University Health Board, Royal Devon and Exeter Hospital, Countess of Chester Hospital NHS Foundation Trust, University Hospitals of Leicester NHS Trust, Cambridge University Hospital NHS Trust, University Hospitals of North Midlands NHS Trust, Belfast Health and Social Care Trust, Nottingham University Hospitals NHS Trust, University Hospitals of Southampton NHS Foundation Trust and Gloucestershire Hospitals NHS Foundation Trust. At international centres the audit has been approved by local boards at: Canberra Health Service, King Saud Medical City, Hippocratio Hospital, Aristotle University of Thessaloniki, Thessaloniki, Greece, University Hospital of Trieste, Dar Al-Elaj Specialized Hospital, Waikato Hospital, Christchurch Hospital, Canterbury District Health Board, University Hospital of Patras, University of Patras and Royal Adelaide Hospital.

Data protection and patient confidentiality

The audit will comply with the Data Protection Act 2018. Participants will be assigned a unique REDCap identifier upon enrolment into the audit to allow pseudonymisation of patient data. Access to patient identifiable information will be restricted to members of the patient's usual clinical team. Hard copies of audit documents will be securely stored in an appropriate location at each centre and will be the responsibility of the lead clinician.

Authorship

A collaborative authorship model will be used for all dissemination methods. To qualify for collaborative authorship, individuals should review and approve any manuscripts for submission to peer-reviewed journals and should either have a significant role in the set-up and management of the DEFINITE audit (including audit department registration/institutional review board approval, creation of a data collection team and engagement with VERN to ensure timely upload of data) or capture sufficient data to warrant authorship. This would be the equivalent of collecting baseline and follow-up data on approximately 10 patients, although it is appreciated that individuals may participate in either baseline data collection or follow-up data capture only.

Current status

The DEFINITE study recruitment of new centres was between 1 December 2021 and 31 March 2022. The expected date of the last patient to be included is 30 June 2022 and data collection will end on 30 September 2022.

Discussion

The DEFINITE audit will capture current worldwide practice on diabetic foot debridement and minor amputation in theatre to identify variations in management and clinical outcomes. This will include information on known patient factors that affect wound healing,[2] preoperative investigations, step-by-step operative details, use of antimicrobials and clinical outcomes to 90 days post-debridement.

Existing global guidelines for the management of at-risk lower limbs in people with diabetes include the IWGDF Guidelines on the diagnosis and treatment of foot infection in persons with diabetes and the Global Vascular Guidelines on the Management of Chronic Limb Threatening Ischaemia.[10,11] There are variable levels of evidence supporting recommendations in these documents. Areas of most uncertainty include microbial sampling,[12,13] wound irrigation,[14,15] choice of dressings,[16–20] ambulation status[21] and use of antimicrobials.[22,23] This audit will demonstrate whether there is significant variation in practice in these key aspects of management.

The guidelines recommend tissue samples should be obtained for isolating micro-organisms. This is supported by the CODIFI study, which also reports that clinicians are more likely to act on results obtained by tissue sampling compared with swabs.[12] However, Travis *et al* reported no difference between tissue samples and swabs on microbial culture results.[13] The ongoing CODIFI2 randomised controlled trial aims to compare the impact of tissue and swab sample results on DFU healing time.[15] This audit will capture the methods used at different centres, will compare microbial growth obtained from different sampling techniques, and determine whether there are geographical differences in microbiological growth.

It is currently unknown whether skin preparation and/or irrigation solution choice impacts upon clinical outcomes for DFU patients undergoing debridement/minor amputation. The current guidelines on managing DFU infections reflect this uncertainty. The National Institute for Health and Care Excellence (NICE) guideline on preventing surgical site infection (NG125) recommends alcohol-based solution of chlorhexidine as first choice skin aseptic

solution.[24] Saline, antibiotic solutions, hydrogen peroxide, chlorhexidine and povidone-iodine solution are commonly used for wound irrigation. There has been no superiority shown between preparations; however, some are associated with severe adverse events.[15,25] The DEFINITE audit will identify the frequency with which these skin preparation and irrigation fluid solutions are used in contemporary practice. The planned regression analyses will determine whether there are associations between skin preparation and irrigation fluid, and key clinical outcomes in this cohort.

Postoperatively, there is limited consensus on appropriate dressings for wound healing by secondary intention. A Cochrane review from 2018 compared negative pressure wound therapy (NPWT) to other dressings for post amputation or debridement in the diabetic foot, finding limited evidence for one dressing type over another in improving time to healing.[16] This finding is not reflected in the IWGDF guidelines, which recommends NPWT post debridement in addition to standard care. The ongoing UK-based SWHSI2 randomised controlled trial aims to address this uncertainty around NPWT in wound healing by secondary intention.[26] This audit will capture use of NPWT immediately post debridement or minor amputation in the diabetic foot.

Guidance on antimicrobial use post debridement recommends that antibiotics should be adjusted to the sensitivity of cultured organisms and given via the oral route. There is ongoing debate regarding the length and route of antibiotic treatment post debridement for the treatment of osteomyelitis in the diabetic foot.[22] A pilot randomised clinical trial comparing 3 weeks to 6 weeks of antibiotics showed no significant difference in remission and adverse events.[23] Antimicrobial prescribing practice will be explored in this audit.

The postoperative mobility status of patients is largely unknown and there is variation in the surgical community on weight-bearing status postoperatively. Offloading and specialist footwear are known to decrease the incidence of recurrence.[21] Ambulation instructions for the immediate postoperative period will be collected in this study, and analysis will determine whether this is associated with clinical outcomes.

The collaborative model of this study is designed to capture practice in a large number of patients in a wide range of healthcare settings over a relatively short period of time. VERN has experience of delivering impactful international studies.[27,28] Outputs from the DEFINITE study will inform future quality improvement and research projects to improve the care of patients with diabetic foot complications. One limitation of this audit will be the inability to determine direct causality between practice and outcome. The study aims to collect data from multiple sites in several countries; however, the results may not necessarily be representative of practice in areas where participation in the audit is low. Despite this, results from this audit will identify areas of variation in practice, identify compliance/non-compliance with international guidelines, and generate hypotheses to guide further research on improving clinical outcomes for this population.

KEY MESSAGES

- There is variation in surgical practice for the management of diabetic foot complications, despite international guidelines.
- DEFINITE is a worldwide prospective audit of patients undergoing debridement or minor amputation in theatre for diabetic foot complications.
- Results from DEFINITE will explore the impact of variation in surgical practices on patient outcomes to help inform and improve patient care in the future.

Pathway to impact

This audit addresses shared patient-clinician priorities and is supported by the UK Vascular Society multidisciplinary special interest group on the diabetic foot. The results presented at national and international scientific meetings and in peer-reviewed publications will be used to initiate improvement in patient level care. A writing team, including those involved with the design, implementation and dissemination of the DEFINITE audit, will be responsible for presentation(s) and submission of manuscript(s) to peer-reviewed journal(s)/publications.

To prompt the results to patients and lay stakeholders, the writing team will work with patients and the public involved in the JLA Priority Setting Partnership to produce a patient-facing lay summary of the results. This will be distributed with support from the audit's charitable supporters. A summary will also be sent to the JLA, Circulation Foundation and Diabetes UK for promotion.

In addition, the results of DEFINITE will be promoted through VERN's Twitter account, newsletter and in dedicated webinars.

Conclusion

The DEFINITE study will provide a comprehensive overview of in-theatre debridement practice of diabetic foot complications worldwide and the associated clinical outcomes. This will identify variation and help target areas of care that can be improved.

Conflict of Interest: None.

Funding: The DEFINITE audit is supported by an Urgo Foundation and Newcastle Hospitals Charity grant. Urgo and Newcastle Hospitals Charity have not been involved in the concept or audit design. Urgo and Newcastle Hospitals Charity will not be involved in the data analysis or interpretation. Urgo and Newcastle Hospitals Charity have not been involved in the drafting of the manuscript or decision to publish.

Reviewer acknowledgement: *JVSGBI* thanks Hashem Barakat, University Hospitals Plymouth NHS Trust for the contribution to the peer review of this work.

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Journal of
VASCULAR SOCIETIES
GREAT BRITAIN & IRELAND

J.Vasc.Soc.G.B.Irel. 2023;2(2):109-113
http://doi.org/10.54522/jvsgbi.2023.061

www.jvsgbi.com

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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Received: 22nd October 2022
Accepted: 16th February 2023
Online: 26th February 2023

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.

Funding: None

Acknowledgement: The authors would like to thank Tim Staniland, lead librarian at Hull University Teaching Hospitals (HUTH), for his input in developing the search strategy.

Reviewer acknowledgement: *JVSGBI* thanks the Editorial team for their contribution to the peer review of this work.

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J.Vasc.Soc.G.B.Irel. 2023;2(2):114-117
http://doi.org/10.54522/jvsgbi.2023.058

www.jvsgbi.com

CASE REPORT

Use of a Heli-FX System Guide steerable sheath for internal iliac artery bridging stent re-intervention following iliac branch procedure via a contralateral femoral approach

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Received: 2nd November 2022
Accepted: 19th December 2022
Online: 30th January 2023

Key words: endovascular, abdominal aortic aneurysm, iliac branch procedure, re-intervention, steerable sheath

Abstract

Endovascular aneurysm repair (EVAR) offers lower early morbidity and mortality at the expense of increased long-term re-intervention. Dilatation of distal landing zones is increasingly managed with iliac branch procedures. Re-intervention for endoleak from the internal iliac artery (IIA) bridging stent component is usually approached from arm access due to concerns regarding inducement of displacement of the EVAR caused by traversing the neobifurcation of the stentgraft from contralateral groin access. We present a novel case of successful re-intervention for IIA endoleak in the setting of previous fenestrated repair using the Heli-FX System Guide steerable sheath.

Introduction

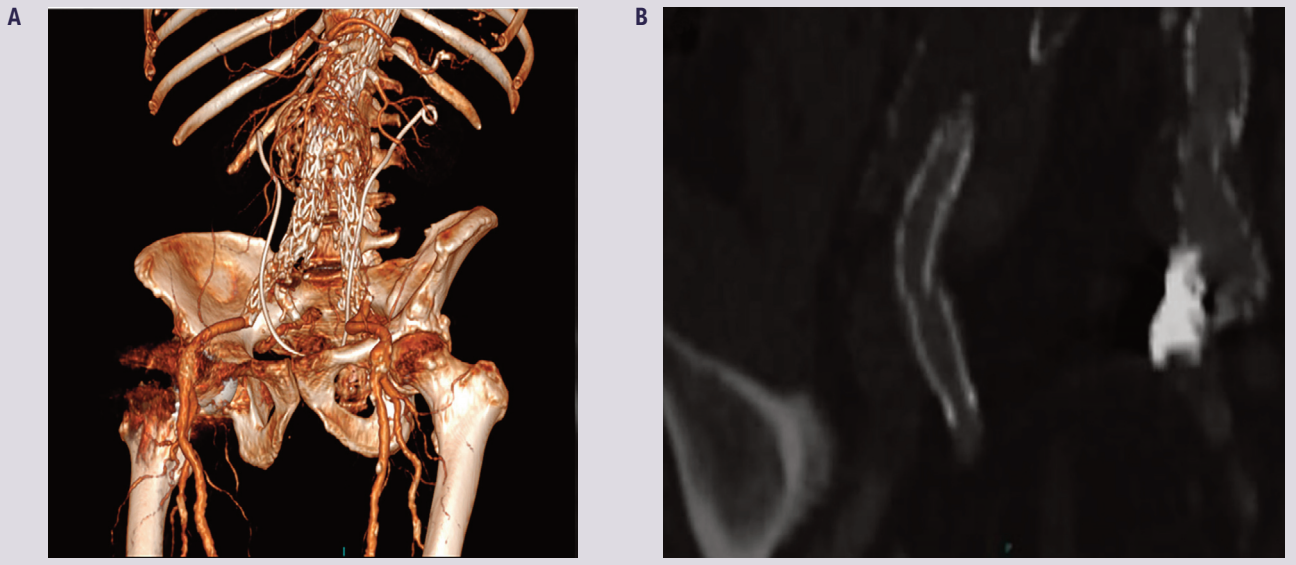
Endovascular aneurysm repair (EVAR) is the dominant treatment modality for patients with anatomically suitable abdominal aortic aneurysms due to improved early morbidity and mortality over traditional open surgical repair. However, surveillance following EVAR is mandatory due to a higher incidence of late failure requiring secondary re-intervention.[1] Dilatation of the iliac landing zones can lead to loss of seal and reperfusion of the aneurysm sac.[2] Secondary interventions, which aim to extend the seal zones to non-diseased vessels, include embolisation and overstenting of the internal iliac artery (IIA) or preservation of IIA flow using an iliac branch procedure (IBP). IIA embolisation is associated with complications including buttock claudication (28% following unilateral embolisation, 42% following bilateral embolisation) and erectile dysfunction (19% and 24%, respectively). Bowel and spinal cord ischaemia can occur in 1–3% of bilateral embolisations.[3] IBPs maintain IIA perfusion and thus reduce the incidence of these complications.[4] Iliac branch device (IBD) implantation during EVAR is usually performed prior to aortic endograft insertion. Insertion of the iliac bridging stent can usually be achieved from contralateral groin access. It is generally accepted that insertion of the IIA component following previous EVAR requires upper limb access, as the traction exerted by a sheath from the contralateral groin over the neobifurcation of the stent graft can lead to endograft dislocation.[5] However, brachial or axillary access is associated with a risk of arterial and peripheral nerve injury, and involves instrumentation around the aortic arch, with consequent risk of cerebral embolisation.[6] Previous authors have reported a case of IBD implantation for re-intervention following EVAR using a steerable sheath from a contralateral femoral approach.[7] We provide a novel report of re-intervention for failed IBD due to internal iliac component separation, using a steerable sheath from a contralateral femoral approach, in a patient with an existing EVAR with fenestrated extension.

Case report

A 75-year-old man underwent a planned re-intervention for internal iliac component separation resulting in a type IIIa endoleak following an IBP.

The patient had originally undergone standard EVAR (Talent; Medtronic CardioVascular, Santa Rosa, California, USA) for an infrarenal abdominal aortic aneurysm in 2008. In 2011, due to aneurysmal dilatation of the distal seal zones, he

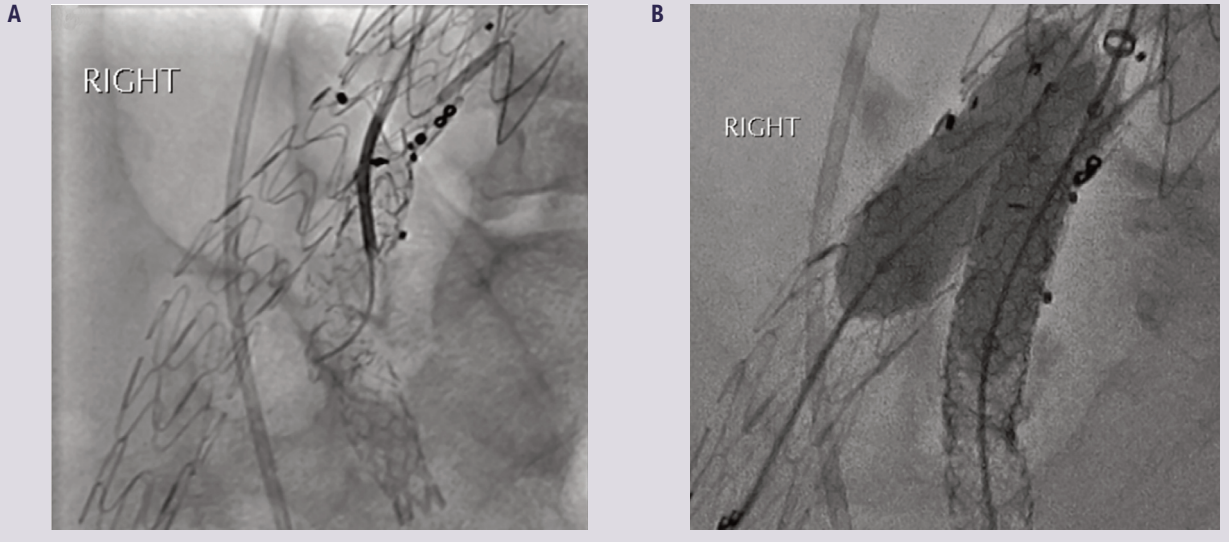
Figure 1 Preoperative contrast-enhanced CT angiogram. (A) 3D reconstruction illustrating previous interventions including standard EVAR, right iliac branch device, proximal fenestrated extension. (B) Reconstructed to illustrate separation of internal iliac stents resulting in type IIIa endoleak.



underwent a successful right iliac branch procedure (Jotec, Germany) and a left IIA embolisation with overstenting into the left external iliac artery (EIA). He was subsequently referred to our institution for a type 1a endoleak due to loss of proximal seal, and underwent a successful proximal extension with a 4-fenestration fenestrated cuff (Cook Medical, Bloomington, Indiana, USA) in 2018 (Figure 1A). Surveillance imaging revealed a type IIIa endoleak due to separation of the IIA bridging stent (9x57 E-Ventus BX, Jotec) (Figure 1B). The procedure was performed expeditiously due to reperfusion of the aneurysm sac by systemic arterial pressure. Arm access was considered but groin access was preferred due to the presence of stents to the visceral branches in the existing stentgraft lumen and increased risk of stroke with instrumentation around the aortic arch.

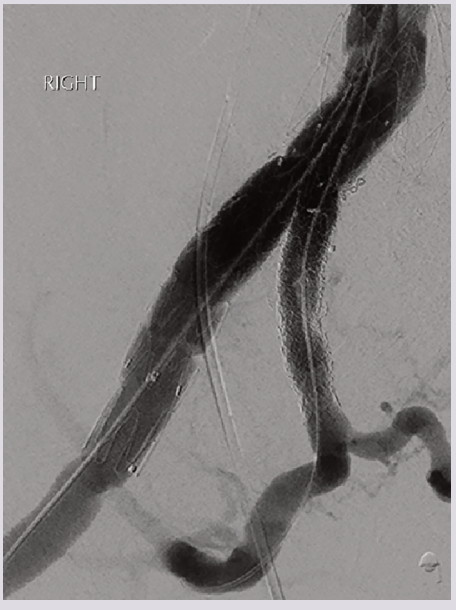
The procedure was performed in a hybrid operating theatre. Percutaneous contralateral femoral access was established using a standard preclose technique with two Proglide devices (Abbott Vascular, Santa Clara, California, USA). Initially a 12F steerable

Figure 2 Procedural fluoroscopic images illustrating (A) internal iliac stent separation and (B) post-dilatation of external iliac and internal iliac stents using kissing balloon technique.



guiding sheath (Destino; Oscor, Palm Harvor, Florida, USA) was advanced from the left groin over the endograft flow divider. An 8F 90 cm flexor shuttle sheath (Cook Medical) was advanced co-axially and positioned above the origin of the IIA. The stent separation was crossed with a 0.035 hydrophilic glidewire (Terumo) (Figure 2A), but it was not possible to track any catheter or device across the lesion due to a lack of stability. The initial steerable sheath was exchanged for a 16F Heli-FX System Guide 22 mm steerable sheath which provided a more stable platform, allowing crossing of the lesion with a 4 mm angioplasty balloon, and pre-dilatation was performed. A 9x57 mm BeGraft Plus (BG+) (Bentley, Germany) over an 0.035 Amplatz Super Stiff 3 cm floppy tip (Boston Scientific, Marlborough, Massachusetts, USA) could not be tracked completely across the lesion, nor withdrawn due to stent slippage from the balloon, necessitating deployment with partial coverage of the lesion and proud of the IIA origin. This changed the geometry and facilitated crossing of the lesion with an 8x38 Atrium (Getinge, Sweden) to bridge the components and seal the type IIIa endoleak. The initial BG+ stent was seen to overhang and impinge on the flow into the EIA origin. Percutaneous retrograde right common femoral artery access was established with a 6F sheath. A self-expanding bare stent (12x60 E-Luminexx; Bard, New Providence, New Jersey, USA) was deployed in parallel. The EIA and IIA stents were post-dilated using a kissing technique to ensure equal expansion (Figure 2B). Final digital subtraction angiography revealed a good final result with patency of both branches and no endoleak (Figure 3). A 6F angioseal was used to close the right common femoral artery access. Left superficial femoral artery access was successfully closed using the preclose technique.

Figure 3 Completion digital subtraction angiogram illustrating good patency of repair with no endoleak.



Discussion

EVAR has become the mainstay of treatment for anatomically suitable abdominal aortic aneurysms. Flared iliac limbs have been used to seal in ectatic or aneurysmal iliac arteries but subsequent degeneration is not infrequent and can result in distal failure.[8] The European Collaborators on Stent/graft Techniques for aortic Aneurysm Repair (EUROSTAR) registry demonstrated an association between sealing in aneurysmal iliac vessels, aneurysm expansion and rupture.[9] Thus, iliac re-interventions in patients with previous EVAR have been well described. Endovascular techniques for treatment of aneurysmal degeneration of the iliac landing zone include IIA embolisation and over-stenting into the EIA and IBPs, with IBPs having fewer complications. IBP following previous EVAR is complicated by the risk of damaging or dislodging the aortic stentgraft, which is thought to be higher when traversing the neobifurcation from a contralateral approach. Use of an upper limb approach for insertion of the IIA bridging stent has been described in efforts to minimise this risk.[5,10,11] However, brachial or axillary access also carries a higher risk of cerebral embolisation and the vessels can be too small to approach percutaneously with the required sheath sizes. Several authors have described using contralateral groin access for IIA bridging stent insertion during IBP in patients with previous EVAR.[7,12,13] Ferrer *et al* reported a case in which they successfully used a steerable sheath.[7] Dawson *et al* described a novel 'up-and-over' technique using two sheaths 'docked' together, negating the need for a steerable sheath.[13] Tadros et al reported two further cases in which this method was used successfully.[12] The main advantages of this method is a cost saving and ability to use the manufacturer's iliac bridging stent – therefore adhering to their instructions for use – which requires a larger internal sheath diameter than a balloon mounted covered stent.

Tenorio *et al* reported on the early and late outcomes of 53 patients treated with iliac branch endoprosthesis, including 13 patients with previous EVAR treated with the 'up-and-over' technique. The outcomes following the up-and-over technique for extension of previous EVAR were comparable to the standard technique used in de novo aneurysm repair.[14]

Regarding re-intervention following IBD implantation, Simonte *et al* reported on a 10-year single-centre experience including 157 consecutive IBD procedures.[15] Freedom from IBD-related re-intervention was 97.4%, 95.6%, 94.0% and 91.8% at 1, 3, 5 and 9 years, respectively, whilst IIA patency was 94.7%, 92.6% and 90.4% at 1, 3 and 10 years, respectively. Owing to a more recent introduction of IBD technology and good long-term outcomes, there are few reports of re-intervention following IBD failure. To the best of our knowledge, this is this first report of re-intervention for IIA bridging stent separation from a contralateral femoral approach using a Heli-FX System Guide steerable sheath. By approaching from the contralateral groin, we avoided traversing the visceral segment of the aorta. However, use of a stearable sheath from the groin can also lead to inadvertent compression of visceral stents in

KEY MESSAGES

- Re-intervention for failed iliac branch procedures will become increasingly common.
- A retrograde approach from the contralateral groin is useful in the setting of prior fenestrated repair to avoid traversing the visceral segment.
- This is possible with the aid of a steerable sheath such as the Heli-FX System Guide, which provides a stable platform.

the setting of previous fenestrated EVAR. Although the procedure was ultimately successful, it required changing of the steerable sheath. Interestingly, in this case the EVAR limbs were in a conventional configuration whilst, in other cases described,[7,12] the limbs were crossed (so-called ballerina configuration), providing a wider curve over the flow divider. This may explain the instability we experienced with the initial 12F sheath.

Conclusion

Use of a Heli-FX System Guide 22 mm steerable sheath provides a more stable platform and facilitates a contralateral femoral approach for IIA bridging stent re-intervention, negating the need for arm access.

Conflict of Interest: None.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Informed consent: Written informed consent for patient information and images to be published was provided by the patient.

Reviewer acknowledgement: *JVSGBI* thanks the Editorial team for their contribution to the peer review of this work.

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Journal of
VASCULAR SOCIETIES
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J.Vasc.Soc.G.B.Irel.2023;2(2):118-120
http://doi.org/10.54522/jvsgbi.2023.062

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CASE REPORT

Management of large post-crossover inguinal lymphocele

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Received: 26th November 2022
Accepted: 16th February 2023
Online: 27th February 2023

Key words: lymphocele, vascular surgery complication, postoperative collection, sclerotherapy, groin collection

Abstract

A 73-year-old man with a history of peripheral arterial disease and previous bilateral common femoral artery reconstruction presented with left foot critical limb-threatening ischaemia and underwent right to left femoro-profunda crossover grafting. Postoperatively, he developed a left groin lymph leak that initially dried up but later re-presented as a very large lymphocele. Initial attempts with aspiration on three occasions and then surgical drainage with sac excision and ligation of long saphenous lymphatics did not lead to resolution. Subsequently, a hybrid approach using percutaneous lymphangiography and drainage, sclerotherapy (bleomycin, then absolute alcohol) and eventual identification and ligation of the afferent lymphatic channel resulted in resolution of the lymphocele without untoward side effects, sepsis or compromise of the revascularisation.

Background

Postoperative fluid collections after groin vascular surgery can commonly include seromas, haematomas, lymphoceles and abscesses. Lymphoceles are abnormal lymphatic fluid collections without epithelial lining that form as a result of disruption of lymphatic channels during surgical procedures. They can result in considerable morbidity with significant swelling, pain, sepsis and failure of revascularisation.

Management strategies include conservative, aspiration, surgical drainage with or without sac excision and ligation of lymphatics, and the use of sclerosing agents (tetracycline, bleomycin, absolute alcohol).

Case report

A 73-year-old man with a history of peripheral arterial disease and previous bilateral common femoral artery vein patch angioplasty presented to the vascular outpatient clinic with left foot critical limb-threatening ischaemia (rest pain without tissue loss). He underwent successful revascularisation with a right to left femoro-profunda crossover graft (6 mm Dacron Graft with a vein cuff at the outflow anastomosis).

Postoperatively, he developed a lymph leak that initially seemed to dry up but then re-presented as a large lymphocele 6 weeks later. This was aspirated on three occasions and samples sent to Microbiology, yielding no growth. The lymphocele recurred and progressively increased in size, producing increasing discomfort and impairment of mobility.

The next line of management was open surgical drainage, performed almost exactly a year after his crossover graft. A thick-walled sac was evident, with dilated lymphatics heading inferiorly. The Dacron crossover graft was visible at the base of the lymphocele. The sac was dissected off the surrounding tissue and excised leaving a small cuff around the graft. Two large lymphatic pedicles lying inferior to the sac were ligated.

Unfortunately, the lymphocele recurred within days of this re-exploration. Given that any further surgical exploration would almost certainly require dissection around the profunda femoris, possibly compromising his revascularisation, a less invasive option was explored.

Computed tomography showed a large superficial homogenous hypo-attenuating collection lying anterior to the crossover graft in the left groin. Figure 1 shows a reconstruction of the scout image of that scan.

Figure 1 CT Scout Reconstruction

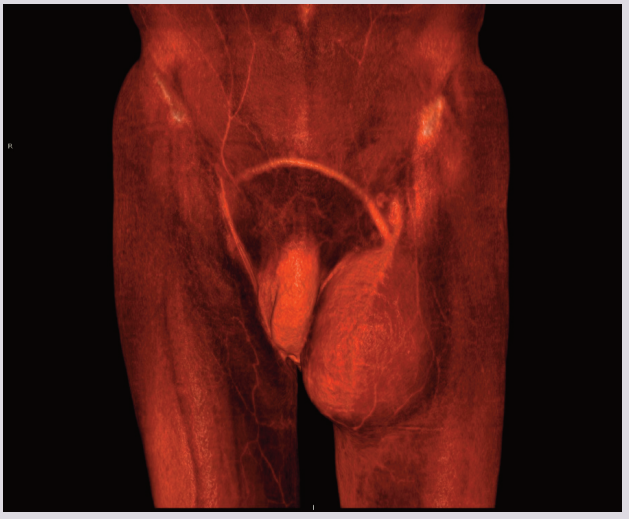
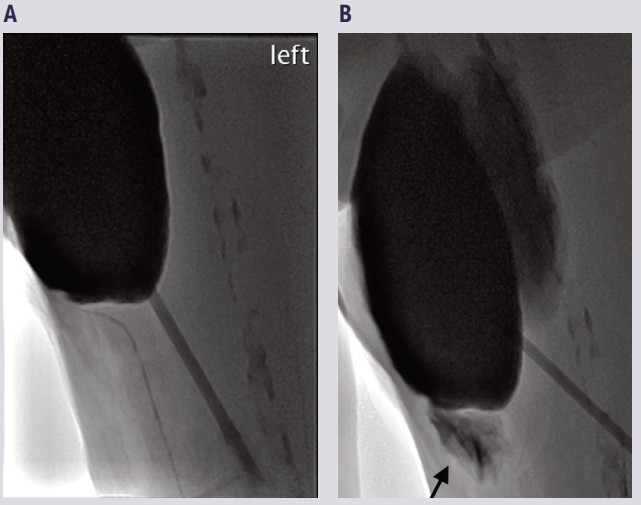


Figure 2 A Initial lymphangiography, and **B** Post-stereotactic localisation and ligation



The case was discussed with the interventional radiologists at the multidisciplinary team (MDT) meeting. Based on the meeting outcome, we proceeded to a further lymphangiography (via incision over the first web space on the left foot) with a view to identifying an afferent vessel. None was found on the initial scan but a subsequent scan with a larger dose of technetium-labelled nano-colloid showed filling of the lymphocele from a lymphatic vessel adjacent to the course of the left long saphenous vein (Figure 2A).

Given this likely target, he underwent a second surgical procedure (at 17 months post-revascularisation) to ligate the proximal long saphenous vein and peri-venous tissue incorporating the feeding lymphatics.

On review a month later, the swelling had recurred, though less tense. After further discussion at the Vascular MDT, sclerotherapy was chosen as the next step. The lymphocele was aspirated (1500 mL) under ultrasound guidance and the cavity infiltrated with 60,000 units of bleomycin. The drug was left in for 2 hours and removed via a 12F locking Pigtail drain. No untoward local or systemic effects were noted. At that time, it was appreciated that more than one sclerotherapy session was likely to be needed.

However, when the fluid re-accumulated in less than a week, it was decided to switch to 100% ethyl alcohol as the sclerosing agent. A 9F sheath was inserted and a variety of catheters used to try to identify possible feeding vessels but none were found. 100 mL of the alcohol was administered via a 12F drain and left inside the cavity for 6 hours. The drain was left uncapped in situ to assess for recurrence.

A few weeks later the patient reported a recurrence of the swelling, but this time much smaller, with thickening of the overlying skin and subcutaneous tissue. A third sclerotherapy session was then undertaken. This time, only 100 mL of mixed saline and contrast was required to fill the lymphocele. A feeding lymphatic channel was evident in the medial aspect of the thigh and, under 22 gauge stereotactic localisation, was successfully ligated (see patch of contrast marked by arrow on Figure 2B representing its disruption). Another 100 mL of 100% ethyl alcohol was administered into the lymphocele, left in overnight, and aspirated the following morning.

Following the third intervention, the patient reported complete resolution of the lymphocele, with the only symptoms being related to skin induration and occasional discharge from the drain site becoming less and less frequent until complete resolution after 3 months.

On last clinic review, mild lymphoedema was evident in the lower leg but was being managed effectively with compression hosiery. Significantly, he has no symptoms or signs of local or graft-related sepsis or any compromise of his successful revascularisation.

Discussion

Lymphoceles are abnormal lymphatic fluid collections without epithelial lining that form as a result of disruption of lymphatic channels during surgical procedures. The fluid is typically straw-coloured with creatinine concentration closely approximating serum levels.

Lymphoceles most commonly occur after surgical interventions that involve limb and groin areas, pelvic lymphadenectomy or renal transplantation. Increased lymphatic pressure, inflammation, infection, foreign material or scar tissue associated with prior groin exposure all increase the likelihood of persistent lymphocele. They can cause considerable morbidity with significant swelling, pain, sepsis and failure of revascularisation.

The oblique groin incision is thought to be less traumatic to the lymphatic channels and can be a preventative strategy in high-risk patients.[1,2] Another way to reduce the incidence is meticulously ligating crossing lymphatic channels in the field of dissection.

Several treatment techniques have been reported. These include repeated percutaneous drainage, marsupialisation, percutaneous image-guided lymphatic ligation (PILL procedure) and sclerotherapy. Percutaneous drainage is usually the first line of treatment for symptomatic lymphoceles. However, the recurrence rate is as high as 60% and the risk of infection increases with every treatment. The PILL procedure, while considered percutaneous, requires a small incision with insertion of a clip applier to occlude leaking lymphatic channels under fluoroscopic guidance using lymphangiography.[3] Sclerotherapy is an effective treatment strategy for resistant large lymphoceles. The type of sclerosing agent that is used seems mostly based on the institutional or treating physicians' preferences. Few data exist on the available treatments and consensus is therefore lacking on the best type, dosage and length of administration of sclerosing agent. Hence, there are no established guidelines or protocols for the use of sclerosing agents.

Bleomycin is a cytotoxic agent. Topical use allows the formation of adhesions, making it an excellent agent for sclerosis. There are some accumulated experiences using bleomycin for sclerosis of malignant pleural effusions and treatment of lymphangioma.[4] Common side effects are pain (23%) and fever (19%).

Ethanol and povidone-iodine are frequently used because these are affordable and easily available agents that are generally well tolerated (discounting people with a history of a reaction to povidone-iodine). Ethanol is also minimally painful, especially if 10 mL of 1% lidocaine is added to it. Some surgeons advocate turning the patient into multiple positions to ensure distribution of the alcohol. Up to 100 mL of 100% ethyl alcohol can be injected per sclerotherapy session and 2–3 sessions are usually required. Possible treatment complications include infection, failure to resolve the seroma and injury to adjacent structures by unintended puncture. Intoxication is also possible with use of ethanol.

Broad-spectrum antibiotics like tetracycline, doxycycline and minocycline induce formation of adhesion and fibrosis after intracavitary injection. The therapeutic effect of tetracycline has also been attributed to the fact that it is associated with inhibition of gelatinase activity which could result in decreased collagen breakdown and hence an increased collagen formation.[5]

Conclusion

Management of a postoperative lymphocele can be complex, more so in the context of a delicate vascular reconstruction as in this case. This was a very challenging situation where a multidisciplinary approach proved beneficial. There are no established guidelines regarding the use of sclerosing agents in these situations. It is very common for large collections to require multiple treatment sessions to achieve a meaningful result.

KEY MESSAGES

- Lymphoceles are post-surgical collections of lymphatic fluid
- Lymphoceles can cause considerable morbidity due to pressure effects and infections
- Management of a lymhocele is complex, best done with a multidisciplinary approach
- Large lymphoceles can require multiple treatment sessions

Conflict of Interest: None.

Funding: None

Patient consent to publication: Yes

Reviewer acknowledgement: *JVSGBI* thanks the Editorial team for their contribution to the peer review of this work.

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J.Vasc.Soc.G.B.Irel. 2023;2(2):121-125
http://doi.org/10.54522/jvsgbi.2023.065

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ABSTRACTS

VS ASM 2022 Prize/Highest Scoring Abstracts

The Vascular Societies' Annual Scientific Meeting 2022, in conjunction with the VSGBI, BACPAR, SVN and SVT, took place at the Hilton Brighton Metropole, on the 23rd-25th November 2022. Here are the 2023 prize/highest scoring abstracts.

VS - Sol Cohen Prize

VO46 – The Limb-related Complications of Injecting Drug Use and the Collateral Consequences for Vascular Surgery: The East of Scotland Experience, a Nine-year Retrospective Cohort

MacLeod C[1,2], O'Neill H[1], Flett M[1], Guthrie G[1], Khan F[2], Radley A[2,3], Nagy J[1], Suttie S[1]

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The UK has one the highest rates of illicit drug use in Europe. People who inject drugs (PWID) are at risk of a range of injecting-related infections and injuries that can threaten life and limb. This study aimed to characterise the limb-related complications of injecting drug use.

Retrospective data collection between 01/12/2011-31/12/2020. Patients were identified through discharge codes and a prospective vascular operative database. Demographic and admission details were extracted from electronic records and a database created. Two diagnoses could be recorded, reflecting the realities of clinical practice.

There were 805 admissions for 445 patients (1-10 admissions/patient): mean age 37.5 (21.2-61.5) years and 488 (60.6%; 277 patients, 62.2%) were male. Admissions were generated by: 333 groin abscesses; 75 other abscesses; 109 pseudoaneurysms; 126 necrotising soft tissue infections; 137 cellulitis cases; 168 deep venous thromboses (DVT); 59 infected DVTs and 138 other pathologies. Surgical specialties managed 570 (70.8%) admissions, with vascular surgery managing 412 (51.2%; 72.3% of all surgical admissions). Surgery was required for 409 admissions (50.8%), with 534 operations performed (1-7/ admission). There were 31 lower limb amputations. During follow-up 97 (21.8%) patients died, mean age 43.6 (26.8-62.8).

Limb-related complications of injecting drug use represent a substantial burden for vascular surgery.

VS - BJS Prize

VO59 – Repair for Infrarenal Aortic Abdominal Aortic Aneurysms, a Nationwide Study

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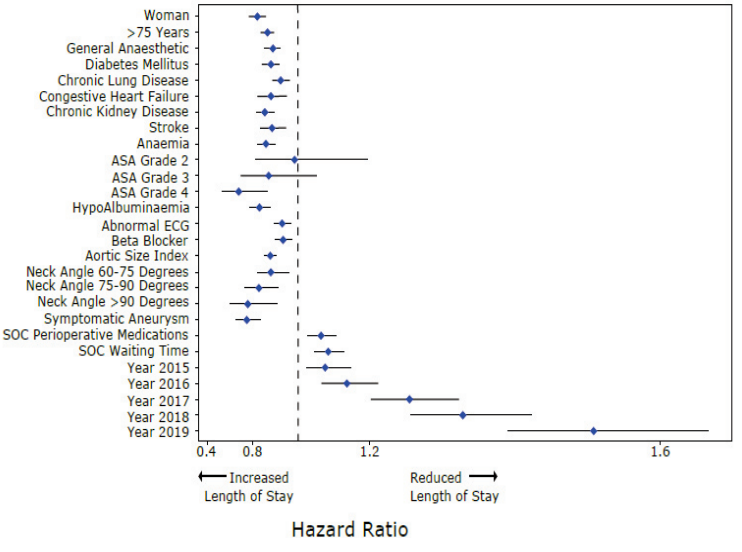
Introduction

Length of hospital stay (LOS) for endovascular infra-renal abdominal aortic aneurysm repair (EVAR), is a major driver of cost and reported to be longer for women. This study investigates drivers of LOS and why women stay longer for EVAR.

Methods

Examination of National Vascular Registry elective EVAR patients, 2014-2020. Survival analysis conducted, censoring for in-hospital death. Cox proportional hazard modelling utilised to assess sex-specific difference in LOS adjusting for age, co-morbidity, anaesthetic, year and standard-of-care.



Results
14,050 (12,518 men:1532 women) patients received elective EVAR. LOS was longer for women (restricted-mean 6.55 (standard error (SE)0.59) vs. 4.49 (SE0.12) days, p<0.001). Following multivariable adjustment, early hospital discharge remained less likely for women (Hazard Ratio (HR) 0.81, 95%CI:0.78-0.87). General anaesthetic (HR 0.89 (95%CI:0.86-0.93), age ≥75 years (HR 0.80, 95%CI 0.84-0.90), co-morbidity and anatomical complexity were associated with increased LOS. Treatment within waiting-times and receipt of peri-operative antibiotics/ thromboprophylaxis were associated with reduced LOS. Between 2014-2019 LOS reduced for both sexes (restricted-mean change -2.46 vs. -2.18 days; HR 1.54, 95%CI 1.44-1.64).
Conclusion
Women have increased LOS for EVAR, despite adjustment for co-morbidity, standard-of-care and advanced clinical practice. Identification of additional drivers of LOS for women is needed to facilitate fast-track pathways and improve quality-of-care.

VS - Poster Prize

P36 – Optimising secondary prevention in patients undergoing carotid intervention (CI) – A Single Centre Cohort Study

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Background
Stroke/TIA patients should receive best medical therapy (BMT; antithrombotic therapy (ATT) and lipid lowering therapy (LLT)). This includes high-intensity statins (HIS), aiming for LDL-C <1.8mmol/L. We explored BMT in patients undergoing CI on admission prior to intervention, at discharge, and 1 year post intervention.
Method
205 patients underwent CI (01/01/18–31/12/20). Differences between time points were assessed with McNemar test.
Results
There were 137 men (67%), median age 73 (CI: carotid endarterectomy n=175; carotid stent n=30).

Increases in prescription of ATT (50%vs96%, p<0.001), statins (65%vs93%, p<0.001) and HIS (47%vs83%, p<0.001) were observed at discharge compared to pre-intervention but no differences were seen at 1 year. At 1 year, 8 patients were not taking statin therapy, 6 were allergic and 3 prescribed Ezetimibe.

At 1 year, there was significant improvement in median LDL-C (2.4mmol/L, IQR(1.9-3.3)vs.1.6mmol/L, (1.2-2.0), and proportion of patients achieving an LDL-C of <1.8mmol/L (21%vs59%,p=0.003) compared to pre-admission. In patients with LDL-C≥1.8mmol/L, 92% had scope for LLT up-titration.
Conclusion
Patients undergoing carotid intervention receive appropriate BMT whilst in-patient. This led to improved lipid control in a substantial proportion. A minority fail to achieve recommended LDL-C targets. Reasons for this need to be understood to allow for optimal risk reduction.

VS - The Richard Wood Memorial Prize

VO82 – A single-centre retrospective hypothesis-generating study investigating Computed Tomography-based body composition metrics in a cohort of aortic aneurysm patients

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Introduction
aortic aneurysms (AAA) remains unknown. This study explored the patterns of Computed Tomography-based body composition (CTBC) metrics in AAA patients, and their associations with outcomes.
Methods
We included 265 patients who received open or endovascular AAA repair from 2015 to 2020 at a single institution. Cross-sectional surface areas of skeletal muscle (SMI), intramuscular (IMAT), visceral (VAT), and subcutaneous (SAT) adipose tissues at the L3 vertebral level were obtained from preoperative CT scans. Sarcopaenia was defined as SMI ≤38.5cm^2 in women and ≤52.4cm^2 in men. Outcomes included hospital length of stay, postoperative complications, and peri-operative mortality (in hospital or within 30 days).
Results
Sarcopaenic patients had less total adipose tissue (p<0.001), lower VAT/SAT ratios (p=0.011), and higher IMAT/SMI ratios (p=0.002).

Lower SMI was associated with peri-operative mortality (p=0.011). Peri-operative mortality was higher among female patients (p=0.027), who had higher IMAT (p=0.017) and IMAT/SMI ratios (p<0.001), and lower VAT/SAT ratios (p<0.001) compared to male patients.

Conclusions

Sarcopaenia is often accompanied by high IMAT and low VAT and is associated with peri-operative mortality. CTBC differences between men and women may contribute to different mortality rates.

	Sarcopaenic (n=203)	Non–sarcopaenic (n=62)	*P*–value	Male (n=228)	Female (n=37)	*P*–value
Age at operation (years)	76 (70 – 82)	70.065 ± 8.573	<0.001	74 (68 – 80)	77.4 ± 8.88	0.028
Sarcopaenic	–	–	–	175	28	0.837
Male sex	175/203	53/62	0.837	–	–	–
BMI (kg/m²)	25.280 (22.685 – 27.787)	31.318 (28.775 – 33.640)	<0.001	26.510 (24.293 – 30.093)	22.430 (19.830 – 30.748)	0.007
Smoker	156	56	0.019	118	24	0.157
Hypertension	137	47	0.270	163	21	0.084
COPD	45	15	0.731	48	12	0.140
Ischaemic heart disease	64	25	0.220	82	7	0.059
Type 2 diabetes mellitus	31	8	0.830	36	3	0.317
Chronic kidney disease	26	11	0.402	32	5	1.000
Length of stay (days)	7.00 (4.00 – 12.00)	7.50 (4.00 – 9.25)	0.920	7.00 (4.00 – 12.00)	7.00 (3.00 – 11.00)	0.348
Complications	88	24	0.559	95	17	0.720
Perioperative mortality	17	2	0.260	13	6	0.034
SMI (cm²/m²)	–	–	–	45.118 (40.519 – 51.633)	34.468 ± 6.648	0.063
IMAT (cm²/m²)	5.641 (3.765 – 8.460)	5.467 (3.871 – 8.747)	0.832	5.262 (3.749 – 7.843)	6.956 (5.197 – 10.311)	0.017
VAT (cm²/m²)	48.210 (26.437 – 72.693)	80.386 (59.638 – 101.643)	<0.001	59.507 (38.661 – 81.273)	26.418 (18.262 – 55.692)	<0.001
SAT (cm²/m²)	43.963 (32.814 – 61.927)	63.380 (50.559 – 85.526)	<0.001	48.751 (35.384 – 66.645)	66.945 ± 40.380	0.106
IMAT:SMI ratio	0.130 (0.090 – 0.212)	0.103 (0.067 – 0.156	0.002	0.118 (0.783 – 0.179)	0.208 (0.132 – 0.323)	<0.001
VAT:SAT ratio	1.007 (0.579 – 1.461)	1.249 (0.857 – 1.592)	0.011	1.167 (0.787 – 1.578)	0.472 (0.286 – 0.657)	<0.001
TAT (cm²/m²)	99.845 (69.883 – 133.160)	149.716 (123.055 – 181.583)	<0.001	115.030 (80.560 – 148.120)	100.605± 59.139	0.073
VAT:TAT ratio	0.487 ± 0.150	0.537 ± 0.131	0.020	0.526 ± 0.131	0.321 ± 0.112	0.205

Table 1: Demographic data of 265 patients with abdominal aortic aneurysms, divided by sarcopaenia status and sex. Sarcopaenia is defined as SMI ≤38.5cm² in women and ≤52.4cm² in men. Perioperative mortality is defined as any death in hospital or within 30 days postoperatively. Discrete data is analysed using a Fishers exact test. Continuous data is analysed by independent–samples T–test when parametric, or Mann–Whitney U test when nonparametric. BMI, body mass index. COPD, chronic obstructive pulmonary disease. SMI, skeletal muscle index. IMAT, intramuscular adipose tissue. VAT, visceral adipose tissue. SAT, subcutaneous adipose tissue. TAT, total adipose tissue which is the sum of VAT and SAT.

VS – Venous Prize

VO93 – Impact of the NHS Evidence Based Intervention Programme on access to NICE recommended Varicose Vein Treatment

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Background

A previous study demonstrated widespread non-compliance of Clinical Commissioning Group (CCG) policies with NICE guidelines leading to geographic variation in access to varicose vein treatment. The Evidence Based Intervention (EBI) programme aimed to improve care quality. This study assesses the impact of EBI.

Method

CCG policies were obtained before and after EBI and categorised by two independent reviewers into levels of compliance with NICE CG168 (green/amber/red). Hospital episode statistics were compared with the NICE commissioning model predictions.

Results

The number of green policies fell from 33.5%(64) to 28.8%(55) in 2019, amber policies increased from 55.5%(106) to 62.3%(119) and red policies remained static (8.9% (17) vs. 8.4%(16)). Over this period 7.3%(14) changed their policy to become fully compliant, but 33.0%(63) changed their policy to become less compliant. Common deviations were to restrict based on clinical severity 51.8%(99) or delay for conservative management 22.5%(43). Nationally the proportion of interventions performed fell from 43.6% to 37.5% of predicted levels, with an estimated loss in net health benefit of £174.6million.

Conclusion

The EBI programme is not associated with improvement in commissioning policy or unwarranted variation, with most patients remaining unable to access NICE recommended treatment in England prior to the SARS Cov-2 pandemic.

SVN - James Purdie Prize

NO4 – Use of Biodegradable Temporising Matrix (BTM) in vascular surgery

Harris L[1], Thapar A[1], Graham A[1], Emmanuel A[1], Mallick A[1]

[1]Mid And South Essex NHS Trust

Introduction

Open wounds over vascular grafts and bone commonly result in graft infection, osteomyelitis and subsequent amputation (1)(2). Traditionally these wounds would be left to heal by secondary intention +/- antibiotics, leading to prolonged treatment. NovoSorb Biogradable Temporising Matrix (BTM) by PolyNovo is a synthetic polymer that can temporarily close the wound allowing for new tissue generation (3). We used BTM in 5 vascular patients for which conventional wound cover was not an option, a first in the UK.

Method

1. Exposed prosthetic graft
2. Exposed vein graft anastomosis
3. Open below knee amputation with bone exposure
4. Open transmetatarsal amputation with bone exposure
5. Post calcanectomy for osteomyelitis with exposed calcaneum

Results

Wounds ranged from surgical bypass wounds to amputation sites. In four cases the BTM integrated well into the wound bed by 6 weeks, covering the critical structures. In the one treatment failure the wound closed by secondary intention.

Conclusion

BTM provides a low-cost option for covering high risk structures, where flaps or grafts are not possible. The thickness of coverage is limited. Further analysis of application technique and patient selection criteria needs to be carried out as well as longer term outcomes.

SVT - Best Scientific Presentation

TO24 – A reflection of measuring and applying qualitative approaches to a Vascular Ultrasound Lab

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Throughout my experiences of working within healthcare, the processes and attention of measuring qualitative data in a clinical setting has taken a back seat when compared to the huge emphasis on quantitative approaches. For example, focus tends to favour on how many scans can be performed on an ultrasound machine per day rather than also assessing patient satisfaction and re-designing patient pathways to facilitate patient centred care.

Vascular sonographers are a vital cog in the patient pathway in assisting in the diagnosis of diseases. However should they wish, they can also play a major role in helping facilitate the qualitative measures to improve patient care given their involvement in large webs of care and their patient facing roles.

This talk is a reflection of my application of qualitative aspects of healthcare through my learning on the Elizabeth Garrett Anderson Program (MSc Healthcare leadership). Topics of reflection include my experiences in the power of honest conversations, the importance of story telling to extract information, sub-conscious behaviours, perceptions, looking beyond the tip of the iceberg the and tools to help facilitate qualitative sciences in a Vascular Ultrasound Lab.

SVT - Best recently completed research presentation

TO13 – Transthoracic ultrasound evaluation of thoracic aortic aneurysms

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Background

Thoracic aortic aneurysms (TAA) can be asymptomatic and life-threatening if they rupture. They are currently detected using computed tomography (CT) which is expensive and uses radiation. A previous study found that ultrasound has the potential to be used as a diagnostic modality for TAA. However, further validation of this methodology is required.

Methods

15 patients (9 with TAA and 6 controls) had a single ultrasound assessment of the thoracic aorta performed by a single vascular scientist. The maximum diameter at the ascending aorta, aortic arch, mid and distal descending thoracic aorta was measured and compared to diameters from a CT scan at thresholds of 35mm and 40mm.

Results
The thoracic aorta was visualised in all 15 patients. At 35mm, the sensitivity and specificity were 100% and 85% and at 40mm it was 78% and 100%. The Bland-Altman plot showed good agreement between ultrasound and CT measurements for the maximum diameter and at the aortic arch, mid and distal descending thoracic aorta.

Conclusion
There is good visualisation of the thoracic aorta using ultrasound with high sensitivity and specificity at both 35mm and 40mm. Results of this study suggest that ultrasound has a potential to be used to assess TAA.

SVT - Best research proposal

TO3 – An audit to determine whether patients receive two forms of carotid imaging pre-operatively when carotid endarterectomy (CEA) is being considered, in line with the European Society for Vascular Surgery (ESVS) 2017 Clinical Practice Guidelines.

Alderson E[1]
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Introduction
The 2017 ESVS Clinical Practice guidelines state two forms of imaging are recommended pre-CEA; this can be a combination of duplex ultrasound (DUS), computed tomographic angiography and magnetic resonance angiography, or two DUS performed by different operators.

Methods
Data was collected retrospectively from the National Vascular Registry to identify patients who underwent CEA between January 2019-December 2021 (n=205). No exclusion criteria were applied. EPIC electronic patient record system was used to obtain relevant data from patients' files including: pre-CEA imaging modalities, complications, outcomes and patient demographics. Data will be analysed using descriptive statistics and chi squared and Mann-Whitney statistical tests.

Results
Between January 2019-December 2021, 87.3% of patients met the ESVS guidelines. Of the 12.6% who did not comply with the guidelines; 80.8% received one form of imaging and 19.2% received two DUS performed by the same operator.

Conclusion
No single reason was identified to explain non-compliance with the 2017 ESVS guideline. Results were disseminated to all interested stakeholders and a common point for intervention in the patient pathway was identified. A six month time lapse (June-December 2022) before re-auditing will enable assessment of the effectiveness of interventions to improve guideline compliance.

BACPAR - Highest scoring abstract submission

BO3 – Sharing stories of lower limb amputation in practice: An exploration into the relatability, usability, and implementation of an animation video package across UK rehabilitation services

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[1]*St Mary's University,* [2]*St George's, University of London*

In 2015, a collaboration between academia and an NHS limb loss rehabilitation centre began. Presented through BACPAR conferences and journal pieces, the partnership has produced research which includes the construction of five narrative trajectories within major lower limb amputation (MLLA) and the translation of these narratives into animation videos. Findings indicated that exposure to the narrative raised less experienced therapists' awareness of MLLA journeys and increase their preparedness for patient care.

When presented in a group activity, people with MLLA connected and resonated with the videos, developed knowledge about what to expect following rehabilitation, and identify helpful behaviours to action. However, it is not known how these videos relate or may be useful to those in differing rehabilitation environments across the UK.

The aim of the presentation is not only to describe, but to do the animation video activity with BACPAR delegates. This will enable delegates to experience the videos as people in MLLA rehabilitation would do. Delegates will be encouraged to discuss and reflect upon the experience with colleagues in the world café event. It is hoped the activity will prompt conversation into the relatability, usability, and implementation of the videos across regional amputee rehabilitation service.

Annual Specialist Registrar Educational Programme (ASPIRE Digital)

VASCULAR SOCIETY OF GREAT BRITAIN AND IRELAND
ASPIRE Digital
Annual Specialist Registrar Educational Programme
WEBINAR SERIES

The Annual Specialist Registrar Educational Programme (ASPIRE) supports the education and development of trainee vascular surgeons throughout their eight years of training, which in turn compliments the national curriculum. The Vascular Society Education and Training Committee develops, manages and delivers the ASPIRE programme.

The Vascular Society GB&I continue to deliver education via the ASPIRE Digital platform. This has resulted in an overwhelming response, and provided a growing resource of education for vascular surgeons.

Each of the recorded sessions are included on the Vascular Society members' website. Here's a list of sessions that are readily available for members of the VS website:

- Management of the Diabetic Foot Attack
- Surgical management of CLTI
- Battle for claudication - exercise vs angioplasty
- Current Management of Acute Aortic Syndrome
- Principles of major lower limb amputation
- How to write a paper
- Strategies for Vascular Trauma
- EVAR planning
- Concept of angiosomes
- Tips and tricks for safe open AAA repair
- Renal Access
- Mesenteric ischaemia
- Carotid Disease Management - Symptomatic and Asymptomatic
- Upper limb ischaemia
- Management of the infected groin
- Managing the rupture AAA - building a team approach
- TOCS
- Why should I consider a career in academic vascular surgery?
- Management of acute / chronic deep venous disease
- Open management of complex AAA
- Options for treating superficial venous reflux
- Endovascular management of complex aortic disease v2
- Iliac intervention - How I do it
- NOTS in vascular surgery
- Radiation Safety in the Hybrid Suite
- New assessments for a new curriculum: The multi-consultant report
- A renal access MDT
- Optimisation of older vascular surgery patients
- Key aspects from the new European Venous Guidelines
- Paediatric Vascular Surgery
- Aortic MDT
- Through – knee amputation
- Thoracic Aortic Disease
- Everything you need to know about to manage AAA except how to fix them
- ASPIRE Digital Fellowships - How to get one, what to get out of it

ALL YOU NEED TO KNOW

To access the above resources, visit the Education section on the Vascular Society members' website www.vascularsociety.org.uk

CIRCULATION FOUNDATION
The Vascular Charity

Our Vision: - is a society free of vascular disease, and its associated suffering.

Our Mission:- is to promote awareness into vascular conditions and to support vital research.

Established in 1992 by vascular surgeons, the Circulation Foundation is the only UK vascular charity dedicated to vascular health. It is the charitable foundation of the Vascular Society of Great Britain and Ireland, run by a committee which is accountable to the Trustees of the Vascular Society of Great Britain and Ireland.

Research

The Circulation Foundation makes three major awards per year to fund vascular research. The value of research funds awarded is currently approximately £1/4 million per year. Like a seed bed, we fund primary research which often goes on to large scale, life-transforming studies. In the last four years the Circulation Foundation has awarded over £500,000 in funds for research, pushing the boundaries in the treatment of vascular disease. Get involved and help us save more lives and limbs through our evolving research programme.

Getting involved

- Donations
- In memory and gift in your will.
- Corporate support
- Ambassador Scheme
- Events - create your own personal event, or sign up for a challenge e.g. London Marathon, Great North Run, RideLondon, Swim Serpentine or the Vitality Big Half

Become a Foundation Ambassador

The Circulation Foundation's goal is to establish a Circulation Foundation Network by having an Ambassador in each Arterial Centre and patient representatives across the UK. We would then be able to work together to increase awareness of vascular conditions, share and repeat fundraising success, increase our research grants and make the Circulation Foundation the support centre for patients.

- **Make a real difference to the lives of people who are affected by vascular disease**
- **Help to raise awareness of vascular disease**
- **Continue to use expertise and knowledge**
- **Learn new skills**
- **Be able to network with like-minded people**
- **Give something back to the vascular community**
- **Be part of a professional and committed charity and a valued member of the team**
- **Recognition on social media, newsletter and on the website**
- **Special recognitions at the Annual Scientific Meeting**

THE BODY WALK

#TheBodyWalk is a national campaign in September to raise awareness of vascular disease and for imperative funding. We are hoping everyone can get to collectively achieve the 60,000 miles that make up the circulatory system! Walk, run, cycle, swim ... it is up to you!

Join us to reach the 60,000 miles and raise funds for Circulation Foundation. Sign up at the stand at the Vascular Soceities' Annual Scientific Meeting!

To visit the Circulation Foundation Website

SCAN ME

To donate to the Circulation Foundation

SCAN ME

To discuss getting involved in the Circulation Foundation by fundraising, legacy donations, becoming an ambassasdor or corporate support, please call 020 7205 7151 or email info@circulationfoundation.org.uk.

Text CIRCULATION to 70560 to donate £10. Texts will cost the donation amount plus one standard network rate message.

www.circulationfoundation.org.uk

Charity Number: 1102769