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VASCULAR SOCIETY

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 the aorta, 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 charitable organisation funded by members subscriptions, an annual scientific meeting, grants and donations. It has a professional structure including a permanent Secretariat, Executive Officers and Council elected by Members.

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Membership of the Society is widely recognised in the vascular community as a mark of professional achievement.

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Editor's foreword

Welcome to the May 2024 edition of the *Journal of Vascular Societies Great Britain and Ireland (JVSGBI)*.

Professor Rob Sayers from Leicester opens this edition with a review of the current management of type B aortic dissection in the UK sign posting specifically the associated tool kit, the need for improved outcome data and the up coming NIHR EARNEST trial – a randomised study to assess endovascular intervention.

This edition contains two fascinating studies in patients with critical limb ischaemia, linking pre existing comorbidities, and particularly frailty, with poorer outcomes following vascular interventions. Such studies are crucial to inform patient centred care and personalised management.

Also included in this edition is a study assessing the safety and efficacy of intravascular lithotripsy during endovascular treatment of patients with peripheral arterial disease. This type of study provides essential underpinning data for future funding applications and research, a fundamental priority for the *JVSGBI*.

There are two protocols published in this edition. Both outline studies, which aim to increase the engagement of claudicants with exercise. This was a highlighted as a priority in the James Lind Alliance research priority setting exercise, and it is fantastic to see this work guiding the direction of research focus.

The four case reports included in this edition not only provide examples of fascinating cases, but in addition are written by early career trainees. Finally included are the excellent Rouleaux Club prize winning essays. These case reports & essays are often a first foray into academic writing / publication and frequently promote academic interest and development. A second fundamental priority for the *JVSGBI*.

I would like to thank all the editorial staff and reviewers for their continued support and all the authors for their submissions.

Ian Chetter
Editor in Chief JVSGBI
Vice President Elect

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EDITORIAL

Where next for type B aortic dissection?

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In April 2021 the acute aortic dissection toolkit was launched by NHS England.[1] It was designed to improve the care of patients with acute aortic dissection (AD) by raising awareness of the condition and introduced seven key principles of management including better governance, 24/7 rotas and specialist care. Each NHS region in England was encouraged to form an AD group, benchmark their current service against the toolkit principles and then try to improve their management of these patients by addressing deficiencies. The toolkit provided tools for self-assessment together with protocols to improve deficiencies by sharing best practice. A regular series of regional meetings has been held with clinicians and managers to advise and help progress – engagement with the process and feedback has been good. National key performance indicators are being developed to monitor the overall effect of the toolkit. Although the toolkit applies to all dissections, there is inevitably a bias towards management of type A dissections because many need urgent cardiac surgical repair. So where next and what about type B dissections?

The next challenge is to improve the long-term outlook for all AD patients and this should include the large group of type B dissections traditionally managed by vascular surgeons – a so-called elective care pathway. Some of these patients may have had a surgical repair (type A, non-A non-B or complicated type B) and others may have had only medical management with pain relief and blood pressure control (uncomplicated type B). However, all require life-long follow-up with lifestyle advice, blood pressure control and monitoring to detect dilation.

For vascular surgeons there is still uncertainty about the acute management of these patients, but there are several recent drivers that should encourage us all to strive for better. Importantly, the scale of the problem is becoming clearer with better data and the myth that type A dissection is more common than type B is being challenged. Recent National Consultant Information Programme (NCIP) data on more than 15,000 admission episodes in AD patients captured by Hospital Episode Statistics in England from 2017 to 2023 suggests that 38% were surgical repairs of type A, 8% were surgical repairs of type B and 53% (over 11,000 admission episodes in nearly 5000 patients) were type B managed medically.[2] What happens to all these patients with type B dissections managed medically? Nobody knows. Of further concern is data from the same source suggesting that mortality for medically managed type B dissections is 26% at 1 year, 32% at 3 years and 47% at 5 years. The cause of death is often uncertain – some may be due to general cardiovascular disease but others will be due to late aortic complications due to aortic dilation (which occurs in 20–50%) and aortic rupture.[3]

So the need for better elective follow-up care for these patients seems clear, but what should an elective pathway look like? Feedback from the acute pathway supports the toolkit approach with advice and sharing of good practice rather than a didactic style. The ability to self-assess and benchmark against the toolkit recommendations was also popular and allowed units to concentrate on areas for improvement. So what areas should the elective pathway cover? They should be patient-focused and give advice and support on various factors such as lifestyle changes, optimal blood pressure control, follow-up imaging, genetic testing, specialist aortic clinics and dedicated nurses. Some of these interventions, such as blood pressure control, have a specific evidence

Key words: dissection, type-B, management

base and are included in recent international guidelines.[4–6] Others, such as lifestyle changes, smoking cessation, increasing exercise and reducing obesity, are part of a general strategy to reduce cardiovascular deaths and feature in the NHS Long Term Plan.[7]

Blood pressure control remains a key factor in preventing death from AD. Recent evidence has confirmed the mortality risk of hypertension and AD and demonstrated that the risk is dose-dependent. These findings strongly support aggressive blood pressure control (usually with a combination of beta blockers and ACE inhibitors) targeting the lower end of normal to reduce late vascular events. These patients require lifelong blood pressure management, ideally in a specialised multidisciplinary aortic dissection or aortopathy clinic. Many units are developing these clinics and exploring the role of specialised nurses. Follow-up imaging with CT or MRI is recommended to assess complications of repair, aortic dilation and state of the false lumen. However, the optimal surveillance intervals are not clear. Genetic testing should also be considered to identify syndromic causes (Marfan, Loeys–Dietz, vascular Ehlers–Danlos, Turner's and bicuspid aortic valve), identify risk to other family members and help determine optimal timing of any future surgery.

Finally, it is hoped that AD research and recruitment of patients into trials will help to determine best practice. For example, indications for intervention in acute type B dissections remain uncertain. According to National Vascular Registry data (2022 annual report), 46 out of 67 UK vascular units (69%) admit and manage type B dissections and 34 out of 67 units (51%) perform thoracic endovascular repair (TEVAR) to treat these patients. However, two-thirds of these centres do <5 cases per year and only eight centres could be considered high volume (>25 cases per year), with four of these in London. Long-term data also appear to be lacking.[8] The recently funded NIHR EARNEST trial, a randomised study to assess endovascular intervention, should provide some answers. It assesses clinical and cost-effectiveness of best medical therapy and surveillance versus intervention with TEVAR. Importantly, patients were involved in the design of the trial. The primary composite end point includes assessment of aortic mortality, cardiorespiratory failure and neurological deficit, but we will have to wait 5 years for the results.[9]

Conflict of Interest: The authors declare that there are no conflict of interest.

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COHORT STUDY

Prognostic value of simple frailty and malnutrition screening tools for determining surgical risk in patients with chronic limb threatening ischaemia undergoing major vascular surgery: a retrospective cross-sectional study

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Plain English Summary

Why we undertook the work: For patients with severe circulation problems to the legs, surgery is often needed. However, these patients can suffer poor outcomes following surgery. If a patient is also frail or malnourished, their outcomes are often even worse. Several tools exist to measure frailty and malnourishment, but they are sometimes complicated and not always suitable for patients with severe circulation problems to the legs, especially if they require walking or physical activity. Other tools, which are simpler to apply, may be more suitable. The aim of this study was to see if these simple frailty and nourishment tools can be used to identify patients with severe circulation problems to the legs who are more likely to have poor outcomes.

What we did: We looked at patients with severe circulation problems to the legs who had surgery. We used two frailty and two nourishment tools to identify which patients were frail and/or malnourished. We then looked at the number of patients who had died, had complications, went back to theatre or had to return to hospital after discharge. We also looked at how long patients stayed in hospital. We then looked at whether people with frailty or malnourishment were more likely to experience these things.

What we found: We included a total of 139 patients. Those who were frail were more likely to die within a year, have complications and return to hospital after discharge. Malnourishment did not increase the risk of dying within a year.

What this means: All patients with severe circulation problems to the legs who are having surgery should be assessed for frailty. Those who are frail should have specific plans to minimise their risk of poor outcomes.

Abstract

Background: This study aims to explore the prognostic value of simple frailty and malnutrition tools for determining postoperative outcomes at 30 days and one year in patients with chronic limb threatening ischaemia (CLTI) undergoing major surgery.

Methods: This was a single-centre retrospective observational cross-sectional study in a tertiary UK Vascular Centre. We applied the Derby Frailty Index (DFI), the Acute Frailty Network Criteria (AFNC), the Prognostic Nutritional Index (PNI) and the Geriatric Nutritional Risk Index (GNRI) to routinely collect clinical audit data recorded from a combination of medical and nursing notes, blood test results and discharge letters.

Results: We included 73 patients who had undergone amputation (mean age 69 (range 57–77) years; 71% male; mean body mass index (BMI) 27 (range 23–31) kg/m^2) and 66 patients who had undergone bypass surgery (mean age 73 (range 64–81) years; 70% male; BMI 26 (22–30) kg/m^2). The 30-day mortality rate of a frail patient (DFI and AFNC, respectively) was 21% (n=8/39) and 23% (n=6/26) compared with 7% (n=7/100) for non-frail patients. Frailty was associated with 30-day (DFI: odds ratio (OR) 3.4 (95% CI 1.2 to 10.2), p=0.027; AFNC: OR 3.4 (95% CI 1.1 to 10.7), p=0.034) and one-year (DFI: OR 7.95 (95% CI 3.4 to 18.6), p<0.001; AFNC: OR 5.9 (95% CI 2.4 to 14.7), p<0.001) mortality. Frailty, according to the AFNC, was also associated with an increased risk of re-admission. Neither of the malnutrition screening tools was associated with 30-day or one-year mortality (p>0.05).

Conclusions: Our analysis confirms that both the DFI and AFNC tools identify patients with CLTI who are at the greatest risk of poor outcomes following major surgery. Frailty warrants further investigation and should be part of the consent and joint decision-making process in this patient population, to personalise care and minimise the risk of poorer outcomes.

Key words: chronic limb threatening ischaemia, frailty, malnutrition, mortality, postoperative complications

Introduction

Chronic limb threatening ischaemia (CLTI) is a severe manifestation of peripheral arterial disease (PAD), characterised by intractable rest pain with or without tissue loss in the form of ulceration and/or gangrene or infection.[1] Approximately 1% of all PAD cases are due to CLTI and first-line treatment includes revascularisation, primary amputation or, in some cases, conservative management.[1,2] In the UK in 2022 there were 9,592 lower limb revascularisations (angioplasty or bypass) and 2,233 amputations performed for CLTI.[3] However, surgery often results in a poor prognosis with high 3-year mortality (37%), re-intervention (57%) and major amputation (12%) rates.[4]

Patients with CLTI are often older and present with multiple comorbidities.[5] This carries an increased risk of morbidity and mortality after surgery and makes them more likely to be frail. Frailty is a state of vulnerability resulting in a poor recovery of homeostasis after a stressor event, triggering disproportionate changes in health status.[6] Recent evidence has shown that the presence of frailty is associated with worse outcomes for patients undergoing vascular surgery, including those with CLTI.[7] However, some of the applied frailty tools may not be suitable for patients with CLTI as they require an assessment of mobility and function. The Clinical Frailty Scale, which is the most widely adopted tool in vascular surgery,[8] does not require such assessments. However, the criteria are open to interpretation, leading to ambiguity in the frailty assessment. Other widely used tools such as the electronic frailty index can be overly complex. Therefore, the application of simple, less ambiguous tools that only require routinely collected information and no training to apply, such as the Derby Frailty Index (DFI) and the Acute Frailty Network Criteria (AFNC) may be more appropriate.

In addition to frailty, the state of malnourishment increases surgical risk. In patients with CLTI undergoing endovascular therapy, certain characteristics (body mass index (BMI) <18.5 kg/m^2) and/or serum albumin <3.0 g/dL) are associated with poorer surgical outcomes.[9] The Geriatric Nutritional Risk Index (GNRI) is a simple and validated tool which considers these factors in its assessment.[10] As stature and BMI may not be easily determined in some patients with CLTI, the Prognostic Nutritional Index (PNI), which has been developed and used in other clinical and surgical populations,[11,12] may be a good alternative for the CLTI population.

These frailty and malnutrition tools have not been previously applied to patients with CLTI, meaning there is a dearth of evidence, despite evidence in the heart failure population.[12] Application of these tools can help to identify the most vulnerable patients, facilitating a more rigorous approach to reducing surgical risk and anaesthetic management.

Therefore, the aim of this study was to explore the prognostic value of simple frailty and malnutrition tools for determining postoperative outcomes at 30 days as well as one-year mortality in patients with CLTI undergoing surgery.

Methods

Study design

A single-centre retrospective observational cross-sectional study (January to December 2016) was undertaken in a tertiary academic vascular unit in the UK, reported in line with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines (see Appendix 1 online at www.jvsgbi.com).[13] The study was registered with the local audit governance department (ID: 2018.047) as it did not require full ethical approval.

Study participants

Participants were >18 years of age, had undergone either a bypass or amputation procedure for CLTI and were identified via a locally maintained database. Patients who had undergone these procedures for other indications were excluded. CLTI was defined as rest pain, ulceration and/or gangrene as assessed by a vascular consultant or registrar. All patients had a full medical history, physical examination and blood tests following admission. BMI, social situation, mobility, falls risk and risk of malnutrition were recorded from data obtained on admission. All data were collated from a combination of medical and/or nursing notes, haematological results and discharge letters.

Frailty indices

Two frailty indices were used, as applied in the heart failure population.[12]

1. The DFI (scored as frail or non-frail) identifies frailty based on meeting one of the following criteria:
   - Age >65 years and a care home resident;
   - Age >75 years with confusion, falls, reduced mobility or a combination of these; or
   - Age >84 years with >4 comorbidities.
2. The AFNC (scored as frail vs non-frail) identifies frailty as meeting one of the following criteria:
   - Age ≥85 years; or

- Age 6≥5 years with:
  – cognitive impairment
  – resident in a care home
  – history of fragility fractures
  – Parkinson's disease
  – recurrent falls.

Malnutrition scores

Two malnutrition indices were used:

1. The GNRI, calculated using the formula: 1.489 x albumin (g/L) + 41.7 x current weight/ideal weight and classified as follows:
   - >98 = not malnourished
   - 92–98 = mild malnourishment
   - 82–91 = moderate malnourishment
   - <82 = severe malnourishment.[10]
2. The PNI, calculated using the formula: 10 x serum albumin (g/L) + 0.005 x total lymphocyte count (10^9 cells/L) and classified as follows:
   - >38 = normal
   - 35–38 = moderate malnourishment
   - <35 = severe malnourishment.[11]

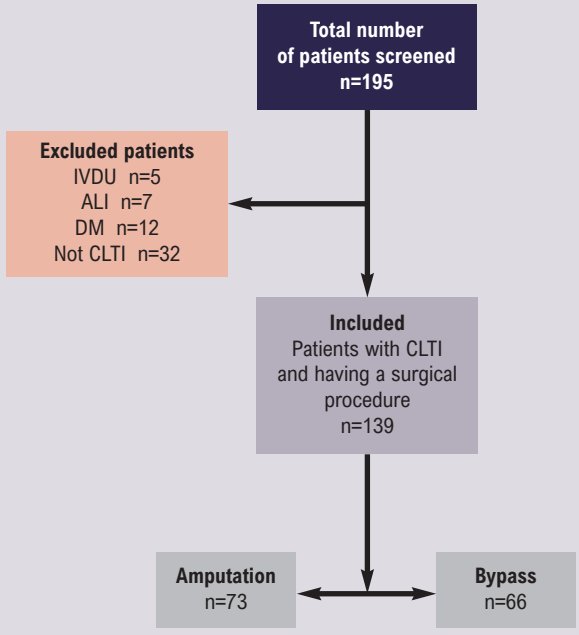
Outcomes

The primary endpoint was 30-day mortality. Other outcomes included one-year mortality, postoperative complications (defined as the occurrence of any complication within 30 days), re-admissions (defined as the requirement to be re-admitted to hospital within 30 days), return to theatre rates (defined as the requirement to return to theatre within 30 days) and length of hospital stay (LoS).

Statistical analysis

Due to the nature of this study, a formal sample size calculation was not performed. All patients undergoing an amputation or bypass procedure for CLTI during the study period were eligible. Descriptive data are presented as mean and standard deviation, median and interquartile range (IQR) or count and percentages as appropriate. A χ^2 test or Fisher's exact test was used for exploring associations and an independent t-test or Mann–Whitney U test for differences between groups, as appropriate. Frailty and malnutrition indices were explored using univariate binary logistic regression for patients who died (at 30 days or one year), had postoperative complications, returned to theatre and/or were re-admitted within 30 days. The type of operation (bypass or amputation) and 30-day mortality, one-year mortality, re-admissions and return to theatre rates were not associated (p>0.05), therefore data were amalgamated and then modelled for the frailty and malnutrition scores with goodness of fit assessed using the area under the curve (AUC). Postoperative complications and the type of procedure (bypass and amputation) were modelled independently (p<0.05). A Kaplan–Meier survival curve with log rank test was used to explore mortality at one year for frail versus non-frail patients. Finally, agreement between the two frailty tools was assessed using Cohen's kappa statistic. Data were analysed using IBM SPSS V24.0; statistical significance was accepted if p<0.05 and missing data were treated as missing and were not imputed.

Figure 1 Patient flow chart.



ALI, acute limb ischaemia; Not CLTI, chronic limb threatening ischaemia (sepsis, claudication, osteomyelitis, pseudoaneurysm or trauma); DM, diabetes mellitus (no history of peripheral arterial disease); IVDU, intravenous drug user.

Results

Baseline

A total of 195 patients who had undergone lower limb bypass or major lower limb amputation over the study period were identified and screened for inclusion. Fifty-six patients undergoing amputation or bypass for reasons other than CLTI (including sepsis, intermittent claudication, osteomyelitis, pseudoaneurysm or trauma) were excluded (Figure 1). The remaining 139 patients (median age 70 (IQR 61–79) years, 71% male) were confirmed to have CLTI, met the inclusion criteria and were therefore included in the analysis, with 73 undergoing major amputation and 66 a bypass procedure. Baseline characteristics for type of procedure and frailty status are shown in Tables 1 and 2, respectively. Patients who underwent a bypass procedure were four years older than those who had an amputation (p=0.011), whilst patients who had an amputation were less mobile (p=0.012) and were more dependent on others for activities of daily living (p=0.018).

Frailty status

Overall, 28% (n=39/139) of patients were identified as frail using the DFI and 19% (n=26/138) using the AFNC (p<0.001). AFNC

Table 1 Demographic and co-morbidity data for CLTI patients undergoing either a bypass or amputation procedure

		Amputation (N=73)	Bypass (N=66)
Age (years), median (IQR)		69 (57–77)	73 (64–81)*
Gender, n (%)	Male	52 (71.2)	46 (69.7)
	Female	21 (28.8)	20 (30.3)
BMI (kg/m^2), median (IQR)		26.5 (23–31)	26 (22–30)
Smoking status, n (%)	Never smoked	14 (19.7)	9 (13.6)
	Ex-smoker	34 (47.9)	34 (51.5)
	Current smoker	23 (32.4)	23 (34.8)
Functional status, n (%)	Independent	49 (72.1)	55 (91.7)*
	Partly dependent	11 (16.2)	3 (5.0)
	Dependent	8 (11.8)	2 (3.3)
Mobility, n (%)	Mobile	19 (27.5)	22 (36.7)*
	Partially mobile	30 (43.5)	33 (55.0)
	Not mobile	20 (29.0)	5 (8.3)
No of comorbidities, median (IQR)		3 (1-4)	3 (2-4)
Hypertension (Y), n (%)		47 (64.4)	50 (75.8)
Renal failure (Y), n (%)		5 (6.8)	2 (3.0)
Diabetes (Y), n (%)	NIDDM	18 (24.7)	14 (21.2)
	IDDM	23 (31.5)	13 (19.7)
Previous MI (Y), n (%)		18 (24.7)	20 (30.3)
Angina (Y), n (%)		20 (27.4)	21 (31.8)
Atrial fibrillation (Y), n (%)		14 (19.2)	18 (27.3)
Respiratory disease (Y), n (%)		14 (19.7)	22 (33.3)
Carotid disease (Y), n (%)		16 (22.2)	15 (23.1)
Congestive cardiac failure (Y), n (%)		11 (15.1)	9 (13.6)

*p<0.05. BMI, body mass index; IDDM, insulin-dependent diabetes mellitus; IQR, interquartile range; MI, myocardial infarction; NIDDM, non-insulin-dependent diabetes mellitus; Y, yes.

data were missing for one patient due to a lack of recording of cognitive status. For amputation and bypass procedures, the proportion of frail patients was similar for both the DFI (p=0.348) and the AFNC (p=0.327). There was moderate agreement between the two frailty tools assessed using Cohen's kappa interrater reliability statistic (0.503, p<0.001). For both tools, the proportion of patients who were mobile without the use of any aids or were independent was significantly lower for frail compared with non-frail patients (p<0.001).

Malnutrition status

In total, 50% (n=69/137) of patients were considered malnourished according to the PNI and 68% (n=79/116) were considered malnourished according to the GNRI (p=0.001). Missing data for the GNRI were due to no height measurement (n=23), and lymphocyte count was not available for the PNI assessment (n=2). For amputation and bypass procedures, respectively, the proportion of malnourished patients was similar for the GNRI (57% vs 43%; p=0.1) but was significantly different for the PNI (75% vs 25%; p<0.001).

Relationship between frailty and malnutrition tools

The frailty tools demonstrated a concordance of 82%, with both classifying 15% (20/138) of the same patients to be frail and 67% to be not frail. Overall, the DFI identified 28% (39/139) as frail compared with 19% (26/138) using the AFNC tool (p<0.001).

The nutritional tools demonstrated a concordance of only 66%. Overall, the PNI identified 52% (n=59/114) as malnourished compared with 68% (n=78/114) with the GNRI (p=0.001). There was no association between the DFI and the PNI or GNRI (p=0.534 and p=0.960, respectively) or the AFNC and the PNI or the GNRI (p=0.430 and p=0.110, respectively).

30-Day outcomes

Mortality

Overall, 30-day mortality was 11% (n=15/139). Causes of death included pneumonia (n=4), sepsis (n=5) and myocardial infarction (n=6). Of the patients who died, 13 (87%) were either frail (n=4), malnourished (n=4) or both (n=5). Although 30-day mortality was

Table 2 Baseline characteristics of Derby Frailty Index (DFI) and the Acute Frailty Network Criteria (AFNC)

Variables	Frail (DFI) (N=39)	Not Frail (DFI) (N=100)	Frail (AFNC) (N=26)	Not Frail (AFNC) (N=112)
Age (years)	82 (78.5–85)	66 (57–72)*	83 (76–86)	69 (58–76)*
Age >65 (years)	100%	53%*	100%	58%*
Male (Y)	64.1%	73%	46.2%	75.9%*
Weight (kg)	69 (58–85)	79 (68–91)*	65 (54–74)	79 (68–91)*
BMI (kg/m^2)	25 (22–29)	26 (22–31)	24 (21–27)	26.5 (22–30)
Smoker (Y)	25.6%	36.7%*	26.9%	35.5%
Co-morbidities				
Hypertension (Y)	71.8%	69%	73.1%	68.8%
Renal failure (Y)	2.6%	6%	0%	6.2%
Diabetes mellitus (Y)	48.7%	49%	46.2%	49.1%
Previous MI (Y)	35.9%	24%	15.4%	29.5%
Angina (Y)	33.3%	28%	23.1%	30.4%
Atrial fibrillation (Y)	38.5%	17%*	42.3%	17.9%*
Respiratory disease (Y)	28.9%	25.3%	23.1%	27.3%
Carotid disease (Y)	36.8%	17.2%*	32%	20.7%
Congestive heart failure (Y)	30.8%	8.1%*	26.9%	11.7%*
Falls (Y)	12.8%	5.5%	30.8%	1.9%*
Cognitive impairment (Y)	28.2%	2.2%*	46.2%	1%*
Independent (Y)	59%	91%*	44%	90.3%*
Mobile (Y)	2.6%	44.4%*	15.4%	35.9%*
Medication				
Optimal therapy (Y)	89.7%	77%	84.6%	79.5%
Laboratory variables				
Albumin	27 (21–33)	29 (23–36)	22 (19–29)	29 (25–36)*
Lymphocytes	1.5 (1.0–2.6)	1.6 (1.2–2.6)	1.2 (0.8–2.2)	1.6 (1.3–2.6)
Haemoglobin	108 (94–124)	111 (92–130)	104 (90–117)	111 (94–130)
Sodium	134 (132–137)	135 (132–137)	134 (131–137)	135 (132–137)
Potassium	4.4 (4–4.7)	4.3 (4.0–4.6)	4.3 (4.1–4.8)	4.4 (4–4.7)
Creatinine	85 (62–111)	82 (61–102)	77 (61–93.4)	84 (61–110)

*p<0.05. BMI, body mass index; Y, yes.

higher in the amputation group (14%, n=10/73) than in the bypass group (8%, n=5/66), this difference was not statistically significant (p=0.245).

In the frail group, 30-day mortality ranged from 21% to 23%, depending on the tool used. Frailty, regardless of the tool used, was associated with 30-day mortality (DFI: OR 3.4 (95% CI 1.2 to 10.2), p=0.027; AFNC: OR 3.4 (95% CI 1.1 to 10.7), p=0.034). The goodness of fit (AUC) for the frailty tools was 0.642 and 0.619, respectively. However, when broken down by procedure, frailty and 30-day mortality were significantly associated in the bypass group (p=0.002) but not in the amputation group (p=0.700). Neither of the malnutrition tools was associated with 30-day mortality (PNI: p=0.254; GNRI: p=0.730).

Postoperative complications

Postoperative complications occurred in 39% of cases (n=54/139; Table 3) but were significantly lower following an amputation compared with a bypass procedure (30% vs 52%; p=0.027). Neither of the frailty indices was significantly associated with postoperative complications following an amputation (DFI, p=0.402; AFNC, p=0.913). However, frailty identified using the DFI (but not the AFNC, p=0.462) was associated with postoperative complications following a bypass procedure (OR 8.5 (95% CI 2.4 to 29.8), p=0.001). The goodness of fit (AUC) for the DFI tool was 0.869. Neither of the malnutrition tools was associated with postoperative complications following amputation (PNI: p=0.214; GNRI: p=0.869) or bypass (PNI: p=0.722; GNRI: p=0.506).

Table 3 Types of complication by procedure.

Complication type	Total N (%)	Amputation N (%)	Bypass N (%)
Cardiac	9 (13.4)	2 (8.7)	7 (15.9)
Respiratory	6 (9)	3 (13)	3 (6.8)
Cerebral	1 (1.5)	1 (4.3)	-
Haemorrhage/bleeding	11 (16.4)	2 (8.7)	9 (20.5)
Infection	9 (13.4)	5 (21.7)	4 (9)
Thrombosis	5 (7.5)	1 (4.3)	4 (9)
Multi-organ failure	3 (4.5)	2 (8.7)	1 (2.3)
Renal failure	1 (1.5)	-	1 (2.3)
Urinary tract infection	1 (1.5)	-	1 (2.3)
Metabolic acidosis	1 (1.5)	1 (4.3)	-
Low haemoglobin	9 (13.4)	2 (8.7)	7 (15.9)
High potassium	2 (3)	2 (8.7)	-
Hypotension	4 (6)	1 (4.3)	3 (6.8)
Graft failure	1 (1.5)	-	1 (2.3)
Urinary retention	1 (1.5)	-	1 (2.3)
Postoperative vomiting	1 (1.5)	-	1 (2.3)
Loose stools and fever	1 (1.5)	-	1 (2.3)
Heparin-induced thrombocytopenia	1 (1.5)	1 (4.3)	-

Re-admissions

Re-admission within 30 days occurred in 6% (n=8/139) of patients, with no significant difference between patients undergoing amputation (7%, n= 5/73) or bypass (5%, n=3/66, p=0.721). Frailty established using the AFNC (but not the DFI, p=0.843) was significantly associated with re-admission within 30 days (OR 4.9 (95% CI 1.1 to 21.1), p=0.033) whereas neither of the malnutrition tools was significantly associated with re-admission within 30 days (PNI: p=0.253; GNRI: p=0.938). The goodness of fit (AUC) for the AFNC tool was 0.665.

Return to theatre rates

In total, 10% (n=14/139) of patients were required to return to the theatre within 30 days. There was no significant difference in return to theatre rates between amputation (6%, n=4/73) and bypass procedures (15%, n=10/66; p=0.058). Neither of the frailty (DFI: p=0.563; AFN: p=0.647) or malnutrition tools (PNI: p=0.792; GNRI: p=0.910) was associated with returning to theatre within 30 days.

Length of stay (LoS)

The median LoS for all patients was 14 (IQR 9–25) days. Patients undergoing amputation procedures (17 (IQR 12–27.5) days) had a significantly longer LoS than those undergoing bypass procedures (13 (IQR 7–21) days; p=0.010). There were no significant differences in LoS between frail and non-frail patients using either the DFI (p=0.388) or AFNC (p=0.626) or between malnourished and nourished patients using the PNI (p=0.050). However, according to the GNRI, malnourished patients had a significantly longer LoS (16 (IQR 10–30) days) compared with nourished patients (12 (IQR 8–18.5) days; p=0.039). This difference was not driven by the difference in LoS between procedures (amputation malnourished vs nourished LoS: p=0.369; bypass malnourished vs nourished LoS: p=0.126).

One-year mortality

One-year mortality was 26% (n=36/139) with no significant difference between amputation (27%, n=20/73) or bypass procedures (23%, n=15/66; p=0.526).

Patients considered frail by either tool had significantly higher mortality at one year, ranging from 56% to 58% (p<0.05; Figures 2 and 3). Frailty was significantly associated with one-year mortality (DFI: OR 7.95 (95% CI 3.4 to 18.6), p<0.001; AFNC: OR 5.9 (95% CI 2.4 to 14.7), p<0.001; Figures 2 and 3), whilst malnutrition was not (PNI: p=0.884; GNRI: p=0.177). Frailty and one-year mortality were significantly associated in the bypass (p<0.001) and amputation groups (p=0.002). The goodness of fit (AUC) for the frailty tools was 0.723 and 0.654, respectively.

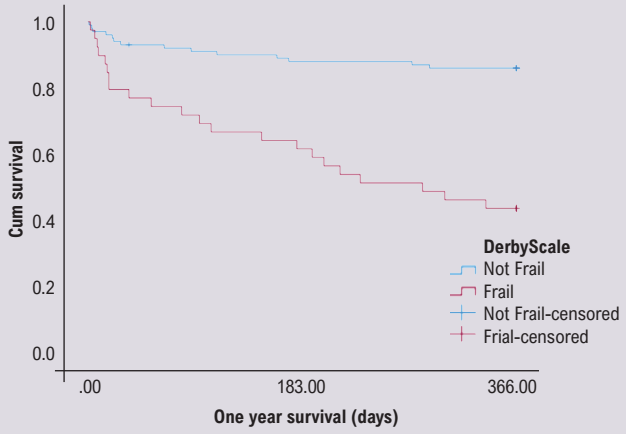
Discussion

This study aimed to assess how frailty and malnutrition, identified using simple to apply, less ambiguous tools, are associated with outcomes in patients with CLTI undergoing lower limb vascular surgery. We have demonstrated that frailty and malnutrition are prevalent in this population and that frailty is strongly associated with both 30-day and one-year mortality, especially in patients undergoing a bypass procedure. Frailty is also associated with postoperative complications and re-admissions. Overall, it appears that both tools are able to strongly describe the risk of poorer outcomes following surgery. These findings mirror those reported previously in that frailty, assessed using more widely adopted tools such as the Clinical Frailty Scale and the Modified Frailty Index, is associated with mortality and morbidity, but not length of stay, for patients with PAD undergoing revascularisation.[12,14-16]

This therefore strengthens the need to consider frailty in general in patients being considered for major vascular surgery, particularly in the joint patient and clinician decision-making process. It also provides new evidence for the utility of alternative tools, the DFI and AFNC, which hitherto have not been considered in patients with CLTI, despite evidence in the heart failure population.[12] This suggestion that frailty needs to be considered in the joint decision-making process is furthered when considering the results recently reported for a study exploring frailty in patients with CLTI presenting to a vascular limb salvage clinic. This study demonstrated that, on multivariable analyses, frailty was not independently associated with death or amputation.[17] However, frail patients were more likely to be managed conservatively, suggesting that, for a select group of frail patients, conservative management may lead to better outcomes than aggressive invasive treatment. This warrants further exploration to identify which characteristics contributing to frailty make conservative management more appropriate.

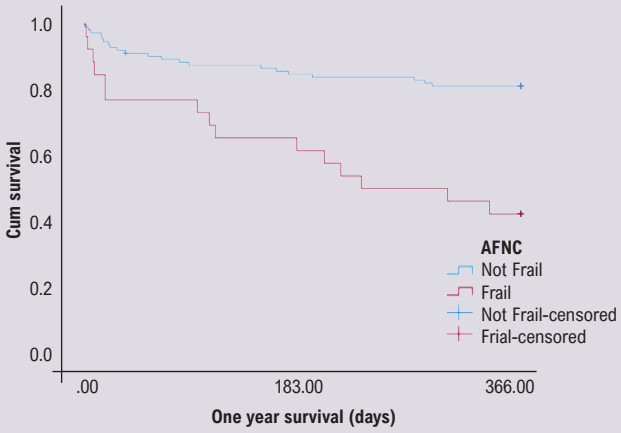
One interesting finding is that frailty was only associated with

Figure 2 One-year mortality using the Derby Frailty Index.



DFI – Not Frail	Number Exposed to Risk	Cumulative Number of Deaths	Cumulative Proportion Of Deaths	Cumulative Proportion Survived	Standard Error
0 Mths	100	3	0.03	0.97	0.02
30 Days	93	7	0.07	0.93	0.03
3 Mths	90	9	0.09	0.91	0.03
6 Mths	87	12	0.12	0.88	0.03
12 Mths	85	14	0.14	0.86	0.03
DFI - Frail					
0 Mths	39	1	0.03	0.97	0.03
30 Days	31	8	0.21	0.79	0.06
3 Mths	28	11	0.28	0.72	0.07
6 Mths	24	15	0.38	0.62	0.08
12 Mths	17	22	0.56	0.44	0.08

Figure 3 One-year mortality using the Acute Frailty Network Criteria (AFNC).



AFNC – Not Frail	Number Exposed to Risk	Cumulative Number of Deaths	Cumulative Proportion Of Deaths	Cumulative Proportion Survived	Standard Error
0 Mths	112	2	0.02	0.98	0.01
30 Days	103	9	0.08	0.92	0.03
3 Mths	97	14	0.13	0.87	0.03
6 Mths	94	17	0.15	0.85	0.03
12 Mths	90	21	0.19	0.81	0.04
AFNC - Frail					
0 Mths	26	2	0.08	0.92	0.05
30 Days	20	6	0.23	0.77	0.08
3 Mths	20	6	0.23	0.77	0.08
6 Mths	16	10	0.38	0.62	0.10
12 Mths	11	15	0.58	0.42	0.10

30-day mortality following bypass but not following amputation, and this association was stronger when using the DFI, as evidenced by the greater AUC. Additionally, frailty established using the DFI was associated with postoperative complications, again only in the bypass group. This suggests that the DFI is able to identify patients who are at an increased risk of complications following bypass procedures and these complications may also be contributing to the increased risk of 30-day mortality in this group. Therefore, any patient with CLTI undergoing a bypass procedure who is identified as frail according to the DFI requires appropriate input and optimisation across the perioperative pathway to reduce their risk of postoperative complications and consequent 30-day mortality.

When considering the AFCN tool, frailty was associated with an increased risk of re-admission. This may be secondary to the fact that, according to this tool, patients aged ≥85 years are considered frail, regardless of any other factors. This notion is supported by a study in a similar patient cohort which demonstrated that patients aged >77 years were at an increased risk of multiple re-admissions.[18] However, although frail patients were significantly older than their non-frail counterparts, they also differed in terms of the incidence of important co-morbidities and a combination of age and co-morbidities is more strongly associated with poorer outcomes than chronological age alone.[19] This suggests that there may be other drivers than age which contribute to the increased risk of re-admission. It is therefore important that non-frail elderly patients are not denied treatment based on age alone.

The incidence of malnutrition in our patient cohort significantly differed depending on the screening tool used. The proportion of patients identified as malnourished using the PNI, which has not been previously applied to vascular patients, was similar to that demonstrated in heart failure patients.[12] Conversely, the proportion of patients identified as malnourished using the GNRI differed substantially to previous studies.[20,21] However, these studies did not consider those with mild malnourishment as malnourished. When the same criteria are applied to our cohort, the proportion of malnourished patients is similar.[20,21] Regardless, our findings do differ from those in vascular[20,21] and other populations,[12] as neither tool was associated with postoperative outcomes. This suggests that, although important, nutritional status may not be as relevant as frailty for patients with CLTI undergoing major surgery.

The finding that these malnourishment tools are not associated with postoperative outcomes is, however, more likely to be related

to the inflammatory process which influences lymphocyte cell count and the synthesis of serum albumin. Indeed, the recent ASPEN position paper specifically states that serum albumin characterises inflammation, rather than describing nutritional status.[22] Given that CLTI is a systemic inflammatory condition, the application of these tools, which are heavily weighted by albumin concentration, may not be appropriate. An example of how these tools may be influenced by inflammation is provided within our data. The PNI, which does not consider other physical patient characteristics in its assessment, characterised a significantly greater proportion of amputation patients as malnourished compared with bypass patients. This is likely to be related to the elevated inflammatory state of patients undergoing amputations compared with that of those undergoing bypass procedures.

Clearly, further work considering malnourishment in patients with CLTI undergoing surgery is required. Such studies should adopt appropriate tools which do not consider serum albumin in their assessment, such as those highlighted in the recent ASPEN position paper.[22]

Implications for practice and future directions

Frailty assessment allows evidence-based quantification of risk during the consent process and should become mandatory. These simple tools can be applied prior to ward rounds or clinic appointments as they use routinely collected data and require no additional training. Identifying frailty provides an opportunity to work with the multidisciplinary team to optimise the patient and plan admission with access to high dependency wards as well as appropriate rehabilitation and discharge. However, there is a need for consensus on the most appropriate frailty tool for use in patients with CLTI. This study suggests that either the DFI or the AFNC may be appropriate, although the DFI may be more appropriate in patients undergoing bypass, evidenced by its ability to predict postoperative complications which may be contributing to 30-day mortality. However, before we can recommend their use, these tools warrant further investigation to explore their validity, reliability, responsiveness, patient acceptability and clinical functionality as well as how they compare with more widely adopted tools such as the Clinical Frailty Scale.

Additionally, although factors relating to frailty are often unmodifiable, frailty is associated with poor physical function[23] and depleted physiological reserve, so it may identify a specific group of patients who could benefit from 'prehabilitation'. Evidence suggests that prehabilitation combined with rehabilitation improves postoperative outcomes in other surgical specialities[24,25] and thus warrants further investigation in frail patients with CLTI. It is, however, important to consider this in the context of the current PAD-QIF targets for revascularisation, which are 5 days for inpatients and 14 days for outpatients.[26] Therefore, prehabilitation, if considered in future investigations, will need to be intensive to maximise the limited timeframe available. If prehabilitation is not feasible, an alternative could be the use of a comprehensive vascular geriatric service, with the inclusion of geriatric experts. Recent evidence suggests a service such as this can improve outcomes and reduce 30-day mortality in frail vascular inpatients.[27]

KEY MESSAGES

- For patients with chronic limb threatening ischaemia, there is a high prevalence of frailty. In this cohort, it ranged from 19-28% and was assessed using two simple to apply tools.
- In this cohort, the presence of frailty was associated with 30-day and 1-year mortality as well as post-operative complications and hospital re-admissions but not length of stay or return to theatre rates.
- Frailty warrants further investigation and should be part of the consent and joint decision-making process in patients with chronic limb threatening ischaemia, to personalise care and minimise the risk of poorer outcomes.

Finally, malnutrition, whilst clearly important, was not associated with poorer outcomes in this study. Further work is required to determine a reliable malnutrition tool for patients with CLTI.

Limitations

This study is not without limitations. First, the study is retrospective with a limited sample size drawn from a single centre. This limits generalisability and increases the possibility of a type II error. In addition, confounders, both known and unknown, could not be controlled for. Furthermore, the data collection period (2016) is now eight years ago and it is possible that the findings presented here may not be reflected in current practice with the more recent developments in perioperative and ward level care. However, the results are still relevant and this study acts as a fundamental starting point to stimulate further prospective, appropriately designed trials considering the impact of frailty, identified using these simple-to-apply tools, and malnutrition, using other appropriate tools, in contemporaneous cohorts of patients with CLTI.

One final limitation is the lack of available data on CLTI severity in the form of Rutherford classifications, WIfI classifications and haemodynamic measures. Due to the nature of this study and its retrospective data collection, we were unable to obtain this information despite the likelihood of it being recorded. Therefore, it is imperative that future prospective studies collect and report these data.

Conclusion

Frailty is associated with an increased risk of worse outcomes for patients with CLTI undergoing major surgery. Frailty should be considered routinely in this patient cohort to inform the consent and joint decision-making processes, to personalise care and to minimise the risk of poorer outcomes, although further research is needed.

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COHORT STUDY

Single-centre prospective cohort study investigating the associations and one-year trends of frailty, cognition, disability and quality of life pre- and post-intervention for chronic limb-threatening ischaemia

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Plain English Summary

Why we undertook the work: We studied the effects of frailty in people with severe artery disease in the legs who had surgery. Frailty is the decline in the body's systems due to getting older. People with frailty get better more slowly after illness or surgery. They are more likely to need care and have a shorter life than those who don't have frailty. About half of people with severe artery disease in the legs also have frailty. Their symptoms can limit their walking, causing disability. Long-term foot pain, ulcer or gangrene can also impact other body systems. We know that people with both severe artery disease of the legs and frailty have a shorter life and more problems after surgery. But, many still need surgery to save their leg. We compared people with and without frailty who had surgery for severe artery disease of the legs. We looked at quality of life, mood and disability over 1 year after surgery. We felt this work was important for helping patients and their doctors with severe artery disease in the legs make decisions about their care.

What we did: Ninety-nine people with severe artery disease in the legs agreed to take part. They had tests of frailty, their memory and thinking, and their physical function. They also answered surveys about quality of life, disability and mood. Eighty-seven people had a procedure. These people also took surveys 3 months and 1 year after their surgery.

What we found: Our results show that people with frailty had worse quality of life, mood and disability before and 1 year after their surgery. However, both people with and without frailty had an average improvement in mood and quality of life. On average, all patients became slightly more disabled over 1 year. About one in 10 people with frailty improved so much after surgery that they were not frail at 1 year. These people were younger. But, nearly a quarter of the people without frailty before their surgery became frail over 1 year. These people were slightly older.

What this means: Most people in this study had a better quality of life at 1 year, even those with frailty before their procedure. This means even people with frailty may benefit from a procedure for severe artery disease in the legs. These results may help people thinking about a procedure for severe artery disease in the legs to predict what their likely outcomes might be and manage expectations. These results will also help their clinicians provide crucial information for shared decision making.

Abstract

Background: Half of people with chronic limb-threatening ischaemia (CLTI) have frailty. This study aimed to describe the associations of frailty with cognition, disability and quality of life (QoL) among CLTI patients over 1 year following surgical or endovascular procedures.

Methods: A single-centre prospective cohort study was undertaken. Patients undergoing a procedure for CLTI between May 2019 and May 2021 were eligible (minimum age ≥65 initially; ≥50 from November 2019). Participants underwent preoperative assessments for frailty, physical and cognitive function, disability, mood, disease-specific QoL (Vascular QoL questionnaire (VascuQoL)) and generic health-related QoL (EuroQoL EQ-5D-5L). Follow-up was at 3 months (clinic or telephone) and 12 months (telephone). Baseline frailty was assessed using both the Edmonton frail scale (EFS) and the clinical frailty scale (CFS). Frailty during

follow-up was re-assessed at 3 and 12 months using the CFS as it can be performed via telephone. Associations of baseline frailty with disability, QoL and mood scores during follow-up were investigated using repeated measures mixed models.

Results: Ninety-nine patients completed the baseline assessments. Forty-five (45%) were classified as frail by the EFS. Frailty was associated with a higher prevalence of cognitive impairment based on the Montreal cognitive assessment (52% vs 17%; p<0.001). Eighty-seven patients were eligible for follow-up. Baseline frailty (EFS) was associated with worse QoL scores at all timepoints (VascuQoL p=0.001; EQ-5D-5L p<0.001). Both those with and without frailty at baseline (EFS) had modest improvement in QoL scores at 12 months (VascuQoL p<0.001; EQ-5D-5L p=0.001). Barthel index (disability) scores were lower for those with frailty at baseline (EFS) (p<0.001) and decreased slightly over 12 months for both groups (p=0.007). Five patients (12%) transitioned from frailty to non-frailty at 12 months based on the CFS. However, 10 patients (23%) transitioned from non-frailty to frailty.

Conclusions: CLTI patients with frailty have worse QoL and greater disability both pre- and post-intervention. However, they demonstrate similar QoL benefit to those without frailty at 1 year following intervention. Baseline frailty assessment is important to inform prognostic discussions, expectations and shared decision making in CLTI.

Key words: frailty, cognitive dysfunction, quality of life, peripheral artery disease, chronic limb-threatening ischaemia

Introduction

Frailty is a complex, dynamic, multi-system health state characterised by susceptibility to significant homeostatic dysregulation from even minor physiological stressors, leading to poor health-related outcomes such as loss of independence and death.[1,2] Frailty is present in around half of all individuals with chronic limb-threatening ischaemia (CLTI) and is related to severity of disease.[3–5] Among vascular surgery patients, including those with CLTI, frailty is related to worse perioperative outcomes and long-term survival.[3–7]

Frailty is closely interrelated to disability and cognitive impairment.[2,8] There is a high prevalence of cognitive impairment among vascular surgery patients, but it is unknown among those with CLTI specifically.[9] CLTI causes lower limb dysfunction and associated disability; however, their interactions with frailty in those with CLTI have not been described.[3,10,11] Furthermore, whilst transition in frailty states has been detailed among vascular surgery patients in general, there has been little investigation of frailty trajectories following intervention for CLTI.[12]

The aim of this study was to describe the associations of frailty with cognition, disability, physical function, mood and quality of life (QoL) among individuals with CLTI at initial presentation and over a 1-year period following intervention.

Methods

The Leg Ischaemia Management collaboration (LIMb) study is a single-centre, prospective cohort study of individuals with CLTI (NCT04027244). The full LIMb study protocol has been published elsewhere.[13] Adults with CLTI presenting to the Leicester Vascular Institute (Glenfield Hospital, University Hospitals of Leicester NHS Trust) were eligible for inclusion. CLTI was defined as a minimum 2-week ischaemic night or rest pain and/or ulceration or gangrene in the affected leg(s) attributable to confirmed peripheral artery disease.[14,15] Recruitment opened in May 2019 and continued until March 2022. Written informed individual patient consent was gained prior to completion of any study procedures. Patients lacking mental capacity to consent were eligible for inclusion with agreement from a suitable personal consultee. The LIMb study received ethical approval from the UK National Research Ethics Service (19/LO/0132).

Frailty and cognitive additional assessments

Those recruited to the LIMb study aged ≥65 years who planned to undergo a procedure for CLTI were eligible to consent to additional frailty and cognitive assessments prior to their intervention and at 3 and 12 months post-procedure. Minimum age for inclusion was lowered to ≥50 years following a protocol amendment in November 2019 after identification, early in the study, of several individuals recruited to the LIMb primary cohort who were living with frailty (clinical frailty scale (CFS) score ≥5) but aged 50–64 and therefore initially ineligible to participate in the frailty and cognitive additional assessments.

Baseline demographics, comorbidities, preoperative blood test results and wound, ischaemia, and foot infection (WIfI) scores were collected for all patients recruited to the LIMb study. WIfI scores were converted to clinical stage based on risk of major amputation.[16] Charlson Comorbidity Index (CCI) scores were calculated using an updated weighting.[17] CFS, Barthel index of activities of daily living, Hospital Anxiety and Depression Scale (HADS) and the Vascular Quality of Life (VascuQoL) 25-item questionnaire were also collected at baseline.[18–21] The EuroQoL EQ-5D-5L tool was added to the study schedule after a protocol amendment in May 2020.[22] EQ-5D-5L scores were converted to validated values for UK patients prior to analysis.[23] Individuals

Table 1 Study procedures and assessment schedule

Assessment	Description	Cut-off point	Baseline	3 months	12 months
CFS	9-point scale based on self-reported function (1 least frail; 9 most frail)	≥5	●	●	●
EFS	Multi-domain 14-point assessment (1 least frail; 14 most frail)	≥8	●	○	○
MoCA*	Multi-domain assessment: max score = 30 (higher score = better cognitive function)	<24	●	●	●
VascuQoL	PAD-specific 25-item questionnaire (max score = 7; higher = better QoL)	N/A	●	●	●
EQ-5D-5L†	Generic 5-item questionnaire & VAS (0–100) (higher score = better QoL)	N/A	●	●	●
HADS	14-item questionnaire (7 anxiety; 7 depression) (max score = 21 each; higher score = worse mood)	≥11	●	●	●
Barthel index	10-item ADLs questionnaire (max score = 20; higher score = less disability)	N/A	●	●	●
SPPB	3-domain physical assessment of lower limb function (max score = 12; higher scores = better function)	N/A	●	○	○
Grip strength	Bilateral hand grip strength (kg) using dynamometer (5 repeats each hand; max grip strength calculated)	N/A	●	○	○

*MoCA-BLIND utilised during telephone follow-up and where patient had visual impairment.
†Added after protocol amendment in May 2020.
● Performed in all patients/at both face-to-face and telephone follow-up.
○ Only performed during face-to-face follow-up.

ADLs, activities of daily living; CFS, clinical frailty scale; EFS, Edmonton frail scale, HADS, Hospital Anxiety and Depression Scale; MoCA, Montreal cognitive assessment; N/A, not applicable; PAD, peripheral artery disease; QoL, quality of life; SPPB, Short Physical Performance Battery; VAS, visual analogue scale; VascuQoL, Vascular Quality of Life Questionnaire.

lacking mental capacity to consent were supported in completion of QoL questionnaires by their personal consultee if required.

Those consenting for additional frailty and cognitive assessments undertook the Edmonton frail scale (EFS), Montreal cognitive assessment (MoCA), Short Physical Performance Battery (SPPB) and standardised bilateral seated hand grip strength (Jamar Plus+ digital hand dynamometer). The original study protocol scheduled follow-up clinic visits at 3 and 12 months where frailty and cognitive assessments were repeated. A summary of assessments is shown in Table 1. Baseline frailty and cognitive assessments used in this study are not part of routine clinical practice (except for the CFS) and were not used by the clinical team in decision making.

Outcome data were collected from written and/or electronic medical records. Study data were collected and managed using REDCap (Research Electronic Data Capture).[24]

Protocol amendments due to COVID-19

The LIMb study was paused in March 2020 at the beginning of the first UK wave of the coronavirus disease 2019 (COVID-19) pandemic. Recruitment to the frailty and cognitive additional assessments reopened in October 2020 but was again suspended throughout January 2021 during a further UK wave of COVID-19. Whilst recruitment to the primary cohort of the LIMb study was extended until March 2022, it was not possible to extend recruitment to the frailty and cognitive additional assessments beyond the original planned study end date of May 2021.

Because of COVID-19 related restrictions, all 3-month and 12-month follow-ups were undertaken via telephone from March 2020. Patients recruited to the study from February 2021 were offered the option of clinic follow-up at 3 months post-procedure. All 12-month follow-up was switched to telephone only. The MoCA-BLIND was used to assess cognitive function via telephone, but it is not possible to perform the EFS, SPPB or hand grip strength via telephone (Table 1).[25]

Statistical analysis

As EFS is a multi-domain clinical assessment of frailty, the baseline EFS score was used to define frailty in the analyses.[26] Variables were presented in tables with data for frail (EFS ≥8) and non-frail (EFS <8) patients separately. Categorical variables were presented as frequencies (%). Histograms were assessed for normality of continuous variables. Normally distributed data were presented as means (standard deviation (SD)) and skewed data as medians (interquartile range (IQR)). Associations of baseline variables with frailty were investigated using a χ^2 test for categorical data, t-test for normally distributed continuous data, and Kruskal–Wallis test for skewed continuous data. Cohen's κ was calculated to assess agreement between EFS and CFS.

The change in SPPB and grip strength at 3 months was investigated using analysis of covariance. Changes in 12-month assessment scores were investigated using repeated measures mixed models (restricted maximum likelihood) and adjusted predictions presented graphically by frailty status with 95% CI.

Sensitivity analyses were performed by excluding those with missing data (complete case analysis).

Association of frailty with 1-year survival was presented using Kaplan–Meier survival curves, using the log-rank test to test differences between groups. Independent associations of frailty, cognitive impairment, age and CCI score with 1-year mortality (pre-selected variables) were investigated using Cox regression and reported as hazard ratios (HR) with 95% CI. Independent associations of frailty, cognitive impairment, age, CCI score and WIfI stage (pre-selected variables) with major amputation were tested using Fine-Gray competing risk analysis (death as the competing risk) and reported as sub-distribution hazard ratios (SHR) with 95% CI.

All statistical analyses were performed in Stata (version 17 for Windows, StataCorp. College Station, Texas, USA). A p value of <0.05 was considered statistically significant.

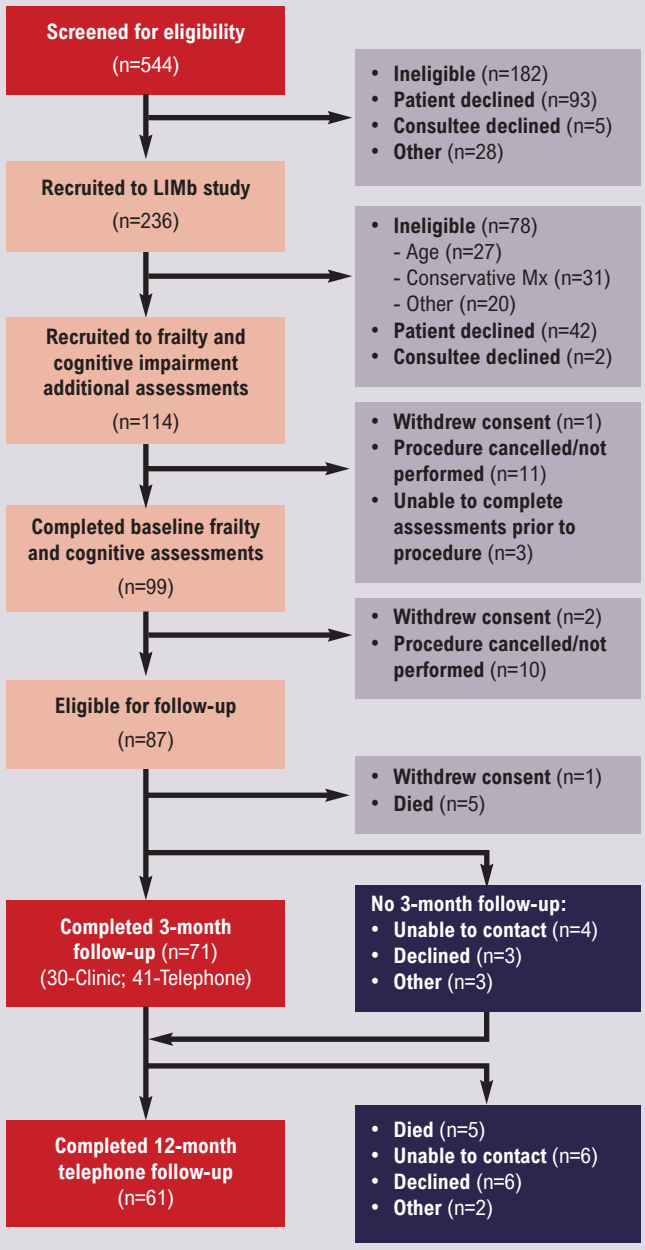
Results

Baseline associations with frailty

In total, 99 (63%) of the 158 eligible patients recruited to the LIMb study completed additional frailty and cognitive assessments at baseline (Figure 1). Four of these patients (4%) were included via personal consultee assent (lacked mental capacity). Forty-five patients (45%) were classified as frail by the EFS and 49 (49%) by the CFS with moderate agreement (78%; κ=0.56). Breakdown of severity of frailty was similar for both EFS and CFS; however, only 16% of patients were classified as vulnerable by the EFS compared with 42% by the CFS (Table 2). Overall, 32 patients (33%) were deemed to have cognitive impairment. Cognitive impairment (MoCA <24) was strongly associated with frailty (52% vs 17%; p<0.001).

Associations of baseline patient characteristics with frailty are presented in Table 3. Frailty was associated with a higher CCI score, greater number of medications and lower haemoglobin concentration. A greater proportion of those with frailty were female (31% vs 15%), but this difference did not reach statistical significance (p=0.052). The mean ages of those with and without frailty were similar. Individuals with frailty had an almost 4-point worse SPPB score and 8.4 kg lower mean maximum grip strength.

Figure 1 Patient recruitment flowchart for the periods when recruitment was open to the frailty and cognitive additional assessments.



Associations of frailty with trends in assessment scores over time

Twelve patients had their procedure cancelled or delayed after undergoing baseline frailty assessments and were subsequently excluded from further analysis. A higher proportion of those with frailty had their procedure delayed or cancelled, but there was no significant difference in the overall management strategy (Table 3). Seventy-one patients completed the 3-month follow-up and 61 patients completed the 12-month follow-up (Figure 1). Six patients not followed up at 3 months were successfully followed up at 12 months, meaning 55 patients completed all additional frailty and cognitive assessments per protocol.

Thirty-one patients received face-to-face clinic follow-up at 3 months. Frailty at baseline was not associated with change in median MoCA score (+1 (IQR –3 – +3) vs 0 (IQR –2 – +1); p=0.856) nor change in mean maximum grip strength (+0.1 (SD 3.1) kg vs –0.6 (SD 4.8) kg; p=0.870). Those with frailty at baseline had a greater improvement in mean (SD) SPPB score (+1.6 (3.6)) than those without frailty (–0.6 (2.5)), although this difference did

Table 2 Breakdown of frailty scores at baseline by both Edmonton frail scale and clinical frailty scale

Edmonton frail scale				Clinical frailty scale			
No frailty*	38 (38)	No frailty (EFS 0–7)	54 (55)	No frailty*	8 (8)	No frailty (CFS 1–4)	50 (51)
Vulnerable†	16 (16)			Vulnerable†	42 (42)		
Mild frailty‡	23 (23)	Frailty (EFS 8–17)	45 (45)	Mild frailty‡	32 (32)	Frailty (CFS 5–9)	49 (49)
Moderate frailty§	13 (13)			Moderate frailty§	15 (15)		
Severe frailty‖	9 (9)			Severe frailty‖	2 (2)		

Data are presented as n (%).
*No frailty: EFS score 0–5; CFS score 1–3. †Vulnerable: EFS score 6–7; CFS score 4. ‡Mild frailty: EFS score 8–9; CFS score 5.
§Moderate frailty: EFS score 10–11; CFS score 6. ‖Severe frailty: EFS score 12–17; CFS score 7–9.

CFS, clinical frailty scale; EFS, Edmonton frail scale.

Table 3 Baseline characteristics of patients by frailty status

	No frailty (EFS 1–7) (N=54)	Frailty (EFS 8–14) (N=45)	P value†
Age	72.1±9.9	72.6±10.9	0.844
Female	8 (15)	14 (31)	0.052
Diabetes	30 (56)	20 (44)	0.271
CCI score*	1 (0–2)	2 (1–4)	**<0.001**
Hb (g/dL)	137.3±17.0	124.4±19.8	**<0.001**
Smoking history			
Never	5 (9)	11 (25)	0.108
Stopped	36 (67)	25 (56)	
Current	13 (24)	8 (18)	
No of medications	7.2±3.1	9.1±3.1	**0.003**
Bilateral CLTI	5 (9)	5 (11)	0.092
WIfI stage			
1	6 (14)	3 (9)	0.824
2	13 (30)	11 (33)	
3	16 (36)	11 (32)	
4	9 (20)	9 (26)	
MoCA score*	26 (25–28)	23 (16–27)	**<0.001**
SPPB score	6.8±3.6	2.9±2.4	**<0.001**
Max grip strength (kg)	33.8±10.5	25.4±11.6	**<0.001**
Initial procedure			
Endovascular	31 (57)	17 (38)	0.393
Hybrid/open surgery	17 (31)	18 (40)	
Major amputation	2 (4)	2 (4)	
Minor amputation/debridement	1 (2)	1 (2)	
Procedure delayed/cancelled	3 (6)	7 (16)	

Data are presented as n (%) or mean±SD unless otherwise stated.
P values in bold are statistically significant.
*Data presented as median (IQR).
† χ^2 test for categorical data, t-test for normally distributed continuous data, or Kruskal–Wallis test for skewed continuous data.

CCI, Charlson comorbidity index; CLTI, chronic limb-threatening ischaemia; EFS, Edmonton frail scale; Hb, haemoglobin; MoCA, Montreal cognitive assessment; No, number; SPPB, Short Physical Performance Battery; WIfI, Wound, Ischaemia, and Foot Infection.

not reach statistical significance (p=0.087). Caution is required in interpreting these results as fewer patients with frailty attended face-to-face clinic follow-up at 3 months (8 frail (21%) vs 23 non-frail (47%)).

Frailty was associated with consistently worse disability, mood, QoL and cognitive function assessment scores at baseline, 3-month and 12-month follow-up (Figure 2 and Table 4). Barthel index scores worsened slightly over 12 months for both frailty and non-frailty groups (p<0.001). Individuals without frailty had a greater improvement in both VascuQoL and EQ-5D-5L scores at 3 months but little further change at 12 months, whilst those with frailty saw further improvement in QoL scores at 12 months. The time trends for the improvement in VascuQoL scores (p<0.001), EQ-5D-5L values (p=0.001) and EQ visual analogue scale (p=0.001) were statistically significant, but there was no difference in time trends by frailty status. Individuals without frailty had an improvement in HADS anxiety scores at 3 months that was lost by 12 months, whilst those with frailty demonstrated little change at 3 months but an improvement at 12 months. This difference in trends in HADS anxiety scores over 12 months was the only statistically significant interaction of frailty status and time (p=0.014). Sensitivity analyses showed no difference in results.

Investigation of frailty trajectory was only possible using the CFS, as the EFS cannot be completed via telephone. Forty-four patients were classified as non-frail (CFS ≤4) at baseline. Of these, two had died and 10 (23%) had transitioned to frail (CFS ≥5) at 12 months (missing data for eight patients) (Table 5). Conversely, of 43 patients classified as frail (CFS ≥5) at baseline, eight had died and five (12%) had transitioned to non-frailty (CFS ≤4) at 12 months (missing data for nine patients). Mean (SD) age at baseline was older in those classified as frail by the CFS at 12 months (74.7 (10.0) years vs 67.2 (9.0) years; p=0.003). Those transitioning from non-frailty to frailty were older than those who remained non-frail at 12 months (mean (SD) age 76.7 (8.1) years vs 67.8 (9.4) years) whilst those transitioning from frailty to non-frailty were younger than those who remained frail at 12 months (mean (SD) age 64.3 (7.2) years vs 73.7 (10.9) years).

Figure 2 Time trends in assessment score by frailty status (adjusted predictions of the interaction of frailty and time from repeated measures mixed models with 95% confidence intervals).

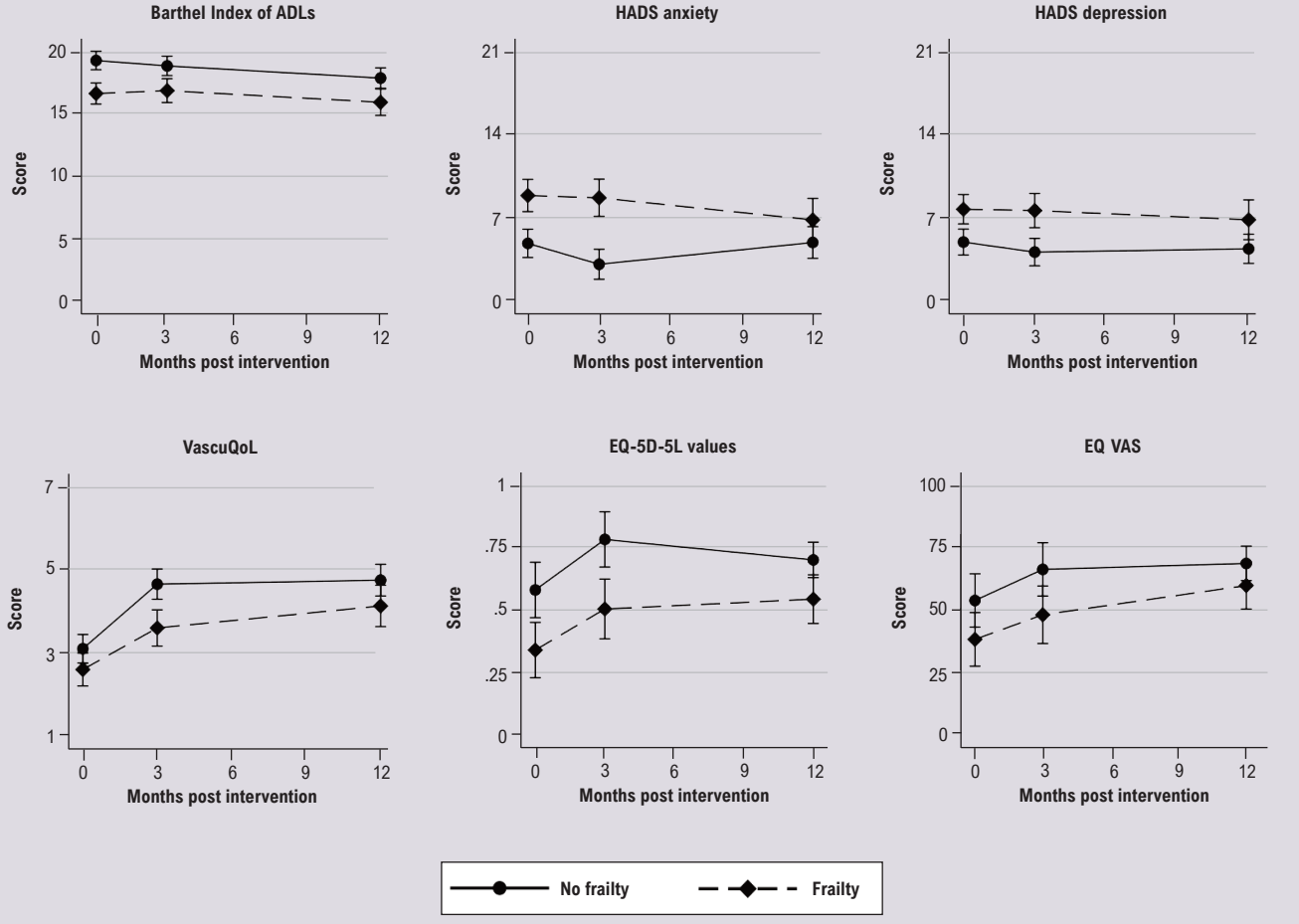


Table 4 Assessment scores at each study visit by frailty status

	No frailty (EFS 1–7)			Frailty (EFS 8–14)			P values		
	Baseline	3 months	12 months	Baseline	3 months	12 months	Frailty†	Time‡	Interaction§
Barthel index*	20 (19–20)	20 (19–20)	19 (16–20)	17.5 (15–20)	17 (15–19)	17 (13–18)	**<0.001**	**0.007**	0.480
HADS									
Anxiety	4.8±3.9	3.0±3.3	5.1±4.4	8.8±4.8	8.7±4.6	7.2±4.7	**<0.001**	0.127	**0.014**
Depression	4.9±3.7	4.0±4.0	4.5±3.9	7.7±3.9	7.5±3.8	6.9±4.4	**<0.001**	0.404	0.641
VascuQoL	3.1±1.1	4.6±1.4	4.7±1.3	2.6±1.0	3.6±1.0	4.0±1.4	**0.001**	**<0.001**	0.233
EQ-5D-5L	0.577±0.201	0.779±0.124	0.698±0.246	0.336±0.189	0.501±0.184	0.540±0.229	**<0.001**	**0.001**	0.458
EQ VAS	53.2±18.1	66.1±23.1	68.4±20.3	37.5±18.3	47.5±17.8	60.2±23.8	**0.002**	**0.001**	0.585
MoCA-BLIND*	19 (18–20)	19 (18–21)	21 (19–21)	17 (13–19)	17 (14–20)	17.5 (14.5–21.5)	**<0.001**	0.098	0.980

Data are presented as mean±SD unless otherwise stated.
P values in bold are statistically significant.
*Data presented as median (interquartile range). Results from repeated measures mixed models (restricted maximum likelihood): †association of frailty with assessment score across all time points; ‡association of change in assessment score over time among all patients; §association of interaction of frailty and time with assessment scores (change in assessment score over time by frailty status).

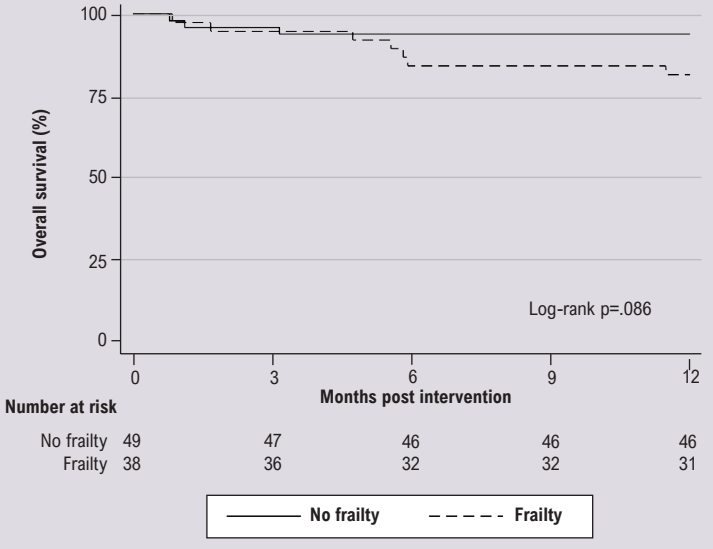
EFS, Edmonton frail scale; HADS, Hospital Anxiety and Depression Scale; MoCA, Montreal cognitive assessment; VAS, visual analogue scale; VascuQoL, Vascular Quality of Life Questionnaire.

Table 5 Transitions in frailty state by CFS

Baseline	3 months		12 months	
No frailty (CFS 1–4) n=44	No frailty (CFS 1–4)	27	No frailty (CFS 1–4)	19
			Frailty	2
			Unknown	6
	Frailty (CFS 5–9)	10	No frailty (CFS 1–4)	2
			Frailty	8
	Unknown	5	No frailty (CFS 1–4)	3
			Unknown	2
	Died	2	–	–
Frailty (CFS 5–9) n=43	No frailty (CFS 1–4)	4	No frailty (CFS 1–4)	3
			Unknown	1
	Frailty (CFS 5–9)	30	No frailty (CFS 1–4)	2
			Frailty (CFS 5–9)	19
			Unknown	5
			Died	4
	Unknown	6	Frailty (CFS 5–9)	2
			Unknown	3
			Died	1
	Died	3	–	–

Data are numbers of patients. CFS, clinical frailty scale.

Figure 3 Kaplan–Meier curves for overall survival over 1-year follow-up stratified by frailty status.



Associations of frailty with survival and major amputation at one-year

At 12 months, 10 patients (11%; 7 frail, 3 non-frail) had died and 11 patients (13%; 5 frail, 6 non-frail) had undergone a major amputation. There was a trend towards worse survival among those with frailty (Figure 3), but this was not statistically significant (p=0.086). Increasing age (HR 1.13, 95% CI 1.04 to 1.24; p=0.007) was independently associated with 12-month mortality on multivariable analysis, whilst frailty was not (HR 4.04, 95% CI 0.80 to 20.40; p=0.090). There was no association of frailty with major amputation at 12 months (SHR 0.62, 95% CI 0.16 to 2.46; p=0.498) on multivariable analysis.

Discussion

This study represents a detailed investigation of frailty in patients with CLTI. Around half had frailty at baseline, consistent with previous research.[27] Frailty was strongly associated with comorbidity, polypharmacy, cognitive impairment, disability and lower limb dysfunction, as well as worse mood and QoL. This is anticipated given their contribution to both the phenotype and cumulative deficit models of frailty, and the EFS includes direct assessment of these domains.[1,2,8,26] The results demonstrate the interrelatedness of frailty with both disability and comorbidity in the context of CLTI, as reported in other populations of older adults.[8] The EFS (which includes timed up-and-go test) had reasonable agreement with the CFS in identifying frailty but classified a higher proportion of patients as 'no frailty' than 'vulnerable' (Table 2). Those with frailty (by EFS) also had significantly lower grip strength. These findings suggest that the EFS score is not unduly influenced by CLTI-related lower limb dysfunction and support its validity as a frailty assessment in those with CLTI. This is an important finding given concerns regarding overestimation of frailty in CLTI patients by measures (such as the EFS) that include assessment of mobility.[28]

Importantly, this study is novel in describing the interactions of frailty status, disability and QoL over time following intervention for CLTI. There were modest improvements in QoL scores at 12 months among those with and without frailty. A recent meta-analysis also showed a small to moderate improvement in QoL over time in those with CLTI.[29] Patients with frailty had significantly worse anxiety and depression scores at baseline but showed modest improvement over 12 months, whilst those without frailty showed little change. These findings demonstrate that those with frailty still have a QoL benefit from revascularisation despite worse QoL at baseline. There was also an overall trend of worsening disability scores across all patients, and nearly a third

of non-frail patients transitioned to frailty at 12 months following intervention. However, data from 3-month follow-up showed improvement in lower limb function (SPPB scores) among those with frailty attending clinic follow-up. Revascularisation for CLTI improves lower limb function, with post-intervention walking ability correlating with baseline Barthel index score.[10,11]

A small number of patients in this study transitioned from frailty to non-frailty at 3 and 12 months following revascularisation. These patients tended to be younger. The transition of a similar proportion of CLTI patients from frailty to non-frailty following revascularisation has been previously described.[12] It is possible that, in a small population of individuals with CLTI, frailty may be reversed with appropriate management. CLTI itself directly and indirectly contributes to severity of frailty due to chronic pain and inflammation, CLTI-related disability and associated social isolation.[8,14,30] In a general population of older adults, frailty trajectories have been shown to slow or reverse with modest increases in exercise and nutrition.[31,32] Revascularisation promotes wound healing, improved lower limb function and CLTI-related disability, as well as global improvement in function and return to normal daily activities. These may, in combination, lead to a reversal or slowing of the frailty trajectory in some individuals with CLTI. Given the small numbers of patients included in this study (and transitioning in frailty states), it was not possible to undertake a detailed analysis of factors associated with improvement or decline in the frailty state. However, results from the 2-year follow-up of the LIMb study primary cohort will provide further evidence of frailty trajectories among those with CLTI.[13]

Collectively, these results show an improvement in QoL scores post intervention in both those with and without frailty despite an overall slight worsening in disability scores and a trend to increasing prevalence of frailty at 1 year. Decision making in CLTI is complex with guidelines recommending assessment of patient risk, severity of disease and anatomy of arterial disease.[14] Current evidence of the risk–benefit balance of intervention in CLTI predominantly focuses on risk of death or major amputation.[33,34] However, older people, particularly those with frailty, often value QoL and functional independence over mortality.[35] It is encouraging that, overall, both those with and without frailty showed a benefit in QoL from intervention in this cohort. However, further research is needed to delineate prognostic factors associated with better and worse functional outcomes among vulnerable CLTI patients to better inform shared decision making.

Strengths and limitations

The strengths of this study are its prospective nature and comprehensive assessments of frailty and related domains. There are several limitations. This was a single-centre study, limiting the generalisability of the results and conclusions. Despite best efforts, some patients had missing follow-up data at 3 and/or 12 months, and missingness of data is assumed to be random in the mixed models. However, no difference in results was demonstrated on complete case analysis. Whilst recruitment to the LIMb study was good, 27% of eligible patients declined to participate and 28% of those recruited to the LIMb study who were eligible for the frailty and cognitive additional assessments declined to participate (Figure 1). The overall prevalence of cognitive impairment (33%) was lower than anticipated.[9] Additionally, age, surprisingly, was not associated with frailty at baseline by either the EFS or CFS and few patients included in this study had severe frailty (Table 2). This may be due to selection bias, as those managed conservatively (ineligible) and those who declined to participate may have had a greater degree of frailty and/or cognitive impairment. Given the numbers of patients and events, it was necessary to dichotomise frailty scores to compare those with and without frailty. However, frailty is a continuum with greater degree of frailty conferring greater risk of poor outcome and should ideally be analysed as an ordinal variable. As few included patients had severe frailty, dichotomisation is unlikely to have significantly impacted the result and conclusions. The main limitation was the impact of COVID-19. Necessary recruitment pauses resulted in two-thirds of the target 150 patients recruited. Follow-up restrictions precluded face-to-face follow-up for most patients and EFS cannot be completed via telephone. CFS is based on history (self-report) alone and has been assessed via telephone in previous research.[36] Finally, the impact of COVID-19 on assessment scores during follow-up cannot be quantified. All patients underwent 12-month follow-up after the first UK wave of the pandemic and COVID-19 related restrictions (eg, lockdowns) may have worsened mood, QoL and disability independent of CLTI symptoms.

Conclusions

In CLTI patients, frailty is associated with greater disability, lower mood and worse QoL both at presentation and over 1 year post-intervention. However, both those with and without frailty showed similar improvements in QoL at 1 year. Frailty may be reversible in a small proportion of younger patients; however, people with CLTI overall will demonstrate progression in disability and frailty status over 1 year. Baseline frailty assessment in CLTI patients is important to guide prognostic discussion and shared decision making.

Conflict of Interest: RDS is the National Chair of the Vascular Clinical Reference Group and a National Specialty Advisor for vascular services, both roles for NHS England. SPC leads the NHS Elect Acute Frailty Network and Specialised Frailty Network programmes.

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KEY MESSAGES

- Frailty is strongly associated with cognitive impairment in CLTI
- Both those with and without frailty demonstrate an improvement in QoL 1 year after intervention for CLTI
- Frailty may be reversible in a small proportion of younger people with CLTI and frailty

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COHORT STUDY

SHOCkwave lithotripsy for patients with peripheral arterial disease: the SHOCC study

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Plain English Summary

Why we undertook the work: Blockages and narrowing in arteries supplying blood to the legs are common. This condition is called peripheral arterial disease or PAD in short. Often, these narrowings and blockages have lots of calcium. A new device called lithotripsy has been developed recently to allow healthcare professionals open up calcified artery blockages. This work aimed to look at whether lithotripsy used for PAD in the NHS is safe and leads to acceptable results.

What we did: A national research study was done, across eight NHS hospitals. A total of 91 people took part in this research, who had PAD and needed lithotripsy treatment.

What we found: Lithotripsy is safe to use as 100% of the procedures for the participants in the study were successfully completed. Complications were not more common compared to other technologies used for such calcified arteries. Also, with imaging before and after lithotripsy treatment, we found that lithotripsy breaks down artery calcium.

What this means: Lithotripsy can be used safely in the NHS. Future work should include a randomised trial, where people with PAD are treated with lithotripsy and compared to other modes of treatment.

Abstract

Objective: To assess the 6-month patency and clinical outcomes after endovascular treatment of lower limb atherosclerotic lesions in patients with peripheral arterial disease presenting with severe claudication or chronic limb threatening ischaemia (CLTI) using intravascular lithotripsy (IVL).

Methods: A prospective multicentre cohort study was carried out in eight centres in the UK. Consecutive patients with CLTI or lifestyle-limiting claudication treated with IVL as a primary vessel preparation based on operator's preference were included. Follow-up occurred at discharge, 30 days and 6 months with clinical and duplex assessments. A subset of patients underwent computed tomographic angiographic (CTA) lesion analysis pre-/post-IVL to assess plaque consistency/morphology using three-dimensional reconstruction of the CTA.

Results: Overall, 91 patients (mean age 73 years, 72% male; 81% with CLTI) were enrolled in the study between September 2021 and March 2023 (21 took part in the CTA plaque imaging substudy). All patients with claudication had presented with severe lifestyle-limiting claudication and had calf claudication at ≤20 metres; those with CLTI all presented with Rutherford stage 5 or 6 disease. Immediate procedural success was 100%; 15 (16%) underwent a hybrid intervention. Mean target lesion peripheral artery calcification scoring system (PACCS) grade was 3.31±1.01. At the latest available follow-up (mean 183±75 days) there were 10 deaths (11%), one access complication (1%), two major cardiovascular events (2%) and eight major amputations (9%). A total of 22 re-interventions (24%) and freedom from clinically derived target lesion revascularisation at 6 months was 96% (95% CI 0.88% to 0.99%). Automated 3D plaque subgroup analysis (n=21) revealed ≥50% remodelling in calcium load within the plaque in 15 plaques (71%), only two dissections (9.5%) and a significant decrease in median plaque calcium load volume (from 7.8 cm3 preoperatively to 5.4 cm^3 postoperatively).

Conclusion: IVL is a safe and efficacious option for vessel preparation with high procedural success rates, acceptable medium-term complications and freedom from re-intervention.

Key words: peripheral arterial disease, lithotripsy, peripheral vascular disease, vascular calcification, endovascular procedures, intravascular lithotripsy

Introduction

Peripheral artery disease (PAD) represents a major health problem worldwide, affecting one-fifth of people over the age of 60 in the UK.[1–3] It is the most common cause of lower limb amputation.[4]

Most patients with chronic limb threatening ischaemia (CLTI) and some patients with severe claudication will require lower limb revascularisation, one of the commonest vascular procedures in contemporary vascular practice, typically in the form of endovascular reconstruction. Arterial wall calcification represents a major challenge for endovascular arterial revascularisation, often resulting in unsuccessful recanalisation, dissection or early restenosis.[5–8] Intravascular lithotripsy (IVL) has emerged as a vessel/lesion preparation strategy to help overcome these issues.[9] The IVL device shatters the calcium within the atherosclerotic plaque using ultrasound (energy) via an angioplasty balloon. A recently completed randomised controlled trial (DISRUPT PAD III) involving 306 lesions (femoropopliteal stenoses or occlusions) treated with either IVL and angioplasty or conventional means (no IVL) showed that IVL resulted in greater procedural success, fewer dissections and comparable rates of major adverse events at 30 days.[10] The DISRUPT PAD III randomised controlled trial presented 2-year patency outcomes in a primarily claudicant population;[10,11] however, it was powered on intra-procedural events and included one vessel bed. There is also a paucity of high-quality prospective multicentre clinical data regarding the use of this technology, especially in patients with CLTI. This multicentre prospective study aimed to assess clinical and imaging outcomes following the use of IVL in a population consisting mostly of patients with CLTI across all lower limb vessel beds over a minimum 6-month structured follow-up period. An additional subgroup underwent computed tomographic (CT) evaluation of their target lesion pre-/post-IVL to objectively assess change in plaque morphology and consistency.

Methods

Regulatory approvals

The SHOCC study was a prospective multicentre observational study performed across eight NHS hospitals in England and Wales over an 18-month period between September 2021 and March 2023. The study received ethical and all relevant regulatory approvals (20/09/2021, Wales Research Ethics Committee (REC)) prior to commencing recruitment. The study was prospectively registered on the ISRCTN registry (ID: 76218607 – protocol available online prior to commencing recruitment) and sponsored independently by the University of Leicester. Research was funded by Shockwave Medical Inc (Santa Clara, California, USA), who had no input into the design, analysis, reporting and no access to data. All participants provided written informed consent before enrolment in the study. A study steering committee and data safety monitoring committee oversaw running of the study.

Eligibility criteria

Patients were eligible if they were >18 years of age diagnosed with CLTI or lifestyle-limiting (defined as severe) intermittent claudication and had at least one peripheral lesion deemed to require use of IVL by the treating clinician, regardless of location. Those who presented with acute disease (symptoms of <3 days duration) requiring emergency treatment or had asymptomatic PAD were excluded. Participants were recruited prior to intervention. The decision to use IVL was made by the operators based on preoperative imaging and local protocols (pragmatic study design).

Data collection and handling

Data were collected prospectively using a predefined form and via a REDCap (Research Electronic Data Capture) database hosted at the National Institute for Health Research Leicester Biomedical Research Centre.[12,13] The following were collected prospectively at baseline, discharge, 30 days and 6 months: demographics, comorbidities, procedure details, all available cross-sectional imaging, cause of death, re-admissions/re-interventions, cardiovascular events; missing data were queried prospectively with recruiting sites. All patients underwent an arterial duplex scan at baseline and 6 months. Those presenting with symptoms at any point during follow-up also underwent cross-sectional imaging based on local protocols and clinician preference. A subgroup consented to have a preoperative and postoperative (within 72 hours of the procedure) CT angiogram of the lesion (focused scan) to analyse the morphology of the plaque and report calcium content using a technique we previously developed and validated, described in detail elsewhere.[14–16] This automated three-dimensional (3D) plaque analysis was performed on this group using a dedicated TeraRecon 3D workstation (Aquarius iNtuition Viewer, Aquarius, TeraRecon, San Matteo, California, USA) by two independent investigators.

Outcomes and definitions

The primary outcome of interest was patency of the lesion treated with IVL at 6 months. Secondary outcomes included death, amputation, re-intervention/re-admission and cardiovascular events. Patency was defined as freedom from clinically driven target

lesion revascularisation (CD-TLR) and freedom from occlusion or >50% on any cross-sectional imaging. Technical success was reported and defined as the ability to cross the lesion with both a wire and an IVL balloon and successfully use IVL as planned (per instructions for use) without immediate embolisation, occlusion or dissection. Procedural success was defined as residual target lesion angiographic stenosis <50% following use of IVL and subsequent adjunct (where necessary) without peripheral embolisation, dissection and in-line flow to the foot (minimum of one crural artery). This research was designed as a prospective cohort study aiming to capture all consecutive patients meeting the eligibility criteria at each site; no minimum sample size calculation was required.

Analysis was performed using STATA Statistical Software (Texas, USA).[17] Results are reported as mean and standard deviation (SD) for normally distributed variables and median with interquartile range (IQR) for non-parametric variables. Categorical variables are reported as counts and proportion (%). Standard tests were used to assess differences between categorical and non-categorical variables of interest. A Kaplan–Meier analysis was performed to assess the primary outcome. The funder was not involved in analyses.

Results

A total of 94 patients were enrolled (70% of eligible participants across sites); three withdrew consent prior to intervention, so 91 patients took part in the study and are presented in this analysis. The baseline characteristics of the 91 patients undergoing IVL and included in the study are reported in Table 1. The mean age of the participants was 73 years (range 50–96) and 72% were male. Overall, 13% reported symptoms in both limbs, 20% presented with claudication, 25% with rest pain, 34% with tissue loss and 21% with both rest pain and tissue loss. All patients with claudication had presented with severe lifestyle-limiting claudication and had calf claudication at ≤20 metres; those with CLTI all presented with Rutherford stage 5 or 6 disease). The mean±SD ankle brachial pressure index at baseline was 0.21±0.03 for those with CLTI and 0.30±0.05 for those with claudication. The majority of patients (Table 2) were treated for infra-inguinal disease. Interestingly, 18 target lesions (IVL-treated) were common femoral arteries. Furthermore, 41 (45%) IVL-treated target lesions with a mean length of 10 mm were included.

All participants were on antiplatelet therapy at baseline, 24% had undergone previous angioplasty, 4% a bypass and 7% a minor amputation to the same limb (no major amputations). Table 2 describes the procedural details and the characteristics of the atherosclerotic lesions within the treated (symptomatic) limb of the patients. Most were femoro-popliteal – that is, superficial femoral artery (SFA) or popliteal (34% proximal SFA, 43% mid SFA, 63% distal SFA, 45% P1, 35% P2, 26% P3) lesions. The mean peripheral artery calcification scoring system (PACSS) grade of the target lesions was 3.31.[8] Overall, 16% underwent hybrid

Table 1 Baseline characteristics of SHOCC study participants undergoing IVL.

Characteristics	Total participants (n=91)
Age, years (mean±SD, min–max)	73±9 (median 73, range 50–92)*
Male, n (%)	65 (72)
Female, n (%)	26 (28)
Ethnicity, n (%)	
White British	88 (97)
Black Caribbean	2 (2)
Asian British/Chinese	1 (1)
Ischaemic heart disease, n (%)	29 (32)
Heart failure, n (%)	14 (15)
Atrial fibrillation, n (%)	16 (18)
COPD, n (%)	19 (21)
Current smoker, n (%)	21 (23)
Diabetes, n (%)	88 (97)
Baseline eGFR, mL/min/1.73 m^2, mean±SD	67±25
Presenting symptomatic limb, n (%)	
Right	38 (42)
Left	41 (45)
Both	12 (13)
Presenting symptoms (main limb), n (%)	
Claudication	17 (19)
Rest pain	26 (29)
Tissue loss	30 (33)
Rest pain and tissue loss	18 (22)
Baseline antiplatelet therapy, n (%)	
Clopidogrel (SAPT)	39 (43)
Aspirin (SAPT)	37 (41)
DAPT including clopidogrel	12 (13)
DAPT other	3 (3)
Anticoagulant therapy, n (%)	
Warfarin	4 (4)
Other anticoagulant	14 (15)
Statin therapy, n (%)	79 (87)
Antihypertensive therapy, n (%)	67 (74)
Previous angioplasty (main limb), n (%)	20 (24)
Previous IVL treatment to same lesion, n (%)	3 (3)
Previous paclitaxel-based treatment, n (%)	3 (3)
Previous atherectomy, n (%)	0
Previous bypass procedure (main limb), n (%)	4 (4)
Previous major amputation (main limb), n (%)	0
Previous minor amputation (main limb), n (%)	6 (7)
Previous amputation (other limb), n (%)	3 (3)

*Median and range also provided to aid data visualisation.

'Main limb' refers to side being treated with IVL, 'other limb' refers to non-treated side.

n=number reported, factoring in missing data.

COPD, chronic obstructive pulmonary disease; DAPT, dual antiplatelet therapy; eGFR, estimated glomerular filtration rate; ESRD, end stage renal disease; IVL, intravascular lithotripsy; SAPT, single antiplatelet therapy; SD, standard deviation.

Table 2 Lesion characteristics and procedural details.

Lesion characteristics and procedural details	Total participants (n=91)
Segment treated, n (%)*	
Common iliac artery	18 (22)
External iliac artery	18 (23)
Common femoral artery	18 (23)
Superficial femoral artery – proximal	28 (34)
Superficial femoral artery – mid segment	36 (43)
Superficial femoral artery – distal	56 (63)
Popliteal artery – P1	40 (45)
Popliteal artery – P2	30 (35)
Popliteal artery – P3	22 (26)
Tibio-peroneal trunk	14 (17)
Anterior tibial artery – proximal	11 (14)
Anterior tibial artery – mid segment	7 (9)
Anterior tibial artery – distal	7 (9)
Posterior tibial artery – proximal	4 (5)
Posterior tibial artery – Mid segment	4 (5)
Posterior tibial artery – distal	3 (4)
Peroneal artery – proximal	7 (9)
Peroneal artery – distal	4 (5)
Foot arch	1 (1)
PACSS grade, mean±SD	3.31±1.01
Participants with an occluded arterial segment, n (%)	41 (45)
Total number of occluded segments	117
Median (IQR) length of occluded segments, mm	10 (5–31)
Hybrid procedure (open surgery), n (%)	15 (16)
Preoperative imaging used to assess target lesion size, n (%)	
CTA	45 (51)
Duplex	10 (11)
MRA	1 (1)
DSA**	27 (31)
IVUS**	5 (6)
Access vessel, n (%)	
CFA	81 (89)
Other	7 (8)
Superficial femoral artery	3 (3)
Upper limb (brachial artery) – all together with femoral access	3 (3)
Anaesthesia type, n (%)	
Locoregional	65 (71)
Sedation	6 (7)
General	20 (22)
Sheath size for IVL (range 4–8Fr), mean±SD	6±0.7
Sheath size for IVL (range 4–8Fr), n (%)	
4	1 (1)
5	2 (2)
6	56 (63)
7	24 (27)
8	6 (7)
Number of IVL catheters used, mean±SD	1±0.8
Number of different IVL catheters used, n (%)	
1	66 (77)
2	15 (17)
3	2 (2)
4	1 (1)
5	2 (2)
IVL catheter size, mean±SD	6±1.3
IVL catheter size, mm, n (%)	
3	3 (3)
3.5	2 (2)
4	5 (5)
4.5	1 (1)
5	17 (19)
5.5	10 (11)
6	25 (27)
6.5	3 (3)
7	8 (9)
7.5	1 (1)
8	16 (18)
IVL cycles, mean±SD	6±2.7
Procedure post IVL on target lesion, n (%)	
None	26 (29)
POBA	28 (31)
High pressure POBA	5 (6)
DCB	12 (13)
DES	6 (7)
DCB followed by high pressure POBA	2 (2)
POBA followed by high pressure POBA	1 (1)
POBA followed by DCB	7 (8)
POBA followed by DES	2 (2)
Technical success, n (%)	91 (100)

*Multiple segments may be treated per patient. **Used intraoperatively to assess lesion size. n=number reported, factoring in missing data.

CTA, computed tomography angiography; DCB, drug-coated balloon; DES, drug-eluting stent; DSA, digital subtraction angiography; IVL, intravascular lithotripsy; IVUS, intravascular ultrasound; MRA, magnetic resonance angiography; PACSS, peripheral artery calcification scoring system; POBA, plain old balloon angioplasty; SD, standard deviation

procedures (combined open and endovascular – all common femoral endarterectomies in the case of open procedures); adjuncts to IVL included plain balloon angioplasty (50%), drug-coated balloons (23%, all paclitaxel) and drug-eluding stents (9%, all paclitaxel). Most procedures were performed under locoregional anaesthesia (71%) rather than sedation (7%) or general anaesthesia (22%). The ipsilateral common femoral artery was the most common access vessel (92%) while the brachial artery (3%) and superficial femoral artery (3%) also featured. Technical success was 100% and procedural success was 71% (no residual stenosis of the target lesion following IVL and adjunct with in-line flow to the foot on completion angiogram, and no dissections or peripheral emboli – all 'procedural success' failures were secondary to residual target lesion stenoses of 50–70% on the completion angiogram without flow-limiting dissections or emboli detected). Median IVL catheter size was 6 mm (range 3–8 mm), used in 27% of cases; the median number of IVL cycles was six.

Table 3 shows outcomes over 6 months. Median length of stay was 3 days (range 0–88 days). Re-intervention occurred in 24% of cases, with a similar volume of endovascular (13%) and open

Table 3 SHOCC study outcome data at 6 months follow-up.

Outcome data	
Length of stay, days, median (IQR)*	3 (1–16)
Re-intervention, n (%)	22 (24)
Endovascular, any	12 (13)
Endovascular, for IVL lesion	6 (7)
Open, any***	10 (11)
Open, for IVL lesion	3 (3)
Mortality, n (%)	10 (11)
Causes of death	
Heart failure	3 (3)
Sepsis	3 (3)
Bowel ischaemia	1 (1)
Acute myocardial infarction	3 (3)
Major amputation, n (%)	8 (9)
Minor amputation, n (%)	11 (12)
MACE, n (%)	2 (2)
Access complications, n (%)	1 (1)
IVL target lesion restenosis ≥50%, n (%)	19 (27)
Follow-up, days, mean±SD**	183±75

*Relating to primary admission for primary IVL procedure.

**Not including patients lost to follow-up.

***Open re-interventions were common femoral artery endarterectomies (7) and femoro-popliteal bypasses (with venous conduit – total of 3).

n=number reported, factoring in missing data.

IQR, interquartile range; IVL, intravascular lithotripsy; MACE, major adverse cardiovascular events; SD, standard deviation.

Figure 1 Freedom from clinically derived target lesion revascularisation (CD-TLR) at 6 months from follow-up.

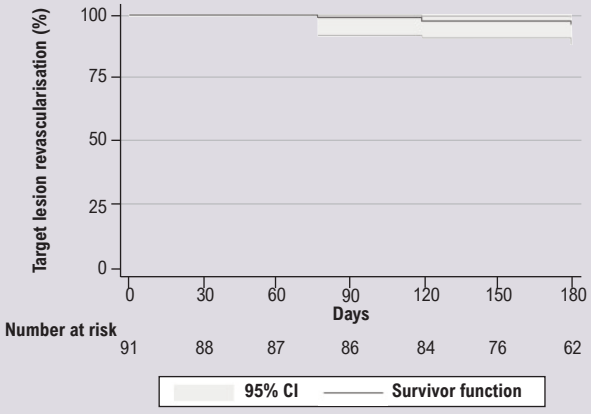


Table 4 Results of automated 3D plaque analysis of CTA imaging pre-procedure and 72 hours post-procedure

	Total participants (n=21)*
Microfragments** present postoperatively (≥1)	20 (95%)
≥3 microfragments postoperatively	17 (81%)
≥50% remodelling in calcium load within the plaque	15 (71%)
Median calcium load (volume) preoperatively	7.8 cm^3
Median calcium load (volume) postoperatively	5.4 cm^3
Ruptures	0
Dissections	2 (9.5%)
Arteriovenous fistulae	0
Pseudoaneurysms	0

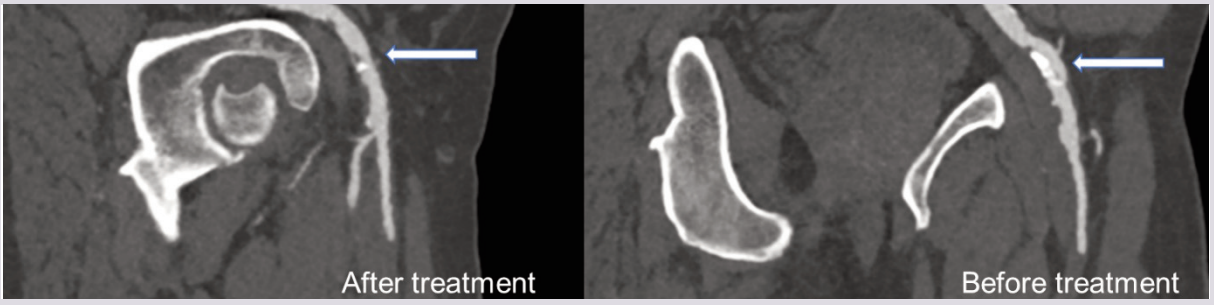
*Twenty-one femoro-popliteal lesions (superficial femoral artery up to and including the first segment of the popliteal artery with a baseline peripheral artery calcification scoring system (PACCS) score of 3 in all cases; all patients with chronic limb threatening ischaemia).

**Microfragments defined as at least one visible gap/fragment in the calcified element of the plaque when reconstructing the plaque in three dimensions.

(11%) re-interventions. All open re-interventions were common femoral artery endarterectomies and femoro-popliteal bypasses (with venous conduit). All endovascular re-interventions were plain balloon angioplasties. The majority of these were not specifically for the IVL-treated lesions, intervention for IVL-treated lesions occurring in 10% (9 patients, 7% by endovascular means and 3% by open surgery – all common femoral endarterectomies). Target lesion re-stenosis ≥50% within 6 months occurred in 19 patients at their latest follow-up and none were symptomatic with stenosis of the lesion that was originally treated using IVL. The Kaplan–Meier estimate for freedom from CD-TLR was 96% (95% CI 0.88% to 0.99%) at the end of follow-up (Figure 1). Overall, 11% of patients died during the follow-up period, mostly due to heart failure (3%) and sepsis (3%). Major amputations occurred in 9% of the cohort and minor amputations in 12%; one patient initially underwent a minor amputation and then a major amputation procedure within 6 months. Major cardiovascular events occurred in two patients (2%), both of whom underwent urgent coronary revascularisation procedures. Other complications included a single access complication (1%), one intensive care admission due to severe delirium post procedure, and another for marked hyperkalaemia. There were no episodes of acute limb ischemia during the follow-up period. No dissections (outside of the plaque analysis subgroup below) were reported.

A subgroup of patients (n=21) underwent automated 3D plaque analysis, the results of which are shown in Table 4 and Figure 2. The inter-observer correlation (20 CTAs analysed by two investigators) was 0.93 (95% CI 0.88 to 0.96) and intra-observer correlation (20 CTAs analysed by the same observer twice) was 0.95 (95% CI 0.85 to 0.99) Lesion length exceed 10 cm in all cases and all were classified as PACCS 2 preoperatively (femoro-popliteal lesions in all cases). All 21 procedures were completed successfully and patients were only treated with balloon angioplasty after application of IVL (three cycles of IVL as per instructions for use in all lesions). Microfragments were present in the majority of treated lesions (95%) with 81% of plaques containing ≥3 microfragments (visible gap in the calcified segment of the plaque on 3D reconstruction at maximum zoom). Overall, 71% had a 50% remodelling in calcium load within the plaque, demonstrated by a reduction in median

Figure 2 Target lesion/plaque after and before six cycles of intravascular lithotripsy using computed tomographic imaging before and within 72 hours of treatment in the subgroup study of 21 participants. Plaques were assessed in terms of calcium load/volume preoperatively and postoperatively, as well as microscopic changes.



calcium load from 7.8 cm^3 preoperatively to 5.4 cm^3 postoperatively (calcium remodelling). No ruptures, arteriovenous fistulae or pseudoaneurysms were detected. However, two dissections were seen on plaque reconstruction (9.5%) which were not detected at the time of the procedure; neither dissection involved more than 10% of the length of the lesion and/or more than 10% of the lumen diameter.

Discussion

This is a prospective cohort study including all-comers predominantly with CLTI and highly-calcified lesions treated with IVL across several centres, showing high success rates and acceptable complication/re-intervention rates over a 6-month structured period. Most patients eligible for inclusion at all recruiting sites agreed to take part (70%) and 91 participants were included in the analyses, having provided high-quality prospective follow-up data (with no missing data). This work adds pragmatic generalisable evidence regarding the use of IVL in the treatment of steno-occlusive PAD as a means of vessel/lesion preparation when treating calcified plaques. The imaging subanalysis also provides novel data regarding the microscopic effects of IVL in calcified lesions.

The main findings of the study can be summarised as follows: (1) IVL as a vessel preparation strategy is a safe procedure in challenging lesions/patients; minimal access (1%), thrombotic or cardiovascular (2%) complications were reported at 30 days, 90 days and 6 months. (2) The femoro-popliteal segment is the most common arterial site treated, as seen in the PAD III randomised controlled trial.[11,18] (3) IVL use was associated with a high technical success rate (100%), acceptable freedom from target lesion revascularisation and number of major limb amputations in this high-risk population (predominantly CLTI, all with extremely calcified lesions and multilevel disease), compared with data from recent trials and data reported in the latest guidance relating to CLTI management in Europe/globally.[11,18–22]

Previously, in the PAD III trial, IVL was shown to be superior to percutaneous transluminal angioplasty (PTA) in terms of procedural success. Vessel preparation with IVL was safely performed using a significantly lower maximum inflation pressure relative to PTA, resulting in lower rates of dissection and a lower risk of post-dilatation and provisional stent placement. The trial concluded that IVL may be a valuable tool for treating patients with calcified arterial lesions, potentially leading to improved outcomes and reduced complications in the management of PAD with heavily calcified arteries.[18]

In a real-world setting, the use of peripheral IVL demonstrated low residual stenosis, high acute gain and a low rate of complications despite the complexity of the disease. Specifically, the average acute gain was 3.4 mm at the end of the procedure with a final mean residual stenosis of 23.6%. Additionally, angiographic complications were rare, with a single perforation following drug-coated balloon inflation unrelated to the IVL procedure out of the 114 femoro-popliteal lesions analysed in the observational real-world trial PAD III.[11]

This study has replicated the findings of the previously conducted efficacy-driven IVL trials in a pragmatic CLTI (mostly) setting, showing a similar safety profile, minimal angiographic complications, high technical (100%) and procedural success (71%), no clinically significant dissections or perforations and few access complications. During follow-up only 19 patients had restenosis of the target lesion ≥50%. It is unknown if the restenosis is related to using IVL, natural progression of the disease, or other adjunctive procedures that were conducted such as stenting. However, in the subgroup analysis of the patients who had an additional CT scan we found no evidence of major complications at the microscopic level due to the use of IVL.

Study limitations

This study has several limitations. First, it is an observational study without a control group, which limits the ability to make direct comparisons with other treatment modalities. Additionally, maximal follow-up was 6 months, therefore the long-term durability of the IVL treatment was not assessed. Furthermore, the study included treatment in multiple vascular segments, which makes it difficult to apply the results to a specific PAD-affected segment.

KEY MESSAGES

- The use of intravascular lithotripsy in the United Kingdom has increased for those with calcified arterial lesions.
- In this national study/registry, the use of lithotripsy in peripheral arterial disease was safe and efficacious with low complication rates.
- A pragmatic randomised controlled trial is necessary to fully elucidate the role of lithotripsy in routine care.

Conclusion

These findings have important implications for the treatment of PAD in patients with heavily calcified arteries, as they suggest that IVL is a safe and efficacious option for vessel preparation in this patient population involving mostly patients with CLTI and some with severe claudication. Longer-term follow-up is required to fully understand the impact of these short to mid-term outcomes on longer-term results. Additionally, further research is needed to compare IVL with other treatment modalities such as atherectomy (ie, other vessel preparation strategies), conducting formal cost analyses to fully understand the impact of vessel preparation in this context.

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Authors' contributions: GLP: design, recruitment, analysis, writing. LM: analysis, writing, final review. SLF: recruitment, data management, administration, study management, data management, data visualization. MJB: writing, overall responsibility, final review, writing, funding. RD: recruitment, writing. SS: recruitment, writing. OR: recruitment, writing. AS: chief investigator, funding, writing, analysis. All collaborators (see Appendix) collected data, verified data accuracy and recruited participants locally. All authors and collaborators reviewed and approved the final version of the manuscript.

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PROTOCOL

Motivating Physical Activity with a Walking Exercise Behaviour Intervention and Pain Management Remotely in Intermittent Claudication (MAvERIC): protocol for a randomised controlled feasibility trial

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Plain English Summary

Why we are undertaking this research: Peripheral arterial disease (PAD) occurs when the arteries in the legs narrow and harden. People with PAD have a lower quality of life and are at risk of heart attack and stroke. Research suggests that people with PAD should increase their walking as with advice given for other heart issues. Yet people with PAD receive less exercise and treatment than those with other heart problems despite the benefits to leg pain, walking function and health. For those with PAD, walking can be hard because it hurts. Our studies have found that a small pain-easing device can help people walk further. We also found that helping people know how to manage their PAD and setting exercise goals can increase walking and well-being. Since not all people can travel for these services, we are looking to see if a pain-easing device and online meetings with a physiotherapist can work.

What we aim to do: We will test if an online walking exercise behaviour programme and using a transcutaneous electrical nerve stimulation (TENS) device can help people with PAD be more active. This involves completing a walking programme at home with support from two video and two telephone sessions with a physiotherapist and using a TENS device to reduce any walking pain. We will check how these compare to usual care offered at this health board. Usual care consists of medication, lifestyle and walking advice or plan. Patients from the vascular units will be invited to join the study. If they are suitable they will be put into a group by chance either trying the new methods or usual care alone. A device will track how much walking each person does. They will also share their views through surveys and feedback. This will help to better the study and programme before being tested on a larger scale.

Abstract

Background: Physical activity (PA) through walking exercise improves functional capacity and quality of life and provides secondary prevention benefits in individuals with peripheral arterial disease (PAD) and intermittent claudication (IC). However, there are many barriers to uptake and maintenance of PA in this population including pain and limited motivation. The aim of this study is to test the feasibility and acceptability of delivering a clinical trial to evaluate the effect of using a walking exercise behaviour change intervention, modified to include the use of a transcutaneous electrical nerve stimulation (TENS) device for non-invasive pain management, to increase walking-based PA in individuals with PAD and IC in comparison with usual care.

Methods: This is a randomised controlled analysis-blinded feasibility study with two parallel groups. We will recruit 48 adults with PAD and IC from NHS Lanarkshire vascular service. Inclusion criteria are: PAD (ankle brachial pressure index $\leq$0.90) and stable IC for $\geq$3 months, being able and willing to participate, and to provide informed consent. Participants will be randomly assigned 1:1 to intervention plus usual care or usual care alone. Usual care includes best medical therapy, information on PAD, walking advice or home exercise programme, and managing risk factors. The intervention consists of a home-based, walking exercise behaviour change intervention (MOSAIC), adapted for remote delivery, and includes non-pharmacological pain management through a TENS device. Feasibility and exploratory outcomes will be assessed at baseline, after 6 and 12 weeks of intervention, and at 6 and 12 months follow-up. The primary outcomes are trial process and intervention feasibility, as well as

intervention acceptability measured using rates of participant recruitment and retention, intervention adherence, and the Theoretical framework of Acceptability questionnaire. Exploratory outcomes include daily PA and patient-reported outcomes including quality of life, pain self-efficacy and catastrophising, and walking impairment pain intensity and quality.

Conclusion: This trial will evaluate the feasibility and acceptability of a remotely delivered walking exercise behaviour change intervention adapted to include the use of a TENS device to improve PA in individuals with PAD and IC.

Key words: peripheral arterial disease, physical activity, behaviour change, walking exercise, transcutaneous electrical nerve stimulation

Trial Registration Number: ClinicalTrials.gov Identifier: NCT06114732

Introduction

Peripheral arterial disease (PAD) affects approximately one in five people aged >60 years.[1,2] In addition, 40–75% of these people experience intermittent claudication (IC), a chronic manifestation of PAD which commonly presents as limb pain and reduced exercise tolerance.[3,4] People with PAD and IC experience disability and impaired quality of life due to reduced physical capacity compared with age- and sex-matched controls.[5,6] Overall, this causes a significant burden to individuals with the disease, as well as wider economic costs and service costs to the National Health Service (NHS) in terms of loss of healthy life-years and treatment.[7–10]

Improving physical activity (PA) is particularly important in individuals with IC as lower PA levels have been recognised as a strong predictor of increased morbidity and mortality in this population.[11,12] National Institute for Health and Care Excellence (NICE) guidance recommends Supervised Exercise Therapy (SET) as a primary treatment for IC with established efficacy in increasing PA, walking distance and improving quality of life, contributing to secondary prevention of major adverse cardiovascular events (MACE).[4,13] However, guideline standard SET is available in only one in four vascular services in the UK.[14] Moreover, where SET is available, uptake and adherence are limited due to reduced mobility from limb pain or low walking capacity, and this may be further restricted with variation in local service provision within a hub-and-spoke healthcare model.[15] This reflects a severe inequality in healthcare to the 17–30% of people in the UK who reside in rural communities and those with increased level of disability.[16,17] Therefore, in light of the prevalence of PAD, the constraints of healthcare resources and variation in provision of services nationally, there is an urgent need for the development of easily accessible and scalable alternatives to conventional SET.

Due to the extrinsic and intrinsic barriers to participation in PA in people with IC, it is vital that, as well as navigating the limitations of SET, the interventions also improve health literacy, illness perception and self-efficacy.[18,19] There is some evidence that the self-management of IC using behaviour change principles may be effective in addressing issues with self-efficacy, health literacy and uptake of walking exercise.[20] Recently, following participation in the walking-based behaviour intervention Motivating Structured Walking Activity in People with Intermittent Claudication (MOSAIC),[21] people with PAD (n=190) were able to walk further at 3-month follow-up and reported improvements in other functional and quality of life outcomes.[22] The intervention included two in-person and two telephone sessions delivered by physiotherapists over 3 months. MOSAIC has the potential to be delivered remotely to ensure that people with PAD can continue to take part in the intervention even if they live within rural communities with limited transport links or if SET is not provided locally. With the increasing access to the internet, even in low-income groups, the practicality of remote delivery of interventions on a large scale may be possible.[23]

While it is promising that novel accessible and scalable alternatives may exist to SET, for people with IC to gain the benefits of secondary prevention through PA, exercising beyond the point when pain occurs is recommended.[24] This represents another barrier to engagement in PA.[25,26] Despite this, a recent systematic review[27] found that pain management as a route to facilitate exercise and PA has rarely been explored. Recent work has suggested that the use of transcutaneous electrical nerve stimulation (TENS) applied to the lower limb during walking on a treadmill can improve absolute claudication distance above placebo.[28] Moreover, the home use of TENS may contribute to improvement in PA in individuals with IC.[28,29]

By managing limb pain and facilitating walking exercise behaviour change, MOSAIC adapted to include TENS may have the potential to help increase walking-based PA and walking capacity in people with IC.[22,28] However, the combination of a remotely delivered walking exercise behaviour change intervention that includes TENS has not previously been evaluated. Prior to assessing the clinical and cost effectiveness of the intervention in a suitably powered randomised controlled trial (RCT), outcome data from which the sample size of a clinical trial could be estimated, the acceptability and feasibility of both trial processes and procedures as well as remote delivery of MOSAIC with a TENS device must be assessed and refined if appropriate.[30] Therefore, the aim of this randomised controlled feasibility trial is to determine the feasibility and acceptability of conducting a trial investigating the effectiveness of a remote walking exercise behaviour change

intervention (MOSAIC) adapted to include TENS in people with PAD compared with usual care.

Methods

Research objectives

1. Assess the feasibility of conducting an RCT of a remotely delivered walking exercise behaviour intervention modified to include TENS in people with IC.
2. Measure participant recruitment, retention and attrition.
3. Measure outcome completion, attendance at appointments, total accelerometer wear time and usage of TENS device.
4. Measure protocol adherence and safety.
5. Conduct semi-structured interviews with intervention completers to assess acceptability and lived experience of the trial processes and intervention.
6. Explore changes in physical activity and quality of life outcomes from which the sample size of a definitive trial could be estimated.
7. Explore participants' experiences and perceptions of the interventions and trial procedures.

Study design

This is an assessor blinded randomised feasibility trial. Forty-eight adults with PAD and IC will be randomised to one of two arms: remote MOSAIC adapted to include TENS plus usual care or usual care alone (Figure 1). The setting in which the trial processes and intervention consultations will take place is within the home or other convenient private area suitable for telehealth consultation. This protocol follows the guidelines recommended by the Standard Protocol Items for Interventional Trials and recommended CONSORT extension to randomised feasibility trials (see Appendix 1 and 2 online at www.jvsgbi.com).

Inclusion and exclusion criteria

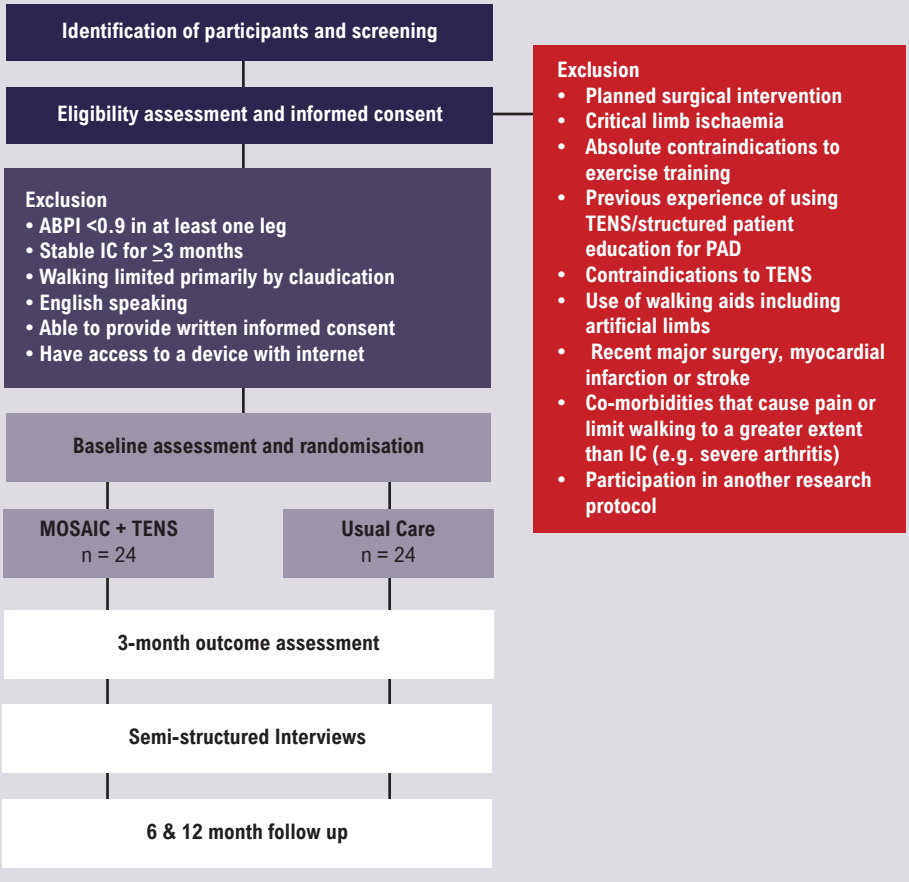
Patients within the NHS Lanarkshire Vascular Outpatient Service with either a clinical diagnosis of PAD by a vascular specialist, an ankle brachial pressure index (ABPI) ≤0.9 at rest or evidence of PAD on Doppler ultrasound or angiography will be invited to participate in the trial. Inclusion and exclusion criteria are listed in Figure 1. Symptomatic stable IC (stage II Fontaine Classification) will be determined by a report of symptoms on the San Diego Claudication Questionnaire (SDCQ)[31] and clinical diagnosis by a vascular specialist including ABPI of <0.9. Participants with critical limb ischaemia (rest pain, ulceration, gangrene) and those in whom lower limb revascularisation is planned within the intervention period will be excluded. Patients who are unable to give informed consent, are participating in another medically prescribed exercise intervention, are unable to walk due to co-existing medical morbidities or those with no internet or computer device for video consultations will be excluded.

Study procedures

Sampling and recruitment

Patients with PAD and IC within NHS Lanarkshire will be invited to take part in this study from February 2024 at the vascular outpatient service by the allied health professional or nurse undertaking the consultation. This is the primary method of recruitment; however, if the recruitment rate is <5% of the required sample after 2 months, a screening questionnaire will be used by a member of the vascular service when examining the clinic lists of

Figure 1 Study flow diagram.



the last 2 years to identify eligible participants attending the vascular outpatient claudication clinic. They will send by post an expression of interest letter along with a participant information sheet which contains a telephone contact number if the patient wishes to opt into the study.

A total sample size of 48 was calculated based on the proportions of uptake, attendance and compliance from the intervention arm.[22,28] An overall sample size of 43 participants was calculated which was increased to 48 participants to allow for potential attrition.[32]

Randomisation

Participants will be block randomised in a 1:1 ratio to either MOSAIC + TENS or usual care. The randomisation will not be conducted by researchers involved in recruitment or outcome assessment. Allocations will be prepared using a random number generator and kept in sealed opaque envelopes prepared by a researcher who is independent of the study team. The envelopes will remain unopened until allocation by the Principal Investigator (PI) at the first contact following baseline data collection.

Control group

Participants will receive usual care and walking/exercise advice from the vascular and claudication service at NHS Lanarkshire. This will be a pragmatic control arm as individual treatment may vary between participants. Usual care follows standard clinical guidance and often involves offering information on PAD and changes in lifestyle (eg, quitting smoking, managing diet and weight), walking advice or home exercise programme, managing risk factors which includes adjusting lipids, using statin and antiplatelet treatments or medication to enhance leg symptoms (vasodilators such as naftidrofuryl oxalate).[4] In NHS Lanarkshire people with PAD are usually diagnosed and treated in primary care within a network of Community Claudication Clinics, with onward referral to vascular outpatient clinics for further investigation and treatment as necessary.

Intervention group

The adapted walking exercise behaviour intervention (based on MOSAIC)[21,22] comprises two 60 min consultations completed by video call (weeks 1 and 2) and two 20 min follow-up telephone calls (weeks 6 and 12). The content of each session is standardised and incorporates evidence-based behaviour change techniques to facilitate understanding and commitment to walking exercise. Sessions will be tailored based on participants' knowledge, goals, symptoms and current walking using a motivational interviewing approach.[33] The session is delivered by the PI who is educated in motivational interviewing techniques.

One week in advance of the first video consultation an interactive manual containing worksheets and a walking diary will be posted out as part of the modified walking exercise behavioural intervention. During the first video consultation the participants, in addition to using the MOSAIC materials in the consultation, will be offered a TENS device as an option to manage their leg pain during walking exercise and a pedometer to self-monitor their step count, using the motivational interviewing approach 'elicit-provide-elicit'.[33] If they opt to use the TENS device or pedometer it will be posted to their home address with an instruction booklet for the device. There will be an opportunity to query or troubleshoot TENS device usage at the next video consultation one week after the first video consultation. The intervention group will receive high-frequency TENS (120 Hz, 200 µs and a participant-determined intensity of 'strong but comfortable'), as this was found in a proof-of-concept study to increase the distance walked in people with IC before reaching their pain tolerance and prolonged time to reach onset of pain (compared with low-frequency TENS).[28]

As part of the second video consultation, walking plans will be agreed collaboratively between the participant and the physiotherapist and include progressive individualised targets for walking frequency, intensity and duration to achieve at least the recommended walking guidance for IC (30–50 min of walking three times/week at an intensity that elicits pain within 3–5 min).[24] Options to use the TENS device will be discussed and agreed alongside walking goals and plans in the second video consultation if the participant agrees to this. Walking plans, progress and goals will be reviewed at weeks 6 and 12 during 20-min telephone booster sessions.

Outcome measures

Feasibility and acceptability outcomes

The study recruitment rate will be recorded by logging reasons for non-eligibility and non-recruitment of eligible participants using the study screening log. Uptake and adherence to intervention sessions by participants will be measured by attendance at appointments, withdrawal from study, TENS usage (via in-built memory of the device and a self-reported TENS diary) and administering the Theoretical Framework of Acceptability questionnaire at the trial endpoint.[34] In addition, a purposive sample of participants will be invited to attend a semi-structured interview regarding their lived experience of the trial and interventions. Adverse events will be monitored, recorded in a study log and followed up if required. Data will be collected by the PI at all time points.

Exploratory outcomes

The habitual PA of participants will be recorded by a trial axial accelerometer, the activPAL™, worn for 7 days and the following outcomes extrapolated from the accelerometery data: total daily steps, total duration of walking, total daily time spent sitting, and event-based claudication index (ECBI; the ratio of walking events to upright events participants undertake in a day).[35] Three days or 72 hours of continuous wear of activPAL™ data at each time point will be the minimum for including a participant's activPAL™ data in the exploratory analysis. Pain-related quality, intensity, self-efficacy and catastrophising will be assessed using patient-reported outcome measures (PROMs): the Short Form-McGill Pain Questionnaire (SF-MCQ)-2,[36] a Visual Analogue Scale (VAS) of Intensity of Pain, Pain Self-Efficacy (PSEQ)[37] and Pain Catastrophizing Scale (PCS).[38] Likewise, quality of life will be assessed using PROMs: the

Table 1 Schedule of enrolment, interventions and assessments.

	Study period							
	Enrolment	Allocation	Post-allocation					Close-out
TIMEPOINT	$-t_2$	0	t_1	t_2	T_6	T_{12}	T_{13}	T_{52}
ENROLMENT:								
Eligibility screen	X	X						
Informed consent	X							
Allocation		X						
INTERVENTIONS:								
MOSAIC + TENS			←	—	—	→		
Control			←	—	—	→		
ASSESSMENTS:								
Feasibility measures	X	X			X	X		X
Acceptability measures	X	X			X	X		
Physical activity behaviour		X			X	X		X
Quality of life		X			X	X		X
Pain intensity		X			X	X		X
Pain quality		X			X	X		X
Pain self-efficacy		X			X	X		X
Pain catastrophising		X			X	X		X
Adverse events						X		
Semi-structured interview							X	

MOSAIC, Motivating Structured Walking Activity in People with Intermittent Claudication; TENS, transcutaneous electrical nerve stimulation.

Intermittent Claudication Questionnaire (ICQ)[39] and the EQ-5D-3L. Data collection time points for each outcome are shown in Table 1. All outcome assessment devices and measures are returned by post so, to maintain blinded data analysis, materials will be assigned a unique code and any identifying information removed prior to data entry and analysis by a researcher outwith the study team.

Evaluation of intervention delivery fidelity

To assess fidelity to the intervention, all intervention sessions will be audio recorded with permission from the participant. A random sample of 10–20% of recorded sessions will be assessed by a member of the study team from the MOSAIC trial, to assess the extent that mandatory components of each session were delivered as intended. Segments of 20 min, chosen at random from the intervention sessions sampled, will undergo evaluation for the physiotherapist's effectiveness in motivational interviewing using the Motivational Interviewing Treatment Integrity scale.[40] This includes assessing relational proficiency on a Likert scale, where a score of 3.5 out of 5 suggests an acceptable level of interpersonal style and technical proficiency, and a score of 3 out of 5 indicates an adequate technique.

Trial schedule

Baseline assessment

Written informed consent will be recorded and baseline measurements will be conducted including questionnaires and fitting of the activPAL™ monitor remotely over video call with the PI. These will be posted out to the participant with an information sheet and further instruction can be sought at the video call with the PI. Paper copies of the PROMs will be posted back using a pre-paid envelope at baseline, week 6 and week 12. These will be collected, anonymised and given a unique identifier by a member of the study team not delivering the intervention or conducting data analysis. Participants will also return the activPAL™ after 1 week of wear via a pre-paid envelope. After this point, participants will be randomised to either intervention or usual care as described under study procedures.

Weeks 6 and 12 assessment

The second and third data collection points (6 and 12 weeks) will occur following a 20 min telephone 'booster' session and review of progress and goals for the intervention. This will be a repeat of the outcome assessment conducted at baseline; however, the Theoretical Framework of Acceptability questionnaire will only be administered at week 12 (intervention end point). The usual care group will only be contacted at 6 weeks and 12 weeks by the research team to post the questionnaires and video fitting of the activPAL™ monitor.

Qualitative interviews and follow-up assessment

At the intervention end point a purposive sample of participants will be invited to an online semi-structured interview session, which will be implemented within 1–3 weeks after the end of the intervention. The setting in which the qualitative interviews will take place is within the home or other convenient private area. The follow-up outcome assessment will be at 6 and 12 months for all groups. This will be a repeat of the outcomes at the baseline assessment.

Data analysis

Analyses will follow the intention-to-treat principle. Secondary per protocol analyses will also be performed. To ensure blinded analysis by the PI, all outcome data received from participants will be sent to the Chief Investigator (CS) who will conceal the group allocation and a unique code in place of identifiable information (eg, participant name). This anonymised data will then be input into an electronic Excel spreadsheet and the Principal Investigator (SC) will conduct data analysis independently to remain blinded. All data will be summarised in accordance with the CONSORT guidelines.[41] Descriptive statistics will be used to describe demographics and baseline characteristics of each outcome, as well as to compare the outcomes at each time point between and within groups.

Feasibility and acceptability analysis

To determine the feasibility of conducting an efficacy trial, descriptive statistics will be used to report the number and proportion of participants who meet the inclusion criteria, who consented to participating, and who dropped out during the trial.

Feasibility of trial processes in the remote setting will be derived from a participant's attendance at appointments, follow-up calls, rate of outcome measure completion, total accelerometer wear time and, if applicable, self-reported and internal memory recorded use of the TENS device.

Recordings from the semi-structured interviews will be transcribed verbatim and analysed using interpretive thematic analysis by the lead author.[42] The researchers will provide written transcripts to the participants to check the accuracy of the transcription. Provisional themes will be discussed with the wider research team with reference to an audit trail, and processes refined if required to agree on and identify the final labeling of themes. In order to manage the data and undertake analysis, NVivo V20 (QSR International Pty Ltd) will be used.

Exploratory analysis

Between-group comparisons for walking outcome measures and group continuous measures will be summarized using mean and standard deviation, or median and interquartile range if the distribution is skewed. To compare different groups allocated to each intervention, an analysis of variance will be used, or a Kruskal–Wallis test if the data are non-parametric. The Theoretical Framework of Acceptability questionnaire scores will be compared between groups cross-sectionally at the intervention end point using a Mann–Whitney U test. Within-group comparisons longitudinally will be examined using a repeated measures analysis, or non-parametric equivalent if appropriate. Analysis will be blinded by a member outwith the study team anonymising the dataset.

Unblinding will be permitted in the event of a spontaneously reported adverse event or unintended effect of trial intervention that requires liaison with the participant's medical care team. In this event, this will be logged on the trial adverse event form and the sponsor and local NHS Research and Development office informed. If appropriate, the participant will be removed from the trial.

Data management

Data will remain confidential and stored securely at Glasgow Caledonian University in accordance with the Data Protection Act and General Data Protection Regulation. Electronic data will be pseudo-anonymised and stored on a password-protected database on a secure device at Glasgow Caledonian University. Only named investigators will have access to the data. All paper documentation including signed informed consent forms will be kept in a secure locked filing cabinet at Glasgow Caledonian University. Data will be retained in accordance with the Good Clinical Practice guidelines or local regulations, whichever specifies a longer retention time.

Trial Management Group

The trial will be coordinated from Glasgow Caledonian University by the Trial Management Group. This will consist of the co-investigators, NHS Lanarkshire Claudication Steering Group chair, Service Manager, and a person with PAD as a patient and public involvement (PPI) representative. The role of the group is to monitor the conduct and progress of the trial, ensure that the protocol is adhered to and take appropriate action to safeguard participants and the quality of the trial itself. The group will meet every 3 months via video conference.

KEY MESSAGES

- We plan to assess the feasibility and acceptability of a remotely delivered walking-based behaviour intervention adapted to include non-pharmacological pain management using TENS.
- This will allow us to determine if any refinements are required to remote delivery of the intervention, which is the first step in testing the behaviour change intervention for telehealth implementation in the NHS.
- If feasibility and acceptability is demonstrated through this trial, exploratory outcomes will inform the sample size for a future definitive randomised controlled trial evaluating effectiveness.

Study registration and ethical approval

The West of Scotland Research Ethics Committee provided approval for this study (Reference: 23/WS/0147) on 30 October 2023 and the study was subsequently registered on ClinicalTrials.gov (Identifier: NCT06114732). The research will be carried out following the principles of the Declaration of Helsinki. Those who qualify for inclusion will be asked to provide written informed consent before taking part in the study. Each participant will be reminded of their right to withdraw. Glasgow Caledonian University is the sponsor for this feasibility trial.

Discussion

People with PAD and IC face a loss of healthy life-years, as well as a heightened risk of MACEs, hospitalisation and mortality.[1–5] Finding accessible, acceptable and scalable methods to support increasing walking-based PA for people with this condition is crucial, given the disease burden for individuals and their families and the economic demand on the NHS.[7–10] The need for this is amplified when considering the significant barriers to walking that prevent uptake and adherence, both intrinsic (self-efficacy, knowledge of PA as beneficial and limb pain) and extrinsic (geography, accessibility to an exercise professional or service).[25,26]

Altogether, these findings emphasise the need for self-management interventions that are accessible and address both pain management and walking-related behaviour change. MAvERIC is a novel combination of a remotely delivered walking exercise behaviour change intervention (MOSAIC)[22] adapted to include TENS[28] for pain management. The intervention aims to address the barriers to physical activity in people with PAD and IC. This is the first step in testing the behaviour change and pain management intervention for telehealth implementation in the NHS.

If feasibility and acceptability of trial processes and intervention are demonstrated in this study, an appropriately powered RCT will aim to test the effectiveness on walking-based PA in people with IC. Despite the novel approach due to the use of internet and of a smart device/computer in receiving the intervention, there may be some socioeconomic bias in the sample. Additionally, the exclusion of ABPI measurement with exercise testing may have reduced sensitivity of the recruitment strategy.

Trial status: Protocol version 1.1: 30 October 2023. Recruitment beginning February 2024 until required numbers are reached.

Conflicts of interest: The authors have none to declare.

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Author contributions: The protocol was written by SC with guidance from SG, LW, LB and CS. All authors have approved the manuscript.

Ethical approval: Ethical approval was given by the Glasgow Caledonian University Health and Life Sciences Ethics Committee. Health Research Authority (HRA) approval has been obtained and Research Ethics Committee favourable opinion has been granted by the West of Scotland REC on 30 October 2023 (reference: 23/WS/0147). Glasgow Caledonian University is the sponsor for this feasibility trial.

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PROTOCOL

Home-based high intensity interval training in patients with intermittent claudication: a systematic review protocol

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Plain English Summary

Why we undertook this work: Reduced blood flow to the legs can cause pain and cramping when walking and exercising. For people with this condition, the recommended treatment is a supervised exercise programme (SEP). However, most vascular centres do not have access to a SEP and, when they do, most patients are unable to attend as it is conducted face-to-face, requiring a significant time and travel commitment. We therefore developed a shorter, less time-consuming high intensity interval training (HIIT) programme which could be easier to provide and more attractive to patients. It means exercising a little bit harder than during the normal SEP, but over a shorter time period. When we tested this programme we found that, despite it requiring less time to complete, most patients still did not want to attend as they were still having to travel to a hospital/community venue to complete their exercise. Therefore, we need to find different ways of providing exercise programmes that reduce the need to attend a hospital or community centre so that more people can perform them. Having the option of participating at home with live remote supervision may be one way. The existing research suggests that SEPs can already be delivered this way, although it is less clear if HIIT can.

What we will do: We plan to look at all the existing research to see how HIIT can be safely delivered at home for people with reduced blood flow to the legs.

What this means: A review of the evidence will help us plan how we can deliver HIIT at home with live remote supervision. Once we have this information, we can compare HIIT with traditional SEPs with the option of attending in person or remotely.

Abstract

Introduction: The aim of this systematic review is to consider the evidence base for home-based high intensity interval training (HIIT) in patients with intermittent claudication (IC). Prior knowledge of the evidence base suggests that there may be little research considering HIIT in patients with IC. If so, the evidence base across all cardiovascular diseases will be considered.

Methods: Medline, EMBASE, CINAHL and Cochrane CENTRAL databases will be searched for terms including 'peripheral arterial disease', 'intermittent claudication', 'home-based exercise', 'high intensity interval training' and 'home-based high intensity interval training'. All prospective randomised trials and non-randomised studies considering home-based HIIT in patients with IC will be included. Studies will not be excluded based on the use of a comparator arm, meaning single-arm studies as well as multi-arm trials will also be included. If appropriate, based on the extant literature, a meta-analysis of randomised controlled trials will be conducted. The outcomes of interest will include intervention components, intervention feasibility (based on uptake and completion rates), intervention tolerability (based on compliance and adherence to the intervention), maximum walking distance, pain-free walking distance, quality of life and cardiorespiratory fitness.

Conclusion: This review aims to assess the evidence for home-based HIIT in patients with IC, to establish its feasibility and to inform the refinement of an existing supervised HIIT intervention to allow it to also be delivered remotely. Following this, a pilot randomised controlled trial to compare HIIT versus usual care supervised exercise programmes will be

developed. For this, the interventions will be delivered either in person or remotely in real-time, depending on centre availability and patient preference.

Key words: intermittent claudication, peripheral arterial disease, high intensity interval training, home-based exercise, supervised exercise therapy

PROSPERO registration number: CRD42024504247

Introduction and rationale

Peripheral arterial disease (PAD) is caused by atherosclerosis of the arteries supplying the lower limbs, limiting blood flow to the legs.[1] PAD is estimated to affect more than 237 million people worldwide and its prevalence is increasing.[2] Intermittent claudication (IC) is the classical symptom of PAD, and is characterised by a reproducible ambulatory muscular leg pain secondary to an oxygen supply/demand imbalance that is relieved by rest.[1]

IC carries an increased morbidity and mortality risk[1,3,4] which also reduces functional capacity and quality of life.[3,5] The first-line treatment for IC, as recommended by the National Institute for Health and Care Excellence (NICE), is cardiovascular risk reduction and, for symptomatic benefit, a supervised exercise programme (SEP).[6] The SEP should consist of two hours of supervised exercise per week for a period of 12 weeks, with patients encouraged to exercise to the point of maximal pain.

Evidence for SEPs is irrefutable, providing superior improvements in walking distances compared with home-based exercise programmes (HEPs) and basic walking advice[7] and comparable longer-term improvements compared with more invasive interventions.[8] Despite this evidence and the NICE recommendations, SEPs suffer from suboptimal provision, uptake and completion. In the UK, only 48% of centres have access to a SEP, with funding, staffing, facilities and equipment being key barriers.[9] When SEPs are available, fewer than 25% of patients attend and, of these, only 50–75% complete the programme.[10,11] Patient-related barriers include the time commitment required to attend and complete a SEP.[10,12]

These barriers led our group to explore a time-efficient alternative in the INITIATE study which investigated the feasibility and acceptability of cycle-based high intensity interval training (HIIT) in two UK centres, a theoretically more attractive and easier to deliver exercise programme for patients with IC.[13,14] The INITIATE study also attempted to answer priority 2 of the James Lind Alliance priority setting partnership "How can we improve provision and access to exercise programmes for patients with PAD?".[15] The results showed that actively supervised cycle-based HIIT improves completion rates and appears to be safe and efficacious. Unfortunately, the uptake rates were comparable to SEPs and remained low at 25%. This is because patients were still required to attend face-to-face sessions and, although the time commitment of HIIT was 50% less than for SEPs, the additional logistical burden associated with centre-based programmes including transport/travel and inflexible timings remained.[12,16] The limited access and uptake for SEPs/HIIT also means that the feasibility of a randomised controlled trial comparing these exercise therapies in their current form is questionable.

A more adaptable approach to supervised exercise therapy, both in terms of SEPs and HIIT, is required. One such approach, which has been delivered in other patient cohorts, is via real-time remote delivery whereby patients exercise at home with real-time supervision provided via video conferencing (eg, Zoom).[17] This adaptation could improve the possibility of a randomised controlled trial as centres without a standard SEP could refer their patients to receive their allocated exercise therapy remotely. Centres with SEP provision can offer patients the choice between in-person or remote delivery. This adaptable provision is also likely to translate to clinical practice should it prove efficacious, potentially increasing access, uptake and adherence. Although HEPs are considered inferior to SEPs for patients with IC, a real-time remotely delivered programme, despite being performed at home, would be considered a SEP. Additionally, HEPs with remote monitoring (albeit not in real time) appear to be equivalent to traditional SEPs in terms of health-related outcomes, providing evidence to suggest that the proposed model has promise.[7,18] Although no study has considered home-based, real-time, remotely delivered SEPs for patients with IC, the current evidence base for HEPs does suggest that a SEP, mirroring the traditional programme, can be feasibly delivered in this way.[19,20]

The current evidence base, however, does not consider the role of home-based HIIT for patients with IC, either remotely delivered or otherwise. Additionally, the cycle-based nature of the current INITIATE HIIT programme means that it cannot be delivered remotely due to the logistical challenge of equipment availability/delivery. It is therefore not known if patients with IC are able to perform HIIT in a home-based setting (with or without supervision), and if they are, how it should be delivered. The aim of this study is therefore to review the evidence for home-based HIIT in patients with IC to establish its feasibility and to inform the refinement of our HIIT intervention to allow it to also be delivered remotely. Prior knowledge of the evidence base suggests that there may be little research considering home-based HIIT in patients with IC.[21] If so, the evidence base across all cardiovascular diseases will be considered (cerebrovascular, coronary and peripheral arterial disease).

Methods

This protocol is written in accordance with the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols (PRISMA-P) guidelines.[22]

Search strategy and inclusion criteria

The Medline, EMBASE, CINAHL and Cochrane CENTRAL databases will be searched from inception for terms including 'peripheral arterial disease', 'arterial occlusive disease', whilst also including terms such as 'high intensity interval training' and 'home-based exercise' (see full draft search in Appendix 1 online at www.jvsgbi.com). In addition to the databases, trial registers such as clinicaltrials.gov and the Web of Science conference proceedings will be searched. Should any relevant abstracts be identified, the authors will be contacted to obtain study outcome reports, if available. Only studies using the English language will be considered in this review and no date restrictions will be applied.

Population: All prospective randomised trials and non-randomised studies evaluating a home-based HIIT programme in patients with IC (Fontaine II/Rutherford stages 1–3) will be included. Studies including other PAD subgroups (eg, asymptomatic or chronic limb-threatening ischaemia) will be excluded.

Intervention: All studies which use HIIT, defined as an interval approach conducted at ≥85% peak heart rate (HRPeak) or another surrogate measure (ie, ≥80% maximal exercise capacity or peak oxygen uptake (VO2Peak) or a rating of perceived exertion ≥15) performed in a home-based setting, will be included.[21] Studies will not be excluded based on the duration, frequency or protocol (ie, ratio between length of exercise and rest periods) used. HIIT can be prescribed via structured advice given in a similar fashion to traditional HEPs[18,23] with or without remote monitoring (via pedometers, accelerometers, physical activity monitors or exercise diaries) or delivered remotely in real time (via a video conferencing/communication platform). Although the former is considered a HEP and the latter a SEP, the aim of this review is to identify if and how HIIT can be performed in a home-based setting to inform our intervention. Therefore, the mode of delivery is less important at this stage.

Comparator: Studies will not be excluded based on the use of a comparator arm. This means single-arm observational cohort studies as well as multi-arm comparative studies will be included. Comparator groups may include centre-based SEPs, HEPs, exercise advice and non-exercise controls.

Outcomes: Because of the aim of this review, studies will not be excluded based on the reporting of certain outcomes. However, outcomes of interest include intervention components, intervention feasibility (based on uptake and completion rates), intervention tolerability (based on compliance and adherence to the intervention), maximum walking distance, pain-free walking distance, quality of life and cardiorespiratory fitness.

Should no studies meet the above inclusion criteria, the population criteria will be widened to include those with other cardiovascular diseases (coronary or cerebrovascular) with the intervention, comparator and outcome criteria remaining the same.

Data management, selection and collection process

Results from the database searches will be uploaded to the Covidence systematic review software (2024, Veritas Health Innovation, www.covidence.org). Two independent reviewers will screen the titles and abstracts identified by the database searches. Studies deemed potentially eligible will be further interrogated with a full-text review. Any disagreements between the two reviewers will be resolved via consensus or by consultation with a third reviewer. The use of Covidence will allow for the automated production of a PRISMA flow diagram.[22]

Two independent reviewers will then perform the data extraction using a standardised form which will be input and managed using a Microsoft Excel database (Microsoft Office, 2016). Where any discrepancies are identified, the original source will be reviewed and the correct data will be extracted and input into the final form. Data extraction will include study characteristics (including appropriate information to assess the quality of the study), a description of the participants (inclusion/exclusion criteria applied), sample size, study design, a description of the intervention and any comparators, adverse events, length of follow-up and main findings related to outcome measures.

Risk of bias and rating the quality of evidence

For randomised controlled trials the risk of bias will be assessed by two independent reviewers using the Cochrane Risk of Bias 2.0 tool.[24] This assesses the risk of bias as 'high', 'low' or 'some concerns' across five domains including: bias arising from the randomisation process; bias due to deviations from intended interventions; bias due to missing outcome data; bias in measurement of the outcome; and bias in the selection of the reported result. In the event of disagreement between the two reviewers, this will be resolved by consensus or via discussion with a third reviewer. The bespoke Excel tool will be used to manage and record the assessments (https://www.riskofbias.info/welcome/rob-2-0-tool/current-version-of-rob-2), which will be summarised with justifications for each outcome across all domains using the risk of bias table. The least favourable assessment across all domains will be used for the overall risk of bias for each trial.[25]

Risk of bias in non-randomised studies will be assessed using the Risk Of Bias In Non-randomised Studies of Interventions (ROBINS-I) tool whereby specific signalling questions will elicit information relevant to the risk of bias. The risk of bias judgement will be low, moderate, serious or critical based on the responses to these questions.

The quality of the evidence will be assessed by two independent reviewers using the GRADE approach.[26] For this assessment, the reviewers will initially consider the design of the trials that contribute to the evidence before upgrading or downgrading based on risk of bias, inconsistency, indirectness,

KEY MESSAGES

- This systematic review aims to explore the evidence for home-based high intensity interval training (HIIT) to help us inform our own home-based HIIT intervention in patients with intermittent claudication (IC)
- All prospective randomised trials and non-randomised studies that have considered home-based HIIT in patients with IC will be included.
- A narrative synthesis of the data will be produced. If sufficient evidence for IC exists, a meta-analysis of relevant outcomes will be performed using only randomised controlled trials. For each selected outcome the quality of evidence will be assessed using the GRADE approach and risk of bias will be assessed using the Cochrane tool.

imprecision and publication bias. All evidence will be rated as high, moderate, low and very low.[26]

Data analysis and synthesis

Given the aim of this study, the inclusion of both randomised trials and non-randomised studies and our prior knowledge of the evidence base, it is likely that only a narrative synthesis of the included studies will be provided, especially if it is necessary to widen the population criteria.

However, should sufficient evidence be available for patients with IC, meta-analyses will be performed of the relevant outcomes using only randomised controlled trials. Meta-analyses will be performed using Review Manager Web (RevMan web, 2022) to produce forest plots and associated 95% confidence intervals. The model used and the appropriateness of meta-analyses will be based on the assessment of heterogeneity considering the I^2, τ^2 and χ^2 statistics and associated p values.

Discussion and conclusion

The proposed review aims to consider the evidence for home-based HIIT in patients with IC to establish its feasibility and to inform the refinement of an existing supervised HIIT intervention to allow it to also be delivered remotely. This work will support our already established body of work considering supervised HIIT in this population.[13,14,21,27] Once the supervised HIIT intervention is refined to also allow it to be delivered at home, a pilot randomised controlled trial comparing HIIT with usual-care SEPs will be performed. For this trial, both interventions will be delivered either in person or remotely in real time, depending on centre availability and patient preference.

There are possible limitations that may occur within the proposed review. These are mainly related to a potential lack of evidence. It is possible that there will be no studies considering home-based HIIT for patients with IC. However, the impact of this will be minimised by the intention to widen the population criteria.

Conflicts of interest: The authors have none to declare.

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CASE REPORT

A rare congenital abnormality mimicking the appearance of a type A aortic dissection

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Abstract

Type A aortic dissection is a tear in the wall of the ascending aorta and/or arch between the tunica intima and tunica media layers. This is a surgical emergency and requires immediate surgical repair. Aortic CT angiography is essential for classification, assessing extent of the disease and planning the management. An intimal flap on CT is characteristic of the pathology. We present a case where a fibrous cord, presumed to be a congenital remnant, mimicked the appearance of an intimal flap but was not an aortic dissection.

Introduction

Aortic dissections are caused by a tear in the tunica intima of the aortic wall allowing blood to enter a new 'false lumen' created between the tunica intima and tunica media. Stanford type A aortic dissections involve the ascending aorta and/or arch. Type A aortic dissections are classified as a surgical emergency and require immediate repair by a cardiothoracic surgeon.

Type A aortic dissections classically present as a sudden 'excruciating tearing chest pain radiating to the back'. There may be a significant difference in blood pressure and pulses in both arms. Modifiable risk factors that may increase the event of a type A aortic dissection including smoking, hypertension, recreational drug use and dyslipidaemia. Genetic abnormalities that may put an individual at an increased risk of developing the disease include a congenital defect to the aortic valve such as a bicuspid aortic valve causing a dissection of the ascending aorta or connective tissue disorders such as Marfan's, Ehlers-Danlos or Loeys-Dietz syndromes.

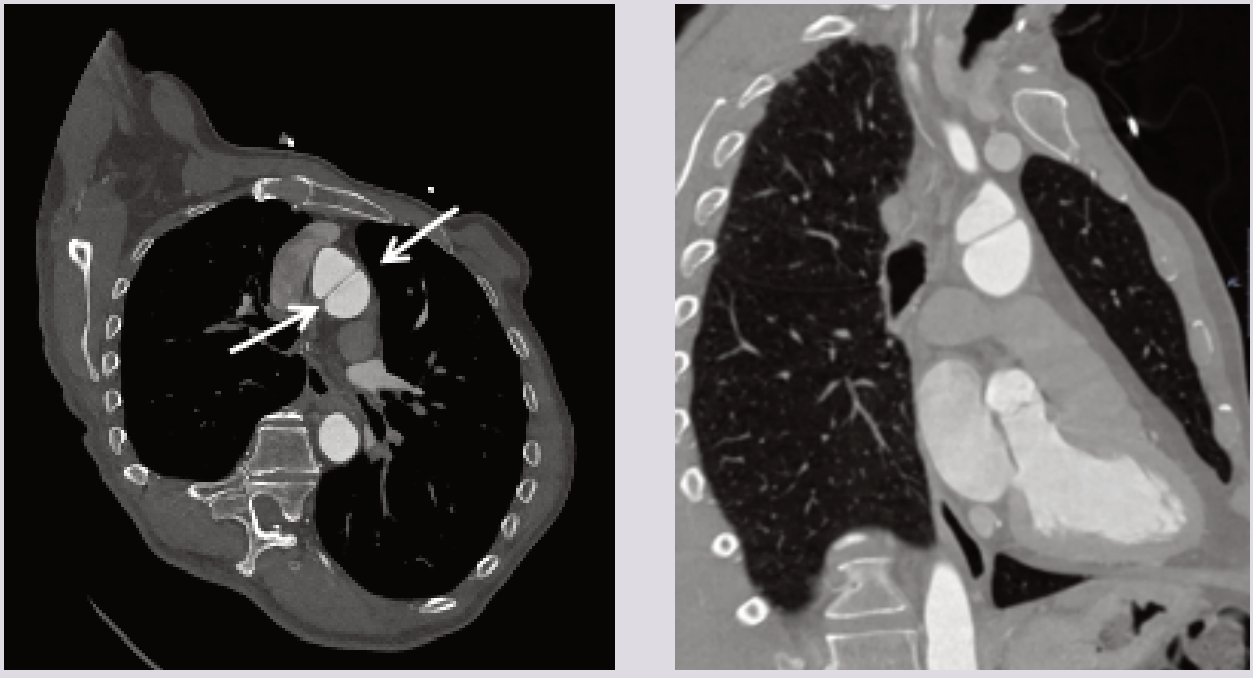
Imaging of a suspected aortic dissection is essential for diagnosis, classification and planning management. The gold standard imaging modality for aortic dissection is aortic CT angiography (CTA). Typical CTA findings include an intimal flap, double lumen, dilatation of the aorta and intramural haematoma. An intimal flap is pathognomonic of the condition. However, one must be cautious when considering this sign as it may not always indicate an aortic dissection.[1] We present a rare case of a fibrous cord in the ascending aorta mimicking an intimal flap.

Case presentation

A 66-year-old man presented to the Emergency Department of a tertiary hospital with two episodes of losing his balance after standing or walking for a prolonged period. He also reported chest pain with no radiation, worse with deep inspiration, and pallor. He denied dyspnoea, sweating, cough or palpitations. His past medical history included frequent light-headed episodes on standing, falls, vacant episodes, schizophrenia, depression, angina, diabetes mellitus, hyperthyroidism, asthma and hypertension. His social history included current smoker (rolling tobacco cigarettes, 11 pack/year history), infrequent alcohol drinker and communication through British Sign Language as he was born deaf. He lived at a residential home.

On examination he was severely hypotensive (61/39 mmHg) with the paramedics with a heart rate of 65 beats per minute (bpm). On attendance at the Emergency Department his blood pressure returned to normal (107/58 mmHg) but his heart rate was 48 bpm and irregular. Lungs were clear on auscultation but a new ejection-systolic murmur was noted. Twelve-lead ECG demonstrated bradyarrhythmia with no prolonged PR interval or heart block. Blood tests showed

Figure 1 CT coronary angiography. Aortic arch showing an indeterminate flap-like appearance indicating a possible type A aortic dissection. White arrows show the tethering of the cord to the adventitia of the aortic wall.



mild renal impairment (eGFR 68 mL/min/1.73 m^2) and C-reactive protein 19.4 mg/L.

During his admission, further investigations to find a cause of his dizziness included a head CT scan which was negative, a 24-hour cardiac tape which showed sinus rhythm with episodes of bradycardia, and a transthoracic cardiac echo which showed an ejection fraction of >50% but was unable to assess the aortic valve for aortic stenosis. A respiratory infection was diagnosed clinically and antibiotics were started. Due to the inability to assess the aortic valve on cardiac echo, a CT coronary angiogram (CTCA) was requested. The CTCA showed an aortic valve calcium score of 514 (non-severe aortic stenosis[2]), normal coronary arteries with right dominance and an indeterminate flap-like appearance of the aortic arch was noted with no associated haematoma (Figure 1).

Subsequent CTA did not show a double lumen but did highlight a cord-like structure that was 27 mm in length and 1.8 mm in diameter. This structure was tethered to the adventitia of the aortic wall and traversed to the opposite wall in a characteristic position (Figure 1).

Discussion

Type A aortic dissections are classified as a surgical emergency and, once identified, patients should be transferred immediately to theatre. Without repair, mortality increases by 10% per hour. CTA is the gold standard for assessing the presence of aortic dissection as it has a sensitivity and specificity approaching 100%, so should be undertaken in all patients with a strong clinical suspicion. Classic features of aortic dissection on CTA include intimal flap, double lumen, dilatation of the aorta and intramural haematoma.[3] In this case, an 'intimal flap' was seen on one CTA slice but no double lumen, intramural haematoma or aortic dilatation.

Only one previous case of a cord-like structure on imaging like this has been reported.[1] These authors presented an asymptomatic patient with an intraluminal line in the distal ascending aorta on CTA and MRI which remained unchanged on imaging over the next five years. They theorised that this was a congenital remnant forming a fibrous cord in the aorta.

The aorta develops in the first few weeks of fetal life from the truncus arteriosus arising from the primitive heart and divides into six paired pharyngeal aortic arches.[4] The fourth arch forms the right brachiocephalic and both subclavian arteries. The aortic arch proper then joins with the descending aorta. The first, second and fifth arches regress whilst the third arch forms the carotid arteries. Abnormal persistence or obliteration of the various arches may lead to anatomical variations which can cause longstanding consequences that may require surgical repair or form congenital abnormalities. Guo *et al* proposed that the congenital intraluminal structure was an incomplete formation then rapid regression of a persistent fifth aortic arch (PFAA).[1]

We also found a cord-like structure like Guo *et al* but in the aortic arch rather than the ascending aorta. Like Guo *et al*, we also consider that this cord may be a remnant of the fifth aortic arch as the formation of the cord-like structure.

KEY MESSAGES

- Rare cord-like structures in the aortic arch, likely remnants of the fifth pharyngeal aortic arch, are benign but may be mistaken for an intimal flap.
- Recognising the characteristic features of this remnant can avoid unnecessary anxiety, radiation and contrast dose for the patient.

Conclusion

Type A aortic dissection is a surgical emergency diagnosed with a combination of clinical and radiological findings. Rare benign pathologies identified on imaging such as a fibrous cord may mimic a dissection and this is important to recognise, especially when the clinical situation does not correlate with the imaging. An opinion from a vascular radiologist in these circumstances can reduce the follow-up surveillance scans, radiation burden and anxiety for the patient.

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Patient consent to publication: Informed consent was obtained from the patient for this publication.

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CASE REPORT

A case of classic Kaposi's sarcoma masquerading as a vascular malformation

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Key words: Kaposi's sarcoma, arteriovenous malformation, Bluefarb syndrome

Abstract

A 45-year-old man presented with painful lumps on his right foot. Imaging suggested a vascular malformation and the patient was referred first to a vascular surgeon, then to a specialist vascular malformation centre. MRA and catheter angiography confirmed a high flow lesion. However, there was clinical and radiological suspicion that an alternative diagnosis was possible. Biopsy confirmed the lesions to be Kaposi's sarcoma. Arteriovenous malformations and Kaposi's sarcoma can appear almost identical clinically and radiologically, so histological analysis is important if there are any doubts about the diagnosis.

Case report

A 45-year-old man presented with a painful lump on his right foot, which had been slowly increasing in size over approximately 9 months and was interfering with his daily activities. He was a marathon runner and had stopped running due to the pain. There was no past medical or family history of note and he had never smoked. He was born in Tunisia and emigrated to the UK.

An ultrasound requested by the primary care doctor described an arteriovenous malformation (AVM) and he was referred to a vascular surgeon at a district general hospital, who found a lobulated subcutaneous mass including soft and fibrotic areas and attributed the pain to repeated thrombosis (Figure 1). He was recommended daily aspirin, an MRA of his foot was requested and he was referred to a specialised unit dealing in vascular malformations for consideration of sclerotherapy.

The MRA (Figure 2) showed distinct but communicating lesions with arterial supply and early venous drainage, suggestive of an arteriovenous lesion. A specialist multidisciplinary team (MDT), consisting of dermatology, vascular, diagnostic and interventional radiology experts, considered the lesions too high flow (ie, arterial) for sclerotherapy and recommended a diagnostic angiogram with a view to possible endovascular embolisation.

Figure 1 Photograph of right foot showing painful growing lumps on the medial aspect of the foot.

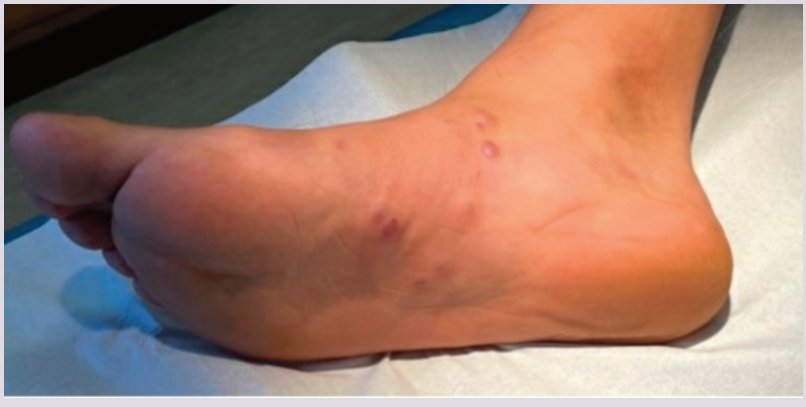


Figure 2 MRA of right foot. Lateral ankle view showing several lesions with arterial supply and early venous drainage.

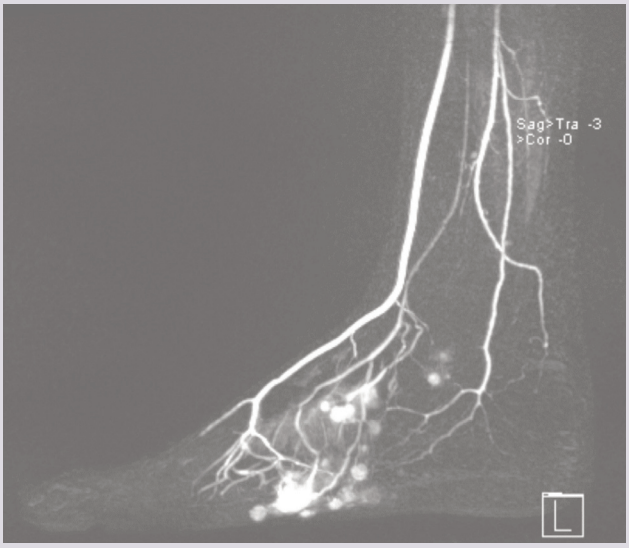
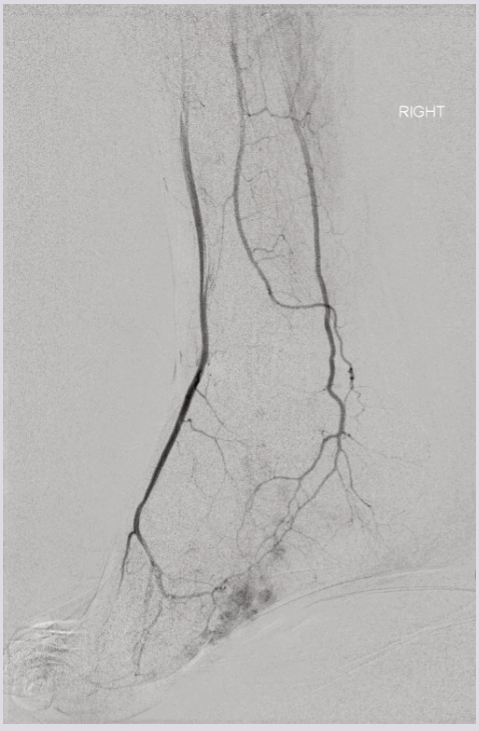


Figure 3 Right lower limb angiogram. Lateral ankle view showing several arteriovenous connections in the right foot arising from the plantar arch with rapid venous drainage.



The diagnostic angiogram (Figure 3) showed abnormal feeding arteries and early venous pooling. Embolisation was not felt to be appropriate due to the high risk of resultant tissue loss and the case was rediscussed in the specialist MDT. Concerns were raised regarding the diagnosis as the lesions had multiplied and were felt to be disproportionally painful since the initial presentation. The decision was made to perform a biopsy prior to any further treatment. Microscopy showed spindle cells with mild atypia, scattered lymphocytes and extravasation of red blood cells. Staining with human herpes virus 8 (HHV8) was strongly positive. The biopsy was diagnostic of Kaposi's sarcoma.

The patient was seen in an oncology clinic, now with multiple lumps on his foot and one on his shin. A viral panel showed he was HHV8 positive and HIV negative. A CT scan of his thorax, abdomen and pelvis showed no concerning lymph nodes or visceral lesions. Radiotherapy was not considered to be appropriate due to the number of lesions and the patient was commenced on a course of chemotherapy (pegylated liposomal doxorubicin). The patient completed eight cycles of chemotherapy but, unfortunately, he presented again 6 months later with new lesions in his foot for which he is currently being restaged.

Discussion

Vascular malformations encompass a wide spectrum of lesions. A fundamental radiological classification is whether the lesion is high or low flow,[1] which can be further expanded based on flow dynamics and cellular features.[2]

AVMs are vascular malformations resulting from developmental defects of the arterial and venous vasculature. They affect any organ, most commonly the head and neck (specifically the most frequent are intracranial AVMs) followed by the extremities. The exact aetiology is unclear. To our knowledge, there are no published data regarding the incidence of peripheral AVMs. The incidence of intracranial AVMs is around 1–10/100,000.[3–5]

Although AVMs are thought to be present at birth, if they are deep or slow growing the patient may not present until adulthood. AVMs can be solitary or multifocal, and usually are slow growing but can grow rapidly. They often present with pain and swelling and can be red/blue/purple in colour.

Kaposi's sarcoma is a low-grade vasoformative/angioproliferative neoplasm (sarcoma is a misnomer) associated with HHV8, also known as Kaposi's sarcoma-associated herpes virus (KSHV).[6–8] There are four main subtypes of Kaposi's sarcoma: classic, endemic (observed in sub-Saharan Africa), epidemic (AIDS related), and iatrogenic (transplant related).

Classic Kaposi's sarcoma is what was originally described by Kaposi in 1872,[9] a cutaneous tumour affecting primarily the skin over the lower legs and feet in a multifocal and classically symmetrical distribution. Kaposi's sarcoma often occurs in older males of Mediterranean (such as Tunisian) or Central/Eastern European ancestry. It is likely multifactorial with one factor being that HHV8 infection rates are substantially higher in these parts of the world.[10–12] Additionally, it is thought that people with classic Kaposi's sarcoma are born with a genetic/immunological vulnerability to the HHV8 virus.[6,7,13,14] Transmission routes of HHV8 are not fully understood, but both vertical and horizontal

transmission are established and it is thought to be via bodily fluids including saliva.[8,15]

The incidence rate of classic Kaposi's sarcoma in the UK is thought to be around 0.014/100,000 person-years.[16] However, in Sardinia the incidence rate was estimated at 1.58/100000 person-years.[17]

Classic Kaposi's sarcoma is characterised by the appearance of purplish, reddish blue or dark brown/black macules, plaques and nodules on the skin. The lesions vary from very small to several centimetres in diameter. They can remain unchanged for months to years or may grow rapidly and can be accompanied by contemporaneous mucous membrane and visceral lesions.

It is well established that the cutaneous manifestation of Kaposi's sarcoma and an AVM can be similar.[18–22] Most cases reported in the literature are of 'pseudo-Kaposi's sarcoma', also eponymously called Stewart–Bluefarb syndrome, where the patient is initially thought to have classic Kaposi's sarcoma and it is discovered to be an AVM. Indeed, to our knowledge there is only one case report describing a case of Kaposi's sarcoma which was initially thought to represent an AVM.[21] It is unusual for these cases to be presented in vascular journals and therefore vascular clinicians may not be aware of this diagnostic pitfall.

This case report serves to highlight to those involved in the patient's journey that these two conditions can be almost indistinguishable both clinically and radiologically. If there is any uncertainty in the history, examination or imaging, then a biopsy and histopathological analysis should be obtained prior to any definitive treatment. The treatment of the two conditions is very different and diagnostic delay can have detrimental consequences for the patient.

KEY MESSAGES

- Kaposi's sarcoma occurs in patients other than immunosuppressed/HIV positive patients.
- Arteriovenous malformations and classic Kaposi's sarcoma can be clinically and radiologically indistinguishable.
- Biopsy and histopathological assessment are crucial to differentiating between the two if there is any diagnostic uncertainty.

Conflict of Interest: None.

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CASE REPORT

Ectopic thyroid tissue presenting as a carotid body paraganglioma

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Key words: ectopic thyroid, carotid body tumor, paraganglioma

Abstract

Ectopic thyroid tissue is a rare developmental abnormality, typically presenting with midline ectopia due to incomplete embryological migration via the thyroglossal duct. The presence of ectopic thyroid tissue lateral to the midline is very rare, accounting for 1–3% of all ectopic thyroid tissue. Clinically, these lesions are often mistaken for other diagnoses including enlarged lymph nodes or metastatic tumours. We present a case of lateral ectopic thyroid tissue presenting as a presumed carotid body paraganglioma in a middle-aged woman. The patient presented with a slow-growing lateral neck mass which was clinically and radiologically consistent with a carotid body paraganglioma. She subsequently underwent tumour excision after which histological analysis identified ectopic thyroid tissue with no evidence of malignancy.

Background

Embryologically, the thyroid gland begins development at the third week of gestation.[1] It is derived from the fusion of a large median anlage and two lateral anlages. The median anlage, which produces the follicular cells (making up the majority of the thyroid parenchyma), arises first as an endodermal growth from the second pharyngeal arch.[2] This growth is known as the thyroid diverticulum. The thyroid diverticulum then descends caudally down the midline until the eighth gestational week when it reaches its final destination, sitting anterior to the trachea and larynx.[3] This line of migration is known as the thyroglossal duct. The two lateral anlages, which produce the parafollicular C cells, are derived from the fourth pharyngeal pouch. They migrate to fuse with the posterior surface of the median anlage during its descent in the fifth week of gestation.[2,4]

In contrast, the carotid body, which sits within the adventitial layer of the carotid bifurcation, is derived from the mesoderm of the third pharyngeal arch and the neural crest ectoderm. Tumours of the carotid body arise from the paraganglioma cells. There is no known relationship between the carotid body and the thyroid gland.[5]

Ectopic thyroid tissue (ETT), defined as thyroid tissue not located anterolaterally to the second to fourth tracheal cartilages,[6] was first described by Hickman in 1869 when a newborn suffocated as a result of a lingual thyroid causing upper airway obstruction.[7] Since then, multiple cases of ETT have been reported. Typically, as with Hickman's case, the ETT is found in the midline due to incomplete descent of the median anlage. The presence of ETT lateral to the midline is rare, likely due to dysembryogenesis in the migration of the lateral anlage.[4] Due to their rarity, these are often clinically misdiagnosed as enlarged lymph nodes, metastatic tumours[8] or, as in our case, carotid body paragangliomas. Even with modern imaging it can be difficult to differentiate ETT from other pathology such as carotid body paraganglioma and therefore many are only diagnosed after surgical excision and histological analysis.[9]

Case presentation

A woman in her 50s presented with a right-sided lateral neck mass which had been present for a few months and was associated with mild discomfort, but no disturbance to speech or swallowing and no symptoms of thyrotoxicosis. Examination revealed a solitary firm mass in the right anterior triangle with no overlying skin

Figure 1 Ultrasound scan of the neck (right) showing a mass at the level of the carotid bifurcation.

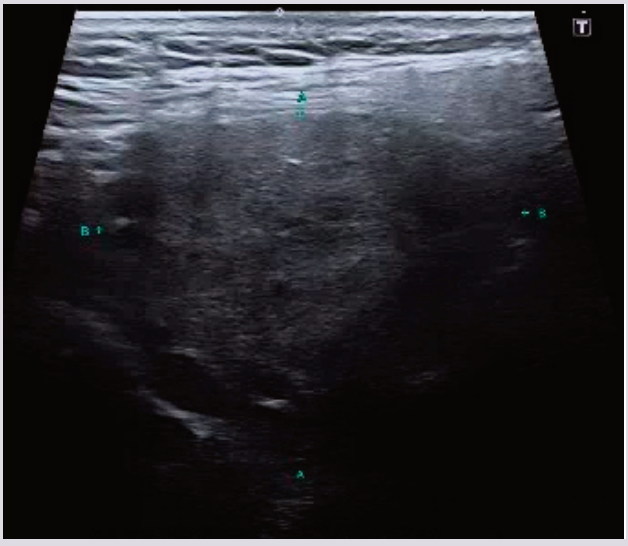


Figure 2 CT neck image (axial view) showing a mass at the level of the right carotid bifurcation.

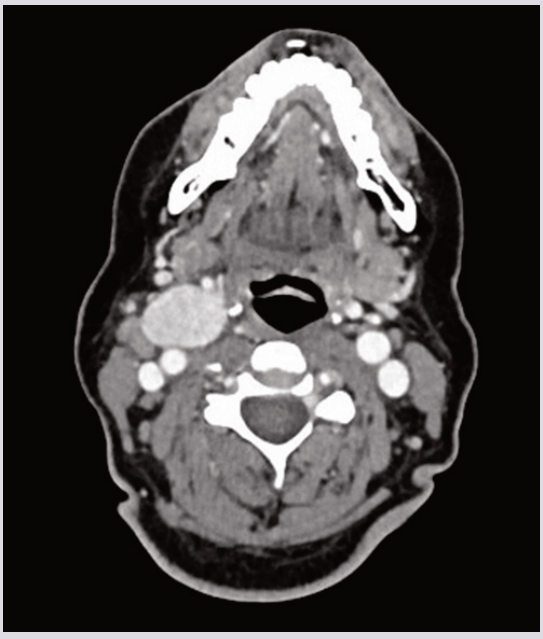
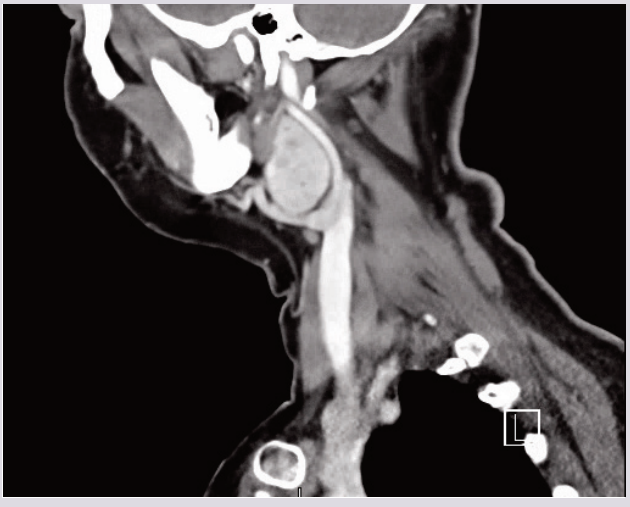


Figure 3 CT neck image (sagittal view) showing a mass at the level of the right carotid bifurcation.



changes and no lymphadenopathy, consistent with a provisional clinical diagnosis of carotid body paraganglioma. An ultrasound scan (Figure 1) of the neck identified a well-defined hyperechoic mass at the right carotid bifurcation, and a subsequent CT scan (Figures 2 and 3) revealed a 51 mm hyper-enhancing mass straddling the carotid bifurcation, sitting 17 mm inferior to the skull base, described as consistent with a carotid body tumour. There was no evidence of any pathological lymphadenopathy and the upper aerodigestive tract appeared normal. The presence of a thyroid gland in the normal orthotopic position was also noted. Based on these findings, the mass was initially diagnosed as a carotid body paraganglioma and the patient was scheduled for endovascular embolisation followed by surgical resection. All pre-procedure haematological and biochemical investigations were normal. Previous thyroid function tests were within normal ranges.

During the endovascular embolisation the angiogram showed modest hypervascularity relating to the mass. The three largest feeder vessels were embolised and this resulted in a 70–80% reduction in the lesion's 'blush'.

Intraoperatively, the tumour was encountered at the level of the carotid bifurcation and complete excision was performed. The tumour encased the carotid arteries but was easily resectable, with no invasion of the adventitia. An enlarged jugulodigastric lymph node lying superficial to the tumour was also excised.

Histological analysis showed lobulated thyroid with marked necrosis and haemorrhage, in keeping with embolisation. There were no features to suggest malignancy from the primary lesion or lymph node. The final diagnosis of ETT was made.

During the initial postoperative period the patient developed left arm weakness. This was initially investigated and treated as a potential cerebrovascular accident; however, a CT and MRI showed no evidence of any infarct. There were no further concerns from the vascular team prior to discharge. The total length of stay was 10 days.

Follow-up at four weeks confirmed the patient was recovering well, with no further neurological symptoms and recovery of most of her arm function. The wound had healed well and there were no symptoms of hypothyroidism and thyroid function tests were normal.

Discussion

ETT is a rare embryological abnormality with a prevalence of 1/100,000–300,000.[1] Typically, it occurs along the median path of migration as a lingual thyroid (80–90% of cases) or thyroglossal cyst (5–15% of cases) secondary to incomplete descent or obliteration of the thyroglossal duct.[4] Ectopic tissue lateral to the midline is rare, accounting for only 1–3% of all ETT. The most accepted hypothesis for its development is failure of the lateral anlage to fuse with the medial anlage and non-migration of the gland.[4,5,10] Mutations in a number of transcription factors (NKX2-1, PAX8, FOXE1 and TSHR) associated with definition and migration of the developing thyroid are recognised causes of thyroid dysgenesis.[11] These are often tested for in patients with congenital hypothyroidism, which is associated with thyroid dysgenesis and ectopy. However, previous biochemistry showed our patient to be euthyroid and therefore this was not examined.

Where reported, 70% of lateral ETT are located in the submandibular region or, less commonly, near the carotid sheath.[4] There have been only six previously reported cases of ETT at the carotid bifurcation.[5,9,12–15] Other unusual locations of ETT include the mediastinum, chest and abdomen.[12]

The clinical presentation of our patient was similar to those in previously reported cases – namely, a slow-growing asymptomatic mass. However, on retrospective review it was noted that our patient's preoperative CT scan identified a thyroid gland located in the normal orthotopic position. In cases of lateral ETT, only 41% have also had a thyroid gland in the normal orthotopic position. However, it is noteworthy that a further 24% had another site of thyroid tissue located elsewhere such as a lingual thyroid. In comparison, a second site of thyroid tissue was seen in only 25% of those with ectopic lingual thyroids.[4]

Given this, it is important to consider the functional effects when excising ETT. It has been reported that, in 70–80% of cases, ETT may be the only functional tissue[5] and therefore excision can lead to irreversible hypothyroidism. This was not the case in this instance. The simultaneous finding of lateral ETT and a normally located functional thyroid gland is extremely rare.[5,16]

Even with modern imaging techniques it can be difficult to discriminate lateral ETT from other diagnoses including carotid body tumours, and therefore management is often via first-line excision biopsy. Consequently, ETT is often only diagnosed after histological analysis.[4,9] When ETT is suspected, technetium-99 or iodine-131 scintigraphy are not only important diagnostic investigations but may also demonstrate the presence or absence of normally located or other functional thyroid tissue.[4,16] Somatostatin receptor scintigraphy such as octreotide scans or 68Ga-DOTATATE PET scans are often used to diagnose neuroendocrine tumours, including paragangliomas. However, uptake of octreotide and 68Ga-DOTATATE within thyroid goitres, and in a case of ETT, has also been reported.[12,17]

Albeit rare, ETT is an important differential to consider given the risk of irreversible hypothyroidism. Others have highlighted the importance of combined investigations such as CT, MRI, scintigraphy (somatostatin receptor, technetium-99 or iodine-131) and fine needle aspiration cytology to give a higher sensitivity and specificity when investigating a lateral anterior triangle neck mass.[4,12,16]

KEY MESSAGES

- Ectopic thyroid tissue presenting at the carotid bifurcation is a rare phenomenon and may clinically mimic carotid body tumours.
- Lateral ETT typically arises due to dysembryogenesis of the lateral anlage.
- ETT is an important differential in the presence of anterior triangle neck mass and thorough investigations including scintigraphy or FNAC should be considered.
- ETT may be the only functional thyroid tissue, therefore excision may lead to irreversible hypothyroidism. If diagnosis is made post-operatively it is imperative the patient undergoes follow up thyroid function tests.

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Patient consent to publication: Informed consent was obtained from the patient for this publication.

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CASE REPORT

A rare case of a dog bite leading to bilateral lower limb amputations

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Key words: *Capnocytophaga canimorsus*, disseminated intravascular coagulation, amputation

Abstract

Capnocytophaga canimorsus is a rare cause of bacteraemia, occurring usually after dog bites, and can have devastating consequences for patients. This report describes the case of a 65-year-old woman who presented acutely unwell 6 days after being bitten on the hand by a dog. She suffered consequences of overwhelming sepsis, disseminated intravascular coagulation and bilateral acute limb ischaemia requiring bilateral major lower limb amputations. *C. canimorsus*-associated sepsis is extremely rare, but early (prophylactic) antibiotic treatment after a dog or cat bite could prevent serious complications associated with this bacterium.

Introduction

Capnocytophaga canimorsus is a Gram-negative bacterium that is part of the normal gingival flora of both dogs and cats. When humans are infected, *C. canimorsus* can lead to fulminant sepsis. The most common cause of human infection with *C. canimorsus* is from a dog or cat bite. Patients most susceptible to this infection are immunocompromised patients, those who have had a splenectomy or those with a history of heavy alcohol use.[1] With doubling of dog bite-related admissions between 1998 and 2018, more patients are likely to be admitted with this bacterial infection.[2] A case of fulminant *C. canimorsus* sepsis from a dog bite leading to disseminated intravascular coagulation (DIC) and eventual bilateral major limb amputation and ultimately death is described.

Case report

A 65-year-old woman was admitted via ambulance with confusion and reduced consciousness on a background of being bitten by a dog on the left hand 6 days prior. The patient had known small sub-threshold abdominal aortic and iliac aneurysms with a past history of two caesarian sections and a hysterectomy. She was a current smoker of 30–40 cigarettes per day, but did not have a history of alcohol excess and lived independently. On initial assessment she was hypoxic with an 8 L oxygen requirement and a Glasgow Coma Scale score of 12/15. Her initial blood results showed a platelet count of 17,000 per µL (normal range 150,000–400,000 per µL), lactate 3.3 mmol/L (normal range 0.5–2.2 mmol/L), C-reactive protein 254 mg/L (normal range <5 mg/L), a high D-dimer (greater than measurable) and a prolonged clotting time. A dog bite was noted on the left wrist which was small but deep and, although the wound showed signs of healing, there was surrounding erythema. During her initial assessment there were no issues noted with her limb perfusion. Following blood cultures, she was started on treatment for sepsis (presumed secondary to community acquired pneumonia) and transfused with platelets for thrombocytopenia, considered due to sepsis-related DIC.

Twenty-four hours into her admission there were concerns about her feet becoming ischaemic. She was assessed overnight; no foot pulses were clinically palpable, hand-held doppler signals were absent on the left but audible over the right dorsalis pedis and posterior tibial arteries. A heparin infusion was initiated for acute limb ischaemia after discussion with a haematology consultant, due to risks of complicating her coagulopathy. An urgent CT

Figure 1 Blood film from patient.

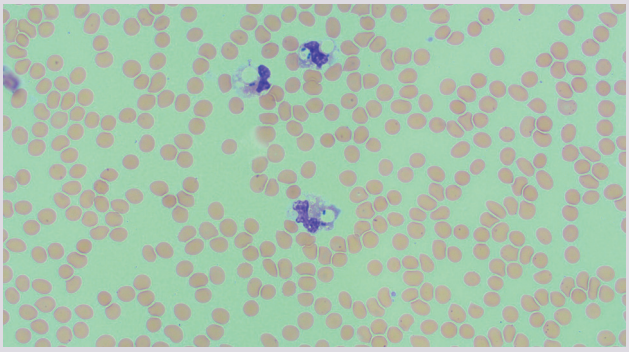


Figure 2 *Capnocytophaga* blood agar 2 days (from Gloucester Royal Hospital Microbiology Library).

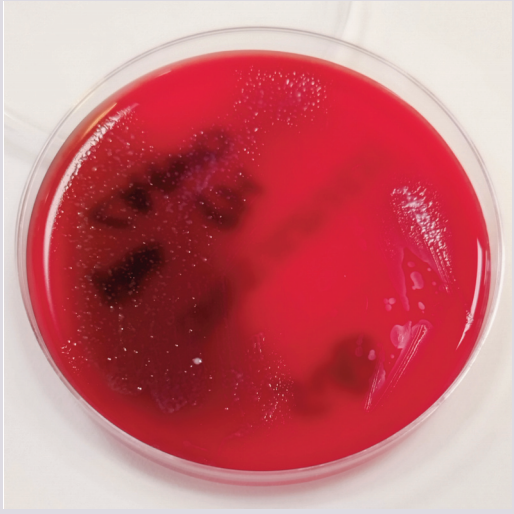
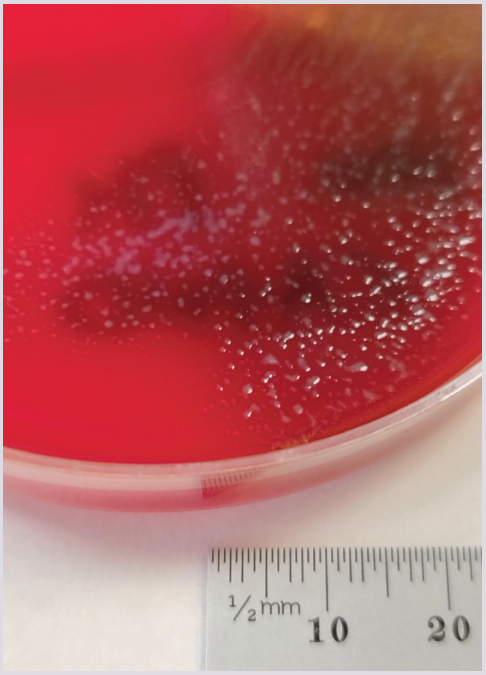


Figure 3 *Capnocytophaga sp* blood agar (from Gloucester Royal Hospital Microbiology Library).



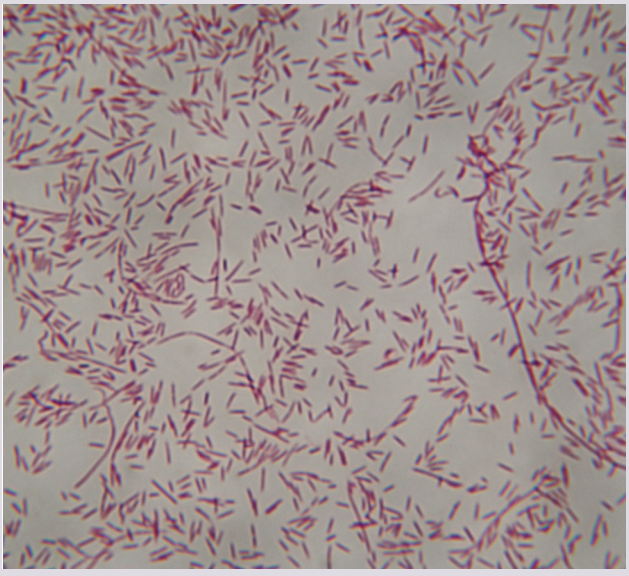
angiogram showed no arterial flow in the lower limb crural circulation below the left mid-calf or right ankle. A vascular consultant review documented bilateral insensate feet with fixed mottling and no ankle/foot movement in the ankles, concluding that the left leg and possibly the right leg were unsalvageable. At this stage her initial blood culture result flagged positive and, although no organisms were cultured, the presence of possible intracellular organisms in the blood film were noted. Later analysis of the culture by 16S rRNA polymerase chain reaction (PCR) confirmed the organism as likely to be *Capnocytophaga canimorsus* (there was no growth on direct or enrichment culture) (Figure 1-4). Microbiological opinion was sought and the antibiotic treatment was escalated to meropenem, linezolid, clarithromycin and gentamicin. Due to the risk of operating given concurrent thrombocytopenia, a multidisciplinary discussion between the vascular surgeon, haematologist and intensivist was arranged. She underwent left above-knee amputation and right below-knee amputation 3 days into admission.

The patient was stepped down to the ward from the intensive care unit 3 days postoperatively and was deemed medically fit for discharge 7 days postoperatively. The patient was finally discharged to a community rehabilitation hospital nearer to her next of kin 2.5 weeks postoperatively. Unfortunately, the patient became unwell 9 days after discharge (<4 weeks postoperatively) and was re-admitted to hospital where she died on the day of admission. A post mortem found the cause of death to be (1a) pulmonary embolism and (1b) deep vein thrombosis of the right leg.

Discussion

Infection with *C. canimorsus* is rare. A national surveillance study in the Netherlands in 2011 showed an incidence of 0.67 cases per million per year,[3] with only one of the 32 bacteraemic patients requiring bilateral lower limb amputation. A 2022 review described 207 cases of *C. canimorsus* infection, 22 of which included irreversible digit or limb ischaemia as a complication.[4] Furthermore, a retrospective review of patients in a Helsinki ICU cohort between 2005 and 2014 found 65 patients with *C. canimorsus* bacteraemia,[5] all of whom were in contact with dogs but only 37% had a history of a dog bite, suggesting that patients can become infected from close contact as well as a physical break in the skin. This study also found that the most commonly affected body system was coagulation (94%), with three of the 65 patients requiring lower limb amputation for tissue necrosis. A review of 484 laboratory-confirmed cases found that patients can present with severe sepsis/septic shock, gangrene of digits or extremities,

Figure 4 Capnocytophaga carbol fuchsin (from Gloucester Royal Hospital Microbiology Library).



meningitis and endocarditis and found a fatality rate of 26%. Major lower limb amputation secondary to acute limb ischaemia is therefore a relatively rare consequence of this infection, but septic shock and DIC have a high mortality rate.[6,7]

C. canimorsus is a highly virulent bacterium due to its catalase and sialidase production, as well as gliding mobility, cytotoxin production and unique lipopolysaccharide.[7]

On review of the patient notes, the dog bite was mentioned in the initial clerking but it was not documented as the presumed source of sepsis until the blood culture result was known. The patient had already been initiated on piperacillin-tazobactam and clarithromycin from the start of the admission, which are acceptable treatments for *C. canimorsus*, therefore it is difficult to know whether earlier recognition of the source of the sepsis would have improved the outcome in this case. However, had the patient been initiated on a penicillin-based antibiotic at the time of the dog bite, this might have prevented her presentation to hospital in a severely unwell state 6 days after the dog bite. Furthermore, this case highlights the importance of further analysis of blood cultures using 16S rRNA PCR when there is a clinical suspicion of *C. canimorsus* without growth on initial direct or enrichment culture.

KEY MESSAGES

- *Capnocytophaga canimorsus* is a rare cause of sepsis in humans which is usually caused by dog or cat bites.
- *C. canimorsus* can lead to sepsis and disseminated intravascular coagulation that can cause acute limb ischaemia.
- Early recognition and treatment with appropriate antibiotics after dog or cat bites can prevent serious consequences of this infection.

Conclusion

C. canimorsus is a rare cause of sepsis in humans, occurring usually after bites or licks to the skin from dogs or cats. It has severe complications as demonstrated by this case, therefore early treatment with antibiotics for dog or cat bites as a prophylactic measure could prevent life-changing or even fatal consequences.

Conflict of Interest: None.

Funding: None.

Patient consent to publication: Informed consent was obtained from the patient for this publication.

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

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ABSTRACTS

VASGBI 2023 Brighton oral presentation abstracts

Authors of the top scoring abstract submitted are given the opportunity to give an oral presentation of their work during our free paper session. The first paper, by Suzanne Harrogate *et al* was awarded first prize.

A National Study of Peri-operative Smoking Cessation in Vascular Surgery

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Background

Smoking is the biggest cause of preventable illness worldwide[1] and is associated with increased peri-operative morbidity.[2] Over 30% of patients awaiting vascular surgery smoke, far higher than the general population.[3]

Aims

To explore smoking-cessation strategies currently offered to vascular surgery patients and to identify barriers and facilitators to the provision of peri-operative smoking-cessation practices.

Method

We designed a survey exploring anaesthetists' knowledge, beliefs, and practice regarding smoking cessation in patients awaiting vascular surgery. The survey was piloted with 9 participants from 2 centres. After refinements, it was distributed to Vascular Anaesthesia Society of Great Britain and Ireland (VASGBI) members by email. Inductive thematic analysis of free text responses was used to identify codes, which were subsequently grouped into themes.

Results

We received 93 responses from anaesthetists representing 46 out of 67 vascular networks. Although most vascular anaesthetists (84%) ask patients about smoking, only 53% regularly recommend smoking-cessation, and only 12% regularly provide specific smoking-cessation interventions. Most anaesthetists (57%) have no formal training in smoking-cessation interventions while 77% are not familiar with the current NICE smoking-cessation guidance. Anaesthetists who had been formally trained had mostly undertaken self-directed learning in Very Brief Advice (34%).

In keeping with research evidence and institutional guidance, most anaesthetists surveyed believe that any degree of preoperative smoking-cessation is beneficial (82%). However, belief in the detrimental impact of smoking-cessation before surgery persists: 15% agreed with the statement that smoking cessation "too close" to surgery is harmful, while 7% felt that perioperative use of nicotine replacement therapy could cause harm.

Respondents described barriers they felt prevented them from implementing smoking-cessation interventions periopertively, and facilitators of good smoking-cessation practice. Themes identified from these responses are listed in table 1, alongside exemplar codes. Themes for barriers were system barriers, lack of patient motivation, patient circumstances, addiction, and barriers to the patient-doctor discusson. System barriers, such as lack of time and resources, was the most commonly coded theme. Themes for facilitators were threat and risk, family and environment, nicotine replacement therapy (NRT), and "who and how".

Conclusion

Despite a high smoking prevalence in patients awaiting vascular surgery, there is a variation in smoking-cessation practice between anaesthetists across the vascular networks. Only half of vascular anaesthetists regularly recommend smoking-cessation to their patients. Most are not familiar with NICE smoking-cessaiton guidance, and few have any formal training in the delivery of smoking-cessation interventions. Where it exists, training is predominantly self-directed. Organisational factors and lack of patient willingness are significant barriers to the provision of effective smoking cessation support, while access to NRT and a clear, protocolised approach (the "who and how") were facilitators of good practice.

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Table 1 Inductive thematic analysis of facilitators and barriers to good peri-operative smoking-cessation practice described by vascular anaesthetists

	Themes	Codes	Quotes
Facilitators	Who and how	Long term support from clinicians Whole team approach Clinician knowledge Clinician attitude e.g. relatable and non-judgemental approach, compassion Protocols Follow up support as necessary	"easy…dedicated referral process" "standard protocol" "Engage yourself. These are your patients" "GP buy in"
	Nicotine replacement and pharmacotherapy	Nicotine replacement therapy Vaping/e-cigarettes Accessibility of pharmacological interventions	"explain that nicotine is not as harmful as tobacco" "easily available NRT"
	Threat and risk	Use risk to motivate Patient knowledge and education of risk Make smoking cessation compulsory	"quantify personal risk for that particular patient" "making pt understand they can influence their outcome" "make it a requirement for surgery"
	Family and environment	Involve family/carers Hospital as a place where smoking cessation is likely/enforced	"family support and input" "peer group" "Barriers to leaving the hospital to smoke"
	Themes	**Codes**	**Quotes**
Barriers	System barriers	Lack of time Lack of resources Timeliness No chance for follow-up Stop people smoking on hospital grounds	"It's too late" "apathy – patients allowed to smoke outside the front doors" "funding…has vanished" "no ownership of the problem"
	Lack of patient motivation	Neutral e.g. motivation, willing Negatively frames e.g. patient refusal, unwillingness, entitlement, apathy	"patients don't want to quit"
	Addiction	Addiction/habit Nicotine replacement therapy and alternatives Patient knowledge of alternatives	"breaking a lifelong habit is tough"
	Barriers to patient-doctor discussion	Clinician reluctance e.g. worried about losing rapport Clinician lack of knowledge of interventions Psychological concerns for patient	"too few professionals risk the discussion" "patients are very anxious about surgery"
	Patient circumstance	Family Poverty Environment Patient knowledge	"the patient then goes home…the cues haven't changed" "smoking is the one luxury that many of my patients have"

The development of a Vascular Post Anaesthesia Care Unit (PACU) in the Royal Victoria Hospital, Belfast - Our experiences and outcomes to date

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Background

High risk non-cardiac surgery represents 12.5% of all surgical procedures, however it accounts for a disproportionate rate of peri-operative morbidity and mortality.[1,2] Vascular surgical patients in particular represent a complex patient cohort undergoing high risk surgery. Belfast is one of the busiest tertiary vascular units in the UK, performing over 50 elective open AAA repairs in 2021 despite the COVID pandemic. Our traditional model of care has been to admit these patients to our regional intensive care unit (RICU) post operatively which has ultimately led to patient cancellations and reduced theatre efficiency due to lack of elective capacity. Following on from the Bengoa Report, the Review of Surgery in Northern Ireland report was published in 2022. One key recommendation was the development of enhanced post anaesthesia care for our high risk patients in order to reduce complication and cancellation rates and to minimise the existing burden on services through improved theatre efficiency, reduced length of hospital stay and reduced burden on critical care, which currently operates at a greater than 95% bed occupancy rate.[3]

Aims
We set about establishing PACU by defining our key goals, which were to ensure the new unit provided time limited, enhanced, intermediate level care within our pre-existing recovery unit for elective patients.
Methods
A local steering group was formed including management, medical and nursing teams. We put in place governance structures and commenced a pilot scheme where one vascular surgical patient per week was identified for admission into PACU. Alongside our pilot we developed a standard operating procedure, drafted a successful business case for submission to the Department of Health NI, devised a user friendly booking system and data collection procedures. Following a hugely successful pilot scheme and release of funding we have now expanded to facilitate four PACU beds per day across all surgical specialties, with multidisciplinary input.
Results
Our results have demonstrated a positive impact across numerous quality indicators. Vascular theatre efficiency has improved, particularly for those undergoing open AAA repair or aorto-bifemoral bypass surgery where there has been a 66% reduction in delays prior to surgery commencing due to lack of ICU bed capacity, and a subsequent 50% reduction in vascular theatre session over-runs, thus increasing capacity for other vascular procedures. There has also been a 50% reduction in patient cancellations due to lack of ICU capacity for those undergoing open AAA or ABF repair. Our impact on critical care has also been noted with a significant reduction in planned vascular admissions, translating into reduced bed pressures through an estimated saving of 3 critical care beds per week. We have also demonstrated a reduction in high dependency outliers within our recovery ward which has further improved theatre and recovery flow. We are providing safe care to our PACU patients, with an escalation rate to critical care of only 2% and no reported adverse incidents to date. This has been achieved in a cost effective manner, with a PACU bed costing approximately 10% of a critical care bed per 24 hour period. Feedback from patients and staff alike has been very positive.
Conclusion
In summary, we have shown that our PACU service is delivering safe, quality care to a complex surgical cohort whilst improving theatre efficiency, reducing cancellations and the burden on our critical care department.

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Observational analysis of the affect of national lockdown on the cardiopulmonary fitness of patients being assessed for aortic surgery

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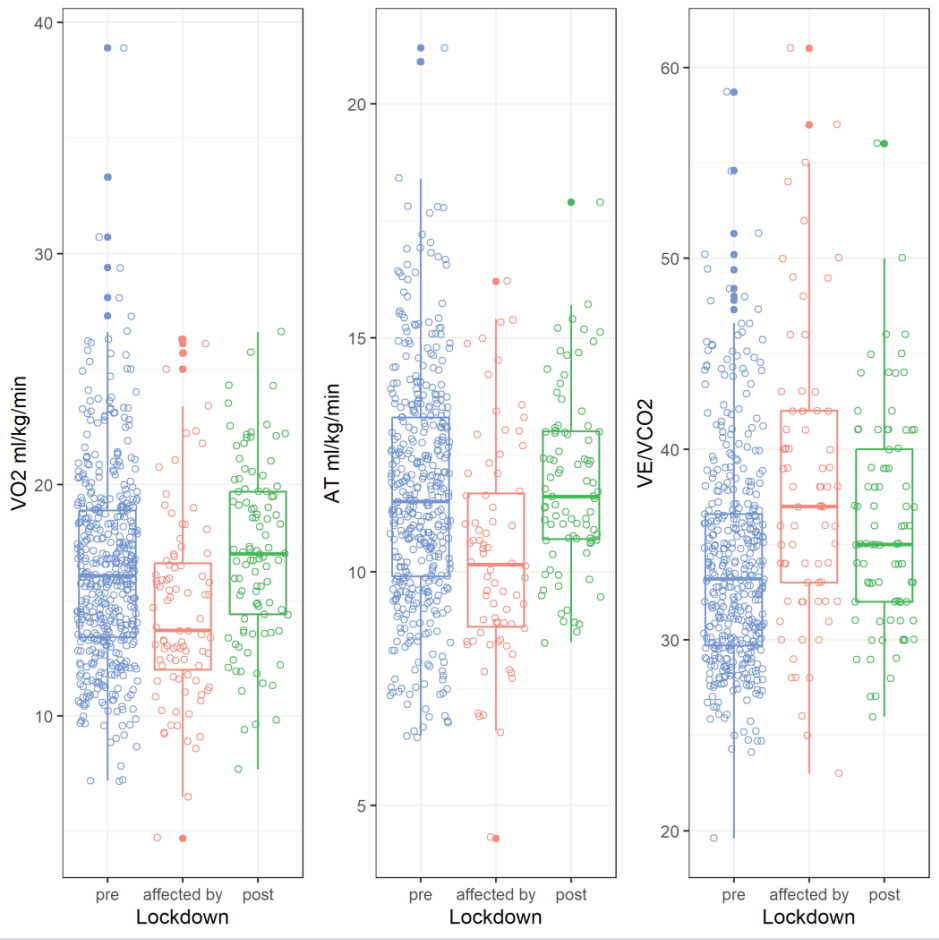
Background
Since 2010, all patients assessed for open or endovascular aortic surgery at the Royal Infirmary of Edinburgh undergo cardiopulmonary exercise testing (CPET) as part of their preoperative assessment. The role of CPET in preoperative assessment is built on three premises. First, that training improves cardiopulmonary fitness.[1] Second, that improved cardiopulmonary fitness is reflected in better CPET performance. Third that better CPET performance is reflected in better operative outcome.[2]

That training improves cardiopulmonary fitness is well demonstrated in athletic training. Broadly however, the patients we see do not do a lot of regular training. They are reliant on activities of daily living for the majority of their daily exercise.

With this in mind, we thought the period of national lockdown associated with the SARS-CoV-2 pandemic might provide an interesting observational window into whether, if you legislate to curtail activities of daily living, do our patients perform less well in CPET.
Aims
We wished to observe the impact of national lockdown on the cardiopulmonary fitness of those assessed for aortic surgery at the Royal Infirmary of Edinburgh (RIE). We hypothesised that behavioural changes during this time might negatively affect cardiopulmonary exercise testing (CPET) results.
Method
We performed a retrospective observational analysis on 714 patients undertaking CPET in the vascular pre assessment clinic at the RIE. 486 patients assessed before lockdown between January 2010 and December 2015, 110 assessed closely following lockdown between July 2021 and August 2022, and 118 assessed after lockdown between August 2022 and May 2023. We

Figure 1 Bar and scatter plots showing the observed change in cardiopulmonary exercise testing values seen in association with the national lockdown, in patients being assessed for aortic surgery.



compared maximal oxygen consumption ml/kg/min (VO2), oxygen consumption at anaerobic threshold ml/kg/min (AT), and ventilatory efficiency at anaerobic threshold (VE/VCO2). These values are all associated with postoperative survival after aortic surgery.[3] Analysis was performed in R version 4.2.2. Values are mean (SD).

Results

Pre, affected by, and post lockdown groups were similar at baseline. Mean group age (68-70), BMI (27-28), Resting heart rate (77-81), Resting blood pressure (124/74-130/79). The group affected by lockdown showed evidence of a statistically significant reduction in VO2 (14.7(4.3) vs 16.3(4.2) $p < 0.001$), AT (10.4(2.3) vs 11.7(2.5) $p < 0.001$), and increase in VE/VCO2 (38.0(7.6) vs (34.0(5.6) $p < 0.001$) compared to the pre lockdown group (figure 1). When compared to average CPET results for patients attending vascular pre assessment at the RIE, these differences represented a 12 centile shift in VO2, 17 centile shift in AT, and 21 centile shift in VE/VCO2 (figure 2). These differences had dissipated in the group assessed at least one year post lockdown.

Conclusion

This retrospective observational cohort shows a significant reduction in key markers of cardiopulmonary fitness following the period of national lockdown. While absolute differences may appear small, they represent a 10-20 centile shift when compared to the population of patients who attend the RIE in the context of assessment for aortic surgery. In these data the observed difference did not persist more than one year after national lockdown. Fitness is maintained by activities of daily life. When these are constrained by public health measures, we should be cognisant of the impact on patients preparing for surgery and continue to encourage prehabilitation where possible.

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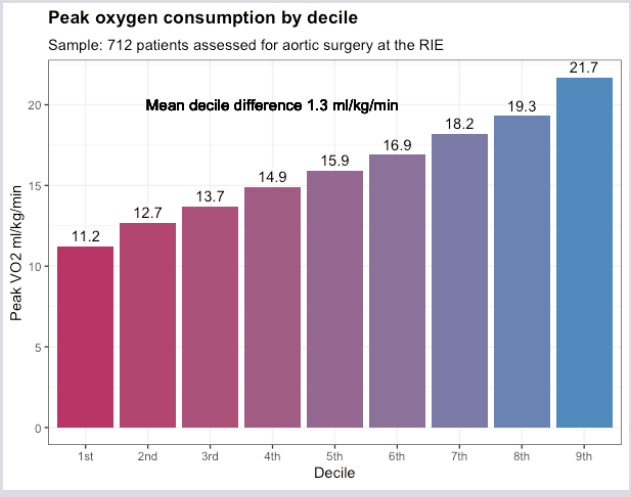
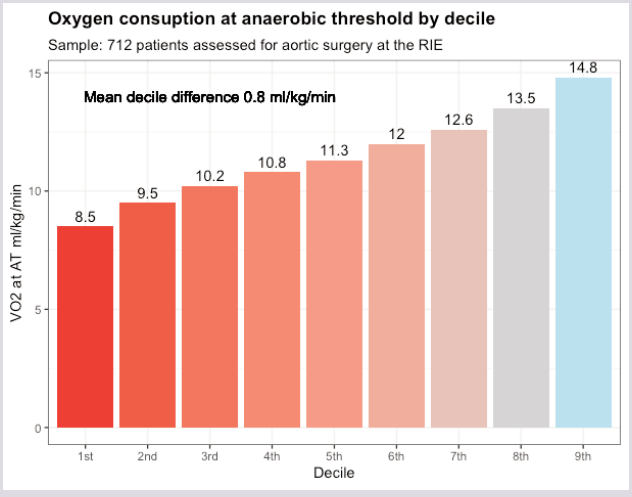
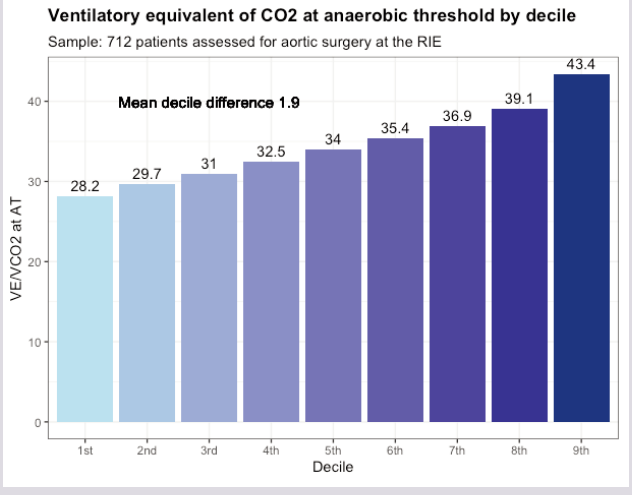
Figure 2 Three bar charts showing key markers of cardiopulmonary exercise testing performance, by decile, for all 714 patients assessed for aortic surgery.







Preoperative thrombin generation is correlated to intraoperative blood loss in open aortic surgery

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Background

Thrombin generation analysis (TGA) is a measure of overall coagulation capacity and reflects the combined effects of pro and anticoagulant factor concentrations. In the setting of cardiac surgery, an inverse relationship between preoperative thrombin generation and operative blood loss has been demonstrated.[1,2] In major vascular surgery, we observe three components of TGA in preoperative blood samples, and their correlation to total intraoperative blood loss. We report the maximum concentration of thrombin generated, or peak thrombin; the area under the curve of thrombin generated, or endogenous thrombin potential (ETP); and the time to initiation of thrombin generation, or lag time. In TGA, a reduced lag time and higher peak thrombin and ETP represent greater coagulation capacity.[3]

Aim

Does an association exist between preoperative capacity to generate thrombin and subsequent operative blood loss in open aortic surgery?

Methods

These observations are part of a prespecified secondary analysis of a randomised controlled trial comparing fibrinogen concentrate to fresh frozen plasma (FFP) for management for coagulopathy during

extent IV thoraco-abdominal aortic aneurysm (TAAA) surgery.[4] Twenty patients had blood samples in the anaesthetic room, before induction of anaesthesia. Thrombin generation was measured in citrated platelet poor plasma samples and triggered with 5pM tissue factor. Data was analysed using R version 4.2.2.

Results

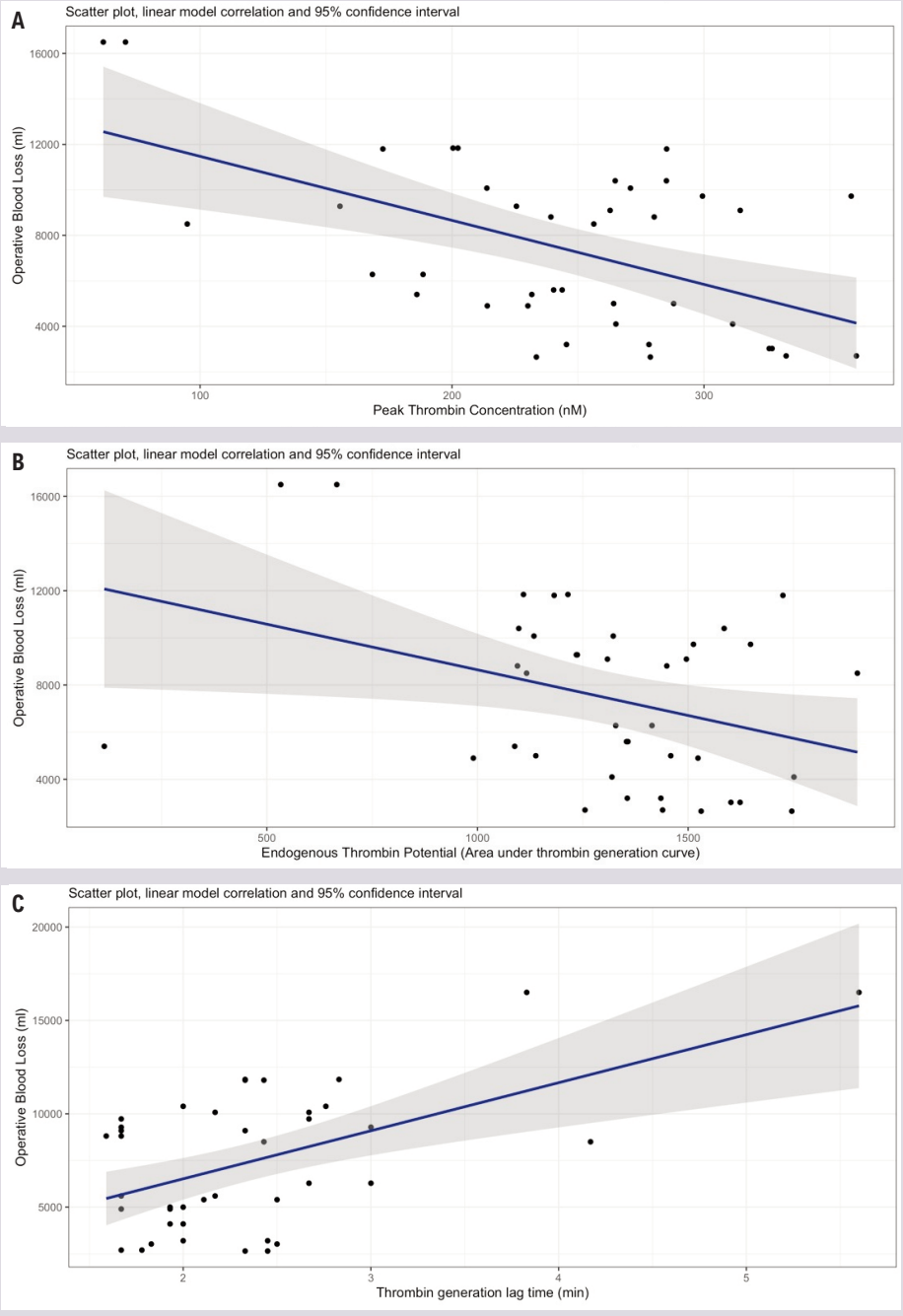
We observe statistically significant correlations between preoperative TGA and intraoperative blood loss (figure 1). Peak thrombin (Pearson Correlation -0.53; 95% CI: -0.26 to -0.72. R2 0.28. $p < 0.001$), ETP (Pearson Correlation -0.35; 95% CI: -0.04 to -0.60. R2 0.12. $p < 0.05$), and Thrombin lag time (Pearson Correlation 0.53; 95% CI: 0.27 to 0.73. R2 0.30. $p < 0.001$). Total intraoperative blood loss ranged from 2650ml to 16500ml. Greater preoperative coagulation capacity was correlated with lower intraoperative blood loss.

Conclusion

Coagulopathy in TAAA surgery is ubiquitous, reflecting the combined effects of blood loss, visceral ischaemia and reperfusion, hypothermia, and the administration of heparin. This observed correlation is hypothesis generating. High intraoperative blood loss, and associated blood product transfusion, is resource intensive and associated with its own morbidity. A preoperative blood test that could better predict intraoperative blood loss would be beneficial for service preparation and planning.

The original RCT on which this secondary analysis is based is registered at clinicaltrials.gov (NCT00994045). CSL Behring part funded this RCT.

Figure 1 Correlation between: **A**. Preoperative thrombin and operative blood loss in Extent IV Open TAAA; **B**. Preoperative ETP and operative blood loss in Extent IV Open TAAA; **C**. Preoperative thrombin lag time and operative blood loss in Extent IV Open TAAA



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ROULEAUX CLUB ANNUAL ESSAY COMPETITION

Rouleaux Club Winning Essays 2023

The Rouleaux Club run an annual essay competition to help promote interest in vascular surgery. Entrants are asked to write 1,500 words on one of three topics selected by the RC Executive. The essays are marked by the committee and the prizes are awarded to the best essay at the annual Vascular Society meeting. There are two prize categories, one for medical students and another for junior doctors. Following the November VS ASM, we are delighted to publish the winning essays.

STUDENT CATEGORY

Is surgical bypass underutilised for patients requiring lower limb revascularisation?

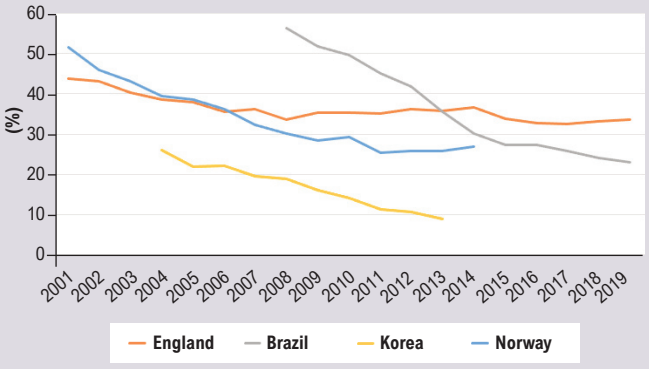
Luke Davies, *University of Bristol*

Introduction

For decades, surgical bypass provided the mainstay of treatment for the most advanced presentation of peripheral arterial disease (PAD), now referred to as chronic limb-threatening ischaemia (CLTI).[1-3] However, the introduction and technical advancements of less-invasive endovascular approaches has led to an undeniable global decline over the past 10-20 years, as demonstrated in Figure 1.[4-7]

Due to a widely acknowledged paucity of high-quality evidence, guidelines remain inconsistent and unclear with their recommendations. Given that CLTI affects 11% of the estimated 230 million living with PAD,[8-10] and the constant strive to minimise procedural and disease-related complications, it is important to question whether the above decline is justified. Following critical evaluation of the evidence and current guidelines, it will be argued that the decline in rates of surgical bypass is justified by the growing body of evidence to suggest endovascular revascularisation as an adequate, less-invasive and lower-cost alternative.

Figure 1 The global decline in proportion of surgical bypass revascularisation procedures. Depicted is a graphical representation of the decline in the proportion of revascularisation procedures represented by surgical bypass for peripheral arterial disease in four different countries using data from four large-scale epidemiological studies.[4-7]



Reviewing the evidence

Only three large-scale randomised-control trials (RCTs) comparing patient outcomes following endovascular and surgical revascularisation for CLTI have been published, and provide a seemingly conflicting range of results. It is important that results are not taken solely at face-value, and are instead interpreted in context through critical appraisal.

The demand for an RCT comparing the two techniques was first met by the BASIL-1 trial in 2005.[11] 452 patients with severe limb ischaemia (synonymous with CLTI) due to infra-inguinal disease were randomised to receive a surgery-first or angioplasty-first approach. At 2 years, there was no significant difference in amputation-free survival (the primary outcome). However, it is important to question the relevance of these results to modern clinical practice, given that endovascular techniques have advanced rapidly since the completion of this trial. There is growing evidence to support a plethora of novel techniques, including stenting, drug-eluting technology and atherectomy.[12,13] The endovascular-first strategy was limited mostly to angioplasty alone, with stent-usage largely excluded. Thus, it no longer represents the ideal endovascular strategy for patients with CLTI. Given the rapid technical advancements of endovascular procedures, it is not unsurprising that technical failure rates have substantially decreased since this trial.[14-16] Furthermore, the trial was not specific regarding anatomical complexity, making it difficult to apply the results to a clinical environment in which decisions are frequently made with this in mind. Finally, in the surgical group, both autologous and prosthetic grafts were employed, with the latter now considered inferior.[17] Therefore, an ideal surgical strategy is also not represented.

Table 1 Summary of the three RCTs comparing surgical and endovascular revascularisation for CLTI or its equivalents.

Trial	Year	Randomised	Main findings	Limitations
BASIL-1[11]	2005	452	• No significant difference in amputation-free survival between surgical and endovascular groups	• High rate of technical failure in the endovascular group • Outdated endovascular techniques
BEST-CLI[18]	2019	C1 - 1434 C2 - 396	• C1 - For those with an adequate autologous vein, surgical bypass associated with significantly reduced incidence of MALE or death • C2 – For those without an adequate autologous vein, rates of MALE or death were comparable between groups	• High rate of technical failure in the endovascular group relative to contemporary data
BASIL-2[21]	2023	345	• Significantly improved amputation-free survival with endovascular-first strategy compared to bypass-first strategy for those requiring infra-popliteal revascularisation	• Availability of adequate autologous vein not accounted for • Heterogeneity in bypass graft-type

The long-awaited BEST-CLI trial[18] sought to address these limitations by investigating a greater number of patients, with emphasis on availability of autologous vein graft. Two parallel cohorts were investigated. Cohort 1 (n=1,434) included patients with CLTI and an identified adequate great saphenous vein, while cohort 2 (n=396) included those without. Patients in each were randomised to undergo either surgical or endovascular revascularisation. The primary outcome was a composite of major adverse limb events (MALE) or death, which occurred significantly less in the surgical group in cohort 1. In contrast, the incidence of the primary outcome in cohort 2 was comparable between the two groups. While these findings seem to suggest a bypass-first approach be optimal for those with an adequate great-saphenous vein, it has not been without criticism.[19,20] Despite taking place roughly 15 years after the BASIL trial, the technical failure of endovascular therapy in cohort 1 was 15%, a figure similar to that of the BASIL trial, and higher than reported in contemporary data.[15-17] The primary composite outcome was mainly driven by reintervention rates, with no significant difference between the two groups in cohort 1 with regards to death or above-ankle amputation. Given the high percentage of technical failure in the endovascular group, it is unsurprising that 42.5% of first reinterventions in this group occurred within the first 30 days. Furthermore, there was a large degree of heterogeneity in endovascular procedure techniques. It appears the single best surgical-first intervention has not been compared to the single best endovascular-first treatment available at the time; results should be interpreted with this in mind. Furthermore, data regarding the anatomical complexity of disease is yet to be published, again making application to real-world clinical scenarios challenging.

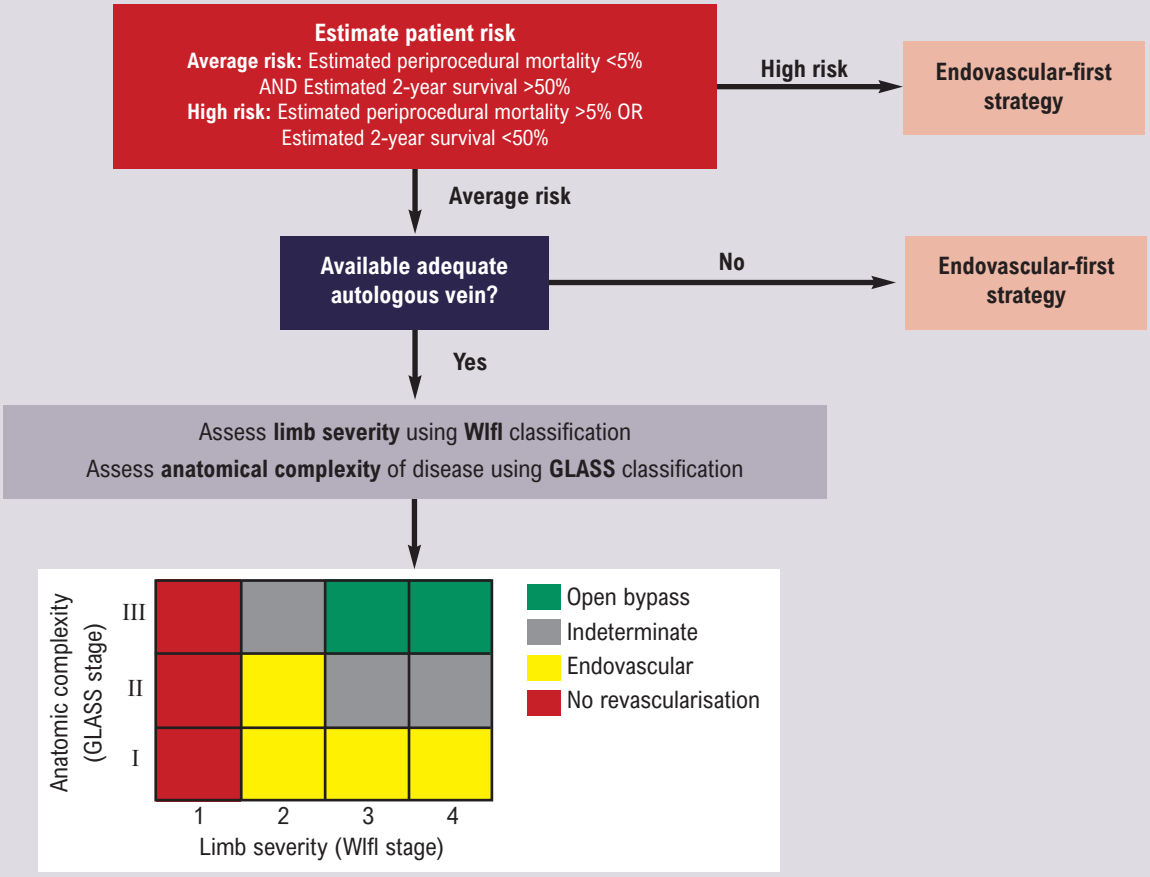
The results of the BEST-CLI trial are seemingly contradicted by the findings of the BASIL-2 trial[21] published in 2023. This was the first to find improved outcomes with endovascular intervention compared to bypass in the context of CLTI. BASIL-2 specifically investigated those requiring infra-popliteal revascularisation, which made up 55% of revascularisation procedures included in the BEST-CLI trial. All 345 patients were randomised to receive either endovascular-first or vein-bypass-first treatment, with the primary outcome (amputation-free survival) significantly higher in the endovascular group. Despite the surgical group being described as "vein-bypass-first", availability of an adequate great saphenous vein was not part of the eligibility criteria. Vein usage was up to the discretion of the surgeon, with the use of prosthetic grafts permitted, a contradiction to the description of the group and the trial name. Nevertheless, the BASIL-2 trial further demonstrates that endovascular revascularisation can be a suitable, less-invasive alternative to surgical bypass.

Table 1 summarises the findings and limitations of the RCTs published comparing endovascular revascularisation and surgical bypass for those with CLTI. These trials appear to seek a black and white answer to a question which deserves a multi-faceted approach. By doing so, there is a constant lack of appreciation for the important details. Anatomical complexity is often disregarded or an afterthought, and there is consistent neglect for either the "ideal" endovascular strategy or "ideal" bypass graft in all trials. This makes application to real-world scenarios challenging. However, when limitations are accounted for there appears to be a case for endovascular revascularisation as an adequate alternative to surgical bypass, particularly with rapidly improving endovascular techniques and falling associated technical failure. Given that endovascular revascularisation can offer comparable outcomes to bypass in patients with a range of disease-complexity, it is important to critically review current guidelines to ascertain whether they provide a robust foundation for clinical decision making. This evaluation will determine whether circumstance-specific decisions represent a justified growing preference for endovascular revascularisation.

What are the current guidelines?

Current guidelines are relatively vague, owing to the established limited body of evidence. The most detailed and circumstance-specific guidelines for CLTI decision-making were created in 2019, known as the Global Vascular Guidelines (GVG).[22] It is firstly recommended that any inflow disease, defined as proximal to the origin of the profunda femoris be treated prior to outflow disease. The guidelines then provide a systematic approach, termed Evidence-Based Revascularisation, to decide between an endovascular-first or bypass-first strategy for remaining patients.

Figure 2 Decision-making tool based on the GVG guidelines[22] for the management of infra-inguinal CLTI.



This is demonstrated by the decision-making tool shown in Figure 2. This approach is more specific than previous guidelines, and results in a vastly smaller proportion of patients deemed as best suited for a bypass-first approach.[23-25]

While these circumstance-specific guidelines are the most current, they were published prior to publication of the BEST-CLI and BASIL-2 trials. They were fuelled by a variety of prospective and retrospective studies, rather than any of the large RCTs, hence the low level of evidence (level C). Furthermore, the paucity of evidence to guide the WIfI and GLASS based recommendations leave the approach somewhat flawed. Firstly, there exists a large indeterminate range in which no optimal revascularisation approach is recommended, as shown in Figure 2. Additionally, the GLASS staging system is new, and various flaws in its usage have been identified. This includes low inter-observer agreement among clinicians, as well as an inability to predict patency rates following endovascular revascularisation in those with lower stages.[26,27] These flaws merit a holistic approach to decision making, considering a range of different factors, rather than relying entirely on guidelines. This includes patient preferences which will tend to favour the less-invasive endovascular option, costs which again tend to favour endovascular therapy (although long-term cost-effectiveness is still unclear), and the clinician's experience.[28-30]

Conclusion – Is the decline justified?

There is a growing high-quality body of evidence to justify endovascular revascularisation as an alternative to bypass in a range of patients with varying disease-patterns and severities of CLTI. The low class of evidence underpinning the current guidelines warrants the adoption of a decision-making approach informed by a range of important different factors, particularly in the indeterminate group. Costs and patient preference will play a large role in these decisions, and both will likely favour endovascular therapy over bypass. Therefore, despite the global decline in use of surgical bypass, it is not yet an under-utilised entity in the management of CLTI.

Nevertheless, surgical bypass will remain a crucial management option, particularly following failed endovascular therapy and in those with well-established anatomically complex disease. Thus, in contrast to current attitudes, surgical bypass and endovascular revascularisation should be viewed as complementary techniques with the combined aim of preserving patient function and quality of life, rather than continue to be pitted

against one another. Such an outlook, paired with an improved regard for disease and procedural specificity in future trials, will ensure neither option goes under-utilised in the future.

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DOCTOR CATEGORY

Discuss the role of Artificial Intelligence (AI) in improving current management of Abdominal Aortic Aneurysms (AAA)

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Introduction

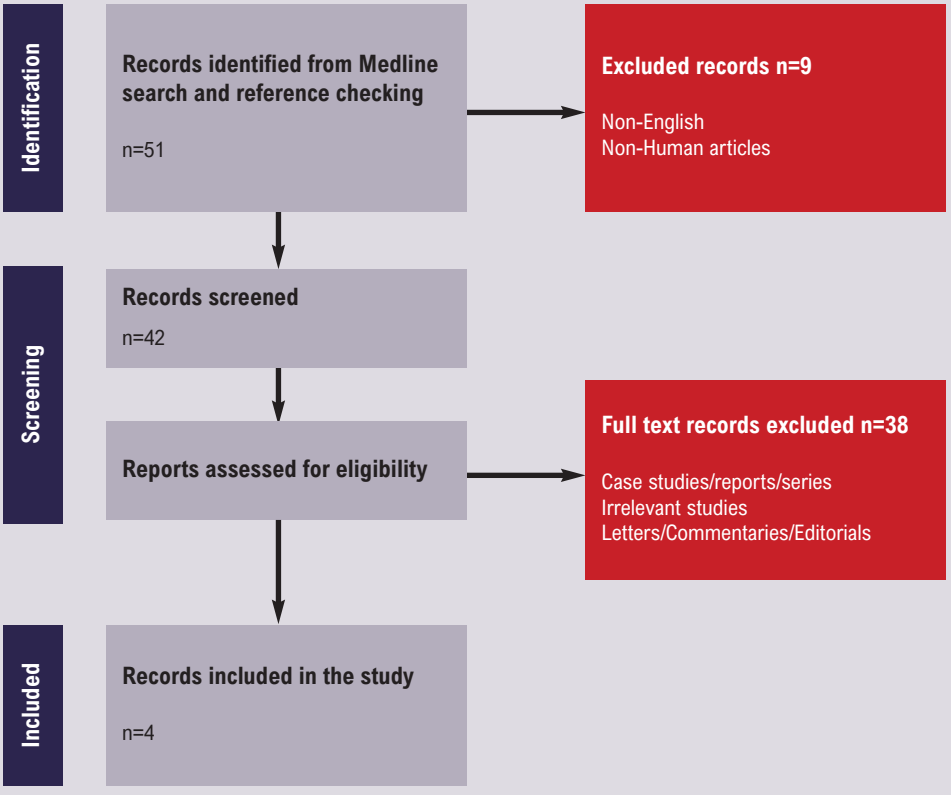
Abdominal aortic aneurysmal disease encompasses a diverse spectrum of pathologies and clinical presentations ranging from incidental findings on imaging to a patient presenting in extremis following rupture. The management of this diverse patient cohort depends largely on clinical presentation and patient characteristics. Artificial intelligence (AI) has permeated modern medicine at an unprecedented rate. In the healthcare landscape, the primary utility of AI lies in clinically tailored neural networks and machine learning. In the field of Vascular Surgery, several AI technologies have been, or are currently being developed in relation to pre-operative planning, improving intra-operative efficiency and assessing post-operative outcomes for patients with abdominal aortic aneurysms (AAA). Despite the exponential development of these technologies, they are not without their limitations, and the current National Health Service is far from implementing them into routine clinical practice.

Literature review

Electronic searches were performed on both Medline (1946 to August 2023) and Embase (1974 to August 2023) using the OVID interface as well as Medline using the PubMed interface. The search terms were as follows: (artificial intelligence OR AI OR machine learning OR neural network*) AND (abdominal aortic aneurysm* OR AAA) AND (management OR treatment). These keywords were searched in the subject headings, in title and in abstract. All reference lists of the included papers were also screened to identify any pertinent studies. The results were current as of August 2023.

732 papers were found using the reported search on Embase (61) and Medline (51) using the Ovid interface whilst 620 were found on Medline using the PubMed interface. Case reports, case studies, editorials, duplicates, and literature reviews were excluded. An example of the screening and eligibility assessment process for the search results obtained from the Medline (Ovid) interface is outlined in the PRISMA diagram below (Figure 1).

Figure 1 PRISMA flow chart for Medline (OVID) search



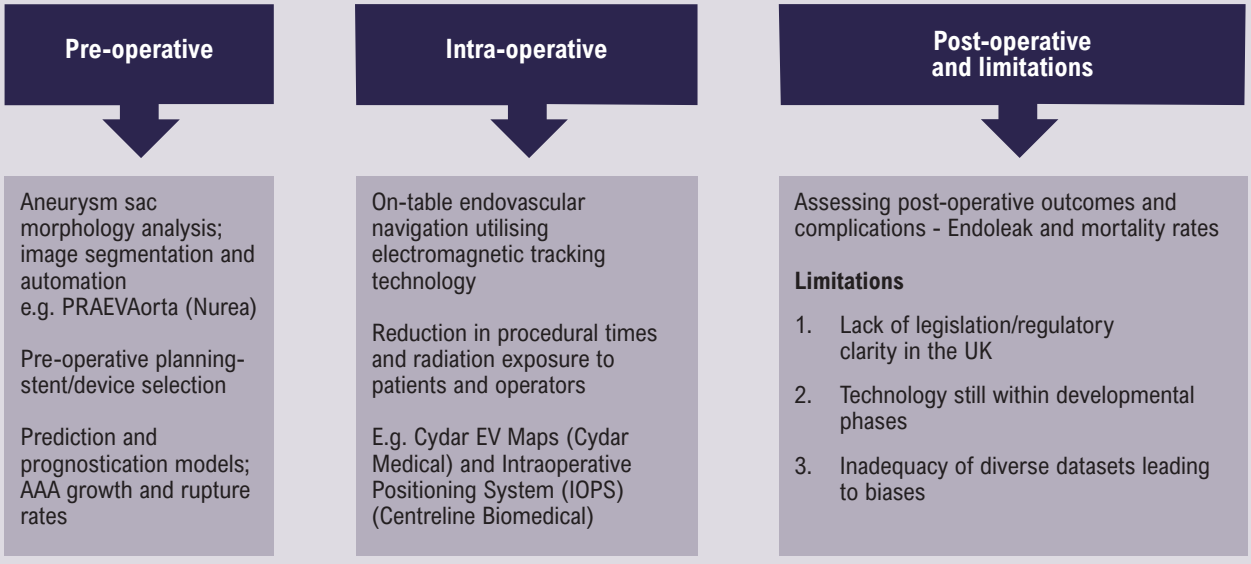
Prediction models, image segmentation and automation

In the United Kingdom, guidelines from the Society for Vascular Surgery and the European Society for Vascular Surgery[1,2] have clear recommendations for the diagnosis and management of patients with AAA. Decisions regarding treatment rely on careful evaluation of the risks associated with operative intervention compared to the risk of aneurysmal growth and rupture. Although initial aneurysmal diameter is a well-established, independent risk factor for rupture, other patient and aneurysm specific factors have been implicated.[3] In practice, estimating sac progression and predicting the risk of rupture can be difficult for clinicians, consequently, AI prediction and prognostication models have been developed to assist vascular surgeons with this undertaking. The maximal aortic diameter is often used in this decision-making process, however, a major downfall of utilising this single measurement, lies in its inability to provide details of the three dimensional (3D) volumetric evaluation of the aneurysm sac. To acquire such characteristics, manual image analysis would need to be undertaken, a laborious and specialist endeavour. Furthermore, in even the most experienced hands, significant discrepancies have been identified, with one study reporting up to 87% of diameter measurements falling outside of the clinically acceptable error range (± 5 mm) in abdominal aortic aneurysms (AAAs).[4] Specific deep learning workstations have been designed to perform analysis of images generated from CT-Aortograms, allowing for more accurate three-dimensional (3D) evaluation of the complete aortic anatomy. The advantages of acquiring volumetric data for these aneurysms cannot be understated and one can appreciate how this type of analysis can improve the sensitivity of estimating disease progression compared to maximum diameter measurements taken in isolation. AI programs have been designed to perform large scale quantitative analysis of AAAs with improved image segmentation by characterising aneurysmal morphology, geometry, and fluid dynamics.[5] This data is then fed into computational AI models with predictive and prognostic capabilities, allowing for recognition of patterns which in turn, can be used to estimate the rates of AAA growth and risk of rupture. PRAEVAorta (Nurea) is a 'decision support AI software' designed by a French company with prediction abilities to describe the evolution of AAA based on geometric and flow characteristics.[6] The same company is currently in the research phase of developing technology which allows for automated analysis of AAA sac measurements pre and post-EVAR.

Pre-operative planning and intra-operative uses

Move over SHO, AI is scrubbing in. Artificial intelligence has found its way into the operating theatre with complex machine learning models assisting with preoperative surgical and endovascular planning as well as on-table image guidance.[7] These algorithms have been developed to optimise stent or device selection, endovascular navigation, and stent placement. Cydar Medical, in conjunction with researchers at Kings College London, are utilising a similar type of vascular navigation technology (Cydar EV Maps) in the ARIA trial - ARtificially Intelligent image fusion system in comparison to standard treatment to guide endovascular Aortic aneurysm repair.[8,9] The trial is currently in the recruitment phase. In a similar vein, AI protocols utilising electromagnetic tracking technology have been developed with the aim of improving surgical efficiency by reducing procedural time and decreasing patient and

Figure 2 Overview of some of the applications of artificial intelligence within the management of AAA and the limitations of these technologies



operator radiation exposure. The Intraoperative Positioning System (IOPS) (Centerline Biomedical) is a 3D image guidance system which employs structural mapping and electromagnetic tracking technology embedded into operating kit (catheters, guidewires) to reduce on-table radiation exposure.[7] Risk assessment and prognostication programs, like those detailed for image segmentation above, were also developed to assess postoperative outcomes, including mortality and potential complications after endovascular repair.[10,11]

Challenges, limitations, and bias

Most artificial intelligence algorithms require high-quality and diverse databases to ensure accuracy and robustness when translated to real-life settings.[12] One major issue ubiquitous within the fields of AI and machine learning, is the acquisition of such high-quality datasets allowing for training and evaluating ML algorithms. Furthermore, there is often a lack of standardisation when curating the imaging databases used in AI associated vascular surgery algorithms, making it difficult to compare and interpret results across different studies.[13] Another major barrier impeding the uptake of AI in healthcare is the lack of clarity regarding legislation, data security and regulation. In the United States for instance, the Food and Drug Administration (FDA) is responsible for approving and regulating AI and ML tools, however in the UK, explicit regulatory frameworks and legislation do not yet exist. Instead, AI's use within healthcare is currently regulated under fragments of pre-existing general legislation, such as the UK Medical Device Regulations 2002 or the Data Protection Act 2018.[14] This ambiguity can complicate and impede the scientific process and may even lead to frivolous litigation, for example, the class-action lawsuit levied at Google's DeepMind AI, following the patient data scandal at the Royal Free in 2016.[15]

Interestingly, the concept of bias within AI and ML algorithms has become somewhat of an area of controversy. The potential sources for these biases include inherently biased software or program designs and incorrect or unbalanced training data being fed into the algorithms.[16] This is especially important when applying algorithms within vascular surgery, where the patient cohort is increasingly diverse and management and post-operative outcomes are dependent on patient variables such as sex and race.[17] One potential means of mitigating these biases would be the inclusion of large, diverse datasets and proactive algorithmic testing for biases within experimental stages of technological development.

Conclusions

Artificial intelligence has made substantial advancements in the field of vascular surgery and has the potential to revolutionise the management of patients with abdominal aortic aneurysms by facilitating earlier detection, improving the accuracy of measurements, personalising treatment plans and optimising operative proceedings. The applications of AI detailed within this piece are by no means exhaustive, and progress within this area is occurring at an unprecedented rate. Despite this, there are many challenges and limitations to the development, commercialisation, and uptake of AI within everyday clinical practice.

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NEWS

Updates from the Vascular Societies

JVSGBI is owned by the Vascular Society for Great Britain and Ireland (VSGBI), for all affiliated societies and the wider vascular community. Here's the latest society news.

British Association of Chartered Physiotherapists in limb Absence Rehabilitation (BACPAR)

www.bacpar.org
@BACPAR_official

The BACPAR Executive committee met as planned in March 2024. The network's objectives for the coming year have been agreed and shared with the membership.

The progress against the same will be reviewed at the next Committee meeting in September.

BACPAR has begun its preparations for the 2024 ASM in Brighton - we welcome abstracts regard all relevant areas of pre and post-operative amputation rehabilitation.

Our ASM committee represents in and outpatient rehabilitation services and the aim is to bring a program together that has items of interest for all the membership.

Dr Miranda Asher will continue to represent BACPAR on *The Journal of the Vascular Societies Great Britain and Ireland* editorial board as part of her role as one of BACPAR's research officers.

The BACPAR 2024 Spring Journal has been published and disseminated per members' choice (paper or digital), it includes feedback from member experiences of Dublin 2023 and highlights of knowledge gained from the same.

BACPAR looks forward to continued collaboration with the Vascular Societies in research, education, service development and patient information.

Louise Tisdale
BACPAR Chair

Rouleaux Club

www.Rouleauxclub.com
@RouleauxClub

The last few months have been a busy time for the Rouleaux Club, helping to deliver numerous educational events and represent the views of vascular trainees on national discussions, particularly surrounding the role of the extended surgical team and medical associate professions roles.

From an educational perspective the association has run several successful 'hands-on' practical skills courses for medical students and junior doctors at both the Association of Surgeons in Training (ASiT) and Charing Cross conferences. The association was also delighted to once again work with the RCSEd to deliver the 'So you want to be a vascular surgeon?' course in April. These courses continue to be well subscribed and are a brilliant way of inspiring the next generation of vascular surgeons. Thanks goes to all those who have volunteered as faculty and to numerous industry partners who are essential to the running of these courses.

Moving forward the Rouleaux Club is working in conjunction with the Vascular Society to recognise excellence in training, something which has historically not been sufficiently championed. To this end, a trainer of the year award has been created to recognise and champion the individual who goes above and beyond to promote the teaching and training of vascular surgeons. Named in honour of Dame Averil Mansfield, nominations for the award will be opening shortly, with the Rouleaux Club undertaking a rigorous shortlisting and interview process to identify a winner. It is planned that the inaugural winner will be announced at the forthcoming VS ASM.

The Rouleaux Club has also been active in representing the views of trainees in the debate about the function and role of the 'extended surgical team' and 'medical associate professions'. This is a sensitive topic but is a cause for concern for many trainees across all surgical specialities. The associated has represented the views of trainees directly to the Vascular Society, as well as the 'Federation of Surgical Specialty Associations' and the Royal Colleges, alongside ASiT, and continues with work to make sure training is maintained, whilst acknowledging the important role of the extended surgical team in modern vascular surgical practice.

Andrew Nickinson
Rouleaux Club President

Society of Vascular Nurses (SVN)

www.svn.org.uk
@vascularnurses

The committee continues to work hard behind the scenes and February was the first of the joint open council meetings with the Vascular Society, BACPAR and SVT. This meeting kick started the joint societies conference planning and at the end of February in our own committee meeting, the SVN began to detail symposia for our part of the conference.

Recently we met with the Aortic Dissection Charitable Trust. They have offered our members places at an educational event hosted by the charity on June 7th 2024 in London. It looks to be a fabulous programme with experts in the field from

across the world sharing their wealth of knowledge. There is no cost to attend and there are travel bursaries available. We hope to strengthen links with the charitable trust moving forward.

In March, Siobhan and I headed to London to represent the SVN in Parliament at the Venous and Vascular APPG. A great opportunity to raise awareness of the devastating effects of vascular disease among those who have influence and network with colleagues.

Vascular Matters, 2nd edition of the year is going out to members in May, we use this forum to advertise up and coming events, highlight clinical trials and share good practice.

Looking ahead, June is a busy month. We are currently putting together a symposium for the Venous Forum. Webinars in June include those for legs matter awareness week and we have an evening event planned for 17th June, dispelling the myths around venous disease.

In July, there is of course the joint VS and SVN summer symposium. It is a free online event. We would ask that you point your vascular ward colleagues towards this event.

Jane Todhunter
SVN President

The Vascular Society for Great Britain and Ireland

www.vascularsociety.org.uk
@VSGBI

The joint themes for the 2024 Society's ASM are '*Complex teams*' and '*Sustainability*'. The ASM in Brighton will formally open with a joint Allied Vascular Society's session on the management of the diabetic foot. '*Doing more with less*' might be a more immediate theme cutting across all surgical specialities. NHS resources are increasingly stretched; NHS staff are reporting high levels of burnout; and some are seeking careers outside the NHS. These pressures are reflected in delays to treatment and the inevitable impact of this on disease severity and treatment complexity. So why focus on complex teams and sustainability?

The needs of people with vascular disease are too complex for care delivery by a single healthcare professional. Multidisciplinary teams (MDTs) are key to delivering safe and effective patient care. RCS England and Health Education England (HEE) describe the Extended Surgical Team that comprises consultants, trainees, nurses, allied healthcare professionals (AHPs) and medical associate professionals (MAPs).

The Vascular Society is working with the Surgical Royal Colleges and Federation of Surgical Specialists (FSSA) to develop curricula and scope of practice for Physician Associates (PAs). This work is urgent as the NHS Long Term Plan includes a significant expansion in PA numbers. We currently have a small number of PAs working in vascular surgery and interventional radiology. They are valued members of their local teams.

As a speciality, we have an opportunity to define the scope of PA roles within our services. This is initially likely to be ward and outpatient based, taking on roles traditionally done by doctors in training but which can be safely delegated – preparing for ward rounds, ward-based investigations (ie, cardiovascular risk factor assessment, taking blood, measuring ABPIs), organising preoperative workup (ie, booking appointments, completing waiting list bookings), booking follow-up and clinical governance activity (ie, preparing cases for presentation at M&M meetings). If planned well, freeing medical colleagues for training opportunities. Tasks that currently cannot be delegated to PAs are prescribing, requesting of ionising radiation and writing discharge summaries. This may change once PAs come into regulation by the General Medical Council (GMC) at the end of 2024. To help inform the Society's position, a questionnaire on the scope of PA practice will go out soon to members.

The culture within a team is as important as its members. It was shocking to read examples of harassment and bullying within surgery, most distressingly the Survey of sexual harassment published in the *British Journal of Surgery* in 2023. PAs have been threatened by the response from doctors to government plans to expand their numbers. Some social media content has been inappropriate and offensive posts have been directed at individual PAs.

Only with adequately staffed and well organised multi-professional teams, with shared aims, and in which people feel comfortable and energised to work, will services deliver high quality patient care. Proper resource planning, recruitment and retention, positive team and organisational cultures and respect for each other's roles are key to achieving these aims.

The most sustainable way to deliver healthcare is through self-care and prevention. These initiatives can also deliver greatest patient benefit. We know from the delivery of supervised exercise programmes (SEPs) how difficult this can be within current NHS models of funding. It is too early to say how devolving budgets to Integrated Care Systems (ICSs) will be a positive change, but hopefully Manchester provides an exemplar model for amputation prevention which others can follow (MARS Project).

Vascular and endovascular surgery are both heavily dependent on medical devices. These devices are often single use. Medical devices have a large carbon footprint from manufacture and transport costs. Few components are recycled. Patients need long-term surveillance and a high proportion have reinterventions. Both have an environmental impact, with the impact of travel made greater by networked models of care.

The challenge is how does vascular surgery, as a small surgical speciality, exert influence in this area? For any impact in this area, we will need to work with our partners including patients, patient groups, charities, provide organisations, commissioners and industry.

Surgery will never be carbon neutral but, with better prevention, pathway redesign, a focus on eliminating waste, evidence-based treatment and reducing unwarranted variation, we can reduce current resource usage. By doing this we protect both our services and our patients.

Other updates

Superficial venous interventions: The ideal team to perform endovenous procedures will be a focus of debate at the Venous Forum meeting in June 'Developing a Venous Service for the Future'. The Vascular Society has convened a working group, chaired by Paddy Coughlin, with multi-professional involvement, to build a consensus on venous interventions.

Aortic dissection: The implementation of standard operating procedures (SOPs) for acute aortic dissection is on target in England. Regions will have an SOP with a single point of contact to ensure that people diagnosed with an acute aortic syndrome receive timely specialist management, including adult critical care transfer to a specialist aortic centre.

NHS England (NHSE) have recently confirmed funding for the NIHR EARNEST trial (Colin Bicknell, Imperial College, London) of early stenting to prevent later aneurysmal dilatation. The National Vascular Registry (NVR) has been approached to partner in the trial.

Data on aortic dissections in England from 2017 to 2023 are being made available on a National Consultant Information programme (NCIP) dashboard (see below to register).

MHRA revise advice on use of paclitaxel DCB/DES: In 2018, a mortality signal was reported by a systematic review and meta-analysis of patients treated using paclitaxel for intermittent claudication and chronic limb-threatening ischaemia (Katsanos *et al,* 2018). In 2022, the MHRA issued advice restricting the use of these devices and advising patients be contacted to inform them of this risk.

Based on a review of new evidence in 2023 and following the FDA's removal of restrictions to use, the MHRA has also removed all restrictions on the use of these devices (DSI/2024/001). Vascular services should now inform patients that the concerns have been dismissed and that paclitaxel devices have returned to routine use.

Outcomes and Registries Platform (ORP): This is the NHSE platform for recording of all NHS medical device implants introduced in response to the Cumberlege report. Since January 2023, NHSE – not the Health Quality Improvement Partnership (HQIP) – is the data controller for all NHS medical device data. The NVR held a separate contract with NHSE to continue aortic device capture in 2023. This contract has not been extended. Contract negotiations are ongoing and promising but, to date, whilst data collection continues through the NVR platform, this data is held by the ORP and is not available for processing by the NVR team. The Vascular Society, NVR Board and the ORP Steering Board, led by Jon Boyle, are keen to resolve this issue soon as processing this data is important to protect patient safety.

National Consultant Information Portal (NCIP): NCIP provides consultants and providers in England with 23 dashboards of vascular activity using HES data on the Model Health System. This data is extremely helpful for appraisal and revalidation. If you work in England and have not registered for an NCIP account, then you are encouraged to do so now (email your request to england.ncip@nhs.net).

Provision of Vascular Services (POVS) 2024: The Vascular Society recommendations from 2021 for the safe and effective provision of vascular care have not changed. However, not all the POVS 2021 recommendations have been implemented into UK clinical practice. POVS 2024 will therefore take a different approach, reinforcing the POVS 2021 recommendations and focusing on seven key areas which influence patient care: (1) people, teams and culture; (2) demand and capacity; (3) variation; (4) sustainability; (5) person-centered care; (6) outcome reporting; and (7) research and innovation. Our aim is that this approach will lead to transformational change, the adoption of best practice and new ways of working.

Charing Cross Vascular Symposium 2024: This was the first Charing Cross International Vascular Symposium without Professor Roger Greenhalgh. Andrew Garnham, Rachel Bell and I represented the Society at a memorial service for Professor Greenhalgh in Westminster Abbey on Monday 22 April.

Marcus Brooks
Honorary Secretary, Vascular Society
secretary@vascularsociety.org.uk

The Vascular Societies' Annual Scientific Meeting 2024

In conjunction with the Vascular Society of Great Britain and Ireland, the British Association of Chartered Physiotherapists in limb Absence Rehabilitation, the Society of Vascular Nurses and The College and Society for Clinical Vascular Science Great Britain and Ireland

27th-29th November 2024

DoubleTree by Hilton Brighton Metropole

REGISTRATION OPENS EARLY JULY

The conference is a three day programme which showcases a wealth of topics for everyone across the spectrum of the vascular field and is a great opportunity to meet and network with the vascular community who share their enthusiasm for best practice and care of patients including consultants, vascular scientist, nurses and physiotherapists

www.vascularsociety.org.uk

The UK event for the whole vascular care team in 2024

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
- Management of the left subclavian artery in complex aortic interventions
- The foot in diabetic foot disease - biomechanics and operative approaches to manage clinical problems
- New Developments in Vascular Access
- Thoracic Aortic Disease
- Through Knee Amputation

ALL YOU NEED TO KNOW

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