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The Vascular Society for Great Britain and Ireland

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

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

The Society focuses on non-cardiac vascular disease, including diseases of the aorta, peripheral arteries, veins and lymphatics. 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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- The VSGBI **publishes virtual educational resources** which are available to members.
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Editor's foreword

Welcome to the May 2026 edition of the *JVSGBI*.

This edition contains two editorials. The first By Nandhra and colleagues succinctly highlights the uncomfortable findings of the recent NCEPOD report on acute limb ischaemia and clearly identifies five priorities to rapidly transform the care of these hugely vulnerable patients. Urgent action is clearly required. The second editorial by Long and colleagues is the latest in a series of editorials dissecting mentorship. This editorial focuses on the responsibilities, roles and benefits of being a mentor.

We also present three original articles, a protocol and a case report. The first original article from Sharma and colleagues is a single centre prospective observational study assessing the environmental impact of four commonly undertaken arterial vascular procedures and potential solutions to reduce their carbon footprint. The second original article from Bitterlin and colleagues presents qualitative research assessing the barriers to health care access experienced by patients with chronic venous disease secondary to intravenous drug abuse. The final original article from Duff and colleagues is a report detailing the serial involvement of patients and carers throughout the development of a research programme to investigate the value of rehabilitation following revascularisation for chronic limb threatening ischaemia. The protocol from Stanley and colleagues outlines the plans for a scoping review to assess decisional regret in patients following vascular surgery. Finally the case report from Gunawardena, a consultant vascular and transplant surgeon in Sri Lanka, describes the presentation and management of a giant true aneurysm of the dorsalis pedis artery.

The wide variety of topics, different research methods and widespread origins of authors speaks volumes of the reach of the *JVSGBI* in a relatively short period of time.

I wish to express my thanks to authors for choosing to publish with the *JVSGBI*, the reviewers for their continued support and enthusiasm, and the editorial staff for their commitment.

I hope readers find the articles of interest.

Ian Chetter
Editor in Chief JVSGBI
Vascular Society GBI President

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EDITORIAL

Risking life and limb: no hiding from failure

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Introduction

Acute limb ischaemia (ALI) is one of the few vascular emergencies where time is quite literally tissue. Delays to treatment risk permanent limb impairment or amputation and death. With that in mind, the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report *Risking Life and Limb* (2025)[1] makes uncomfortable reading. Despite firm principles of care, avoidable delays and missed opportunities have been exposed throughout the patient pathway. Dissecting the report reveals the need for an urgent care pathway revolution.

How common is common?

One of the most striking findings is that ALI is both common and poorly characterised. There is no specific ICD-10 code[2] or national registry dataset, and thus no consistent national data collection. As a result, the true incidence of ALI is unknown. This is extraordinary for a condition associated with such high morbidity and mortality. The NCEPOD study cohort included 330 adults admitted to vascular hubs as emergencies in early 2024 and demonstrates that ALI is not confined to the very elderly. The mean age was 71 years, but nearly one quarter of patients were aged 60 or younger and females accounted for over a third of cases. Nearly half were managing well without frailty. Almost 80% were current or former smokers, over 70% had multiple comorbidities, and 40% of patients with atrial fibrillation were not anticoagulated. These findings are concerning and perhaps signal that some ALI episodes are not random events. In some instances they are predictable and possibly preventable vascular events occurring in high-risk populations. In many cases ALI is the culmination of undertreated cardiovascular disease, with poor compliance with best medical therapy recommendations.

Inadequate recognition

A sobering statistic is that only 23% of patients presented within six hours of symptom onset, while over half presented more than 24 hours later. For Rutherford IIb limbs, where revascularisation within six hours is considered essential for optimal salvage, only one-third presented within that window. The report identifies that the most frequent contributor to delayed presentation is lack of patient awareness. This is not surprising. Unlike stroke ('FAST')[3] or myocardial infarction (heart attack), ALI has no national awareness campaign, no simple public messaging and no widely recognised trigger for urgent action.

The '6Ps' are taught to medical students; however, across the modes of presentation documentation was inconsistent, perhaps the devil in the detail being that not all the 6Ps must be present to trigger the suspicion of ALI and consequently some cases were missed. Peripheral pulses were recorded in only a third of primary care assessments, and a Rutherford category was never or rarely recorded across all points of patient presentation (4% of cases in 'spoke' hospitals). ALI was often misdiagnosed as deep vein thrombosis, cellulitis, stroke or vasculitis at first healthcare contact.

It is important to recognise that communication barriers (language, hearing, learning disability and post-stroke impairments), reported in one in 10 cases, may contribute to delays in recognition. Additional attention is warranted when considering the diversity of the cohort studied; 97% were of a white British

Key words: Acute Limb Ischaemia, pathways, NCEPOD

ethnicity, 15% higher than the national census data.[4] Does ALI discriminate or are there endemic barriers to accessing care from within ethnic minority groups? Educational and public awareness initiatives must therefore be appropriately targeted and accessible to all.

The report makes a clear recommendation that awareness must go beyond vascular specialists. Emergency clinicians, general practitioners, community teams, ambulance services, NHS 111 call handlers and patients themselves must recognise ALI as an emergency equivalent to stroke or myocardial infarction.

Lack of a connected network

The UK vascular hub-and-spoke model has improved outcomes for many complex procedures.[5] However, for ALI it has exposed a vulnerability, with 42% of patients first attending a spoke hospital before transfer to a vascular hub. The median time from arrival at a spoke hospital to arrival at a hub was >8 hours, which exceeds the recommended treatment window for immediately threatened limbs. Worryingly, more than one quarter of patients were admitted to a ward before transfer, including patients with threatened limbs. Another barrier preventing smooth flow of information was the inconsistent electronic patient record and imaging sharing between spoke and hub. These findings reveal a fundamental concern that we have centralised the expertise but not optimised the pathway to share access or information.

Ambulance bypass protocols for ALI were inconsistent, which represents a straightforward opportunity for improvement. If a patient with chest pain and ST-elevation can be triaged directly to a cardiac catheter laboratory for intervention or patients with a suspected ruptured abdominal aortic aneurysm bypass spoke hospitals, why is a patient with motor and sensory loss in a limb not sent directly to a vascular hub?

What missing guideline?

Unlike stroke or myocardial infarction, there is no comprehensive national guideline covering the entire ALI pathway from community recognition to definitive treatment and aftercare. While the European Society of Vascular Surgery guidelines provide recommendations and an evidence base for specialist clinical practice,[6] comprehensive written guidance was absent in many hospitals and primary care settings. The NCEPOD recommendation for a complete national guideline should be considered an essential urgent priority as, without standardised recommendations, variation ensues and, critically, in the case of ALI this is not without consequence. In the NCEPOD report the 30-day mortality was 12.7% and the major amputation rate was 18.5% in patients undergoing an operative intervention.

Any guidance should include:

- Clear triage criteria based on the Rutherford score (sensory and motor impairment)
- Defined ambulance bypass criteria
- Imaging and data sharing standards between hub and spokes
- Explicit targets for Rutherford IIb limbs

This is about creating a time-critical pathway and providing education across the breadth of the healthcare system.

How can we know what is happening?

The powerful recommendation to capture focused ALI data within the National Vascular Registry (NVR) is noteworthy. Both the NCEPOD programme and the NVR are commissioned by the Healthcare Quality Improvement Partnership (HQIP) as part of the national programme of audits (NCAPOP), and we can only urge our commissioning colleagues to take heed of these recommendations. Without this data improvement is anecdotal but, with data, it becomes specific and measurable. ICD-11 includes specific codes for acute arterial occlusion (BD30) subdivided into upper and lower limb and presents a future opportunity.[7] However, as yet there is no time scale for its adoption in the NHS. We must ensure ALI is not captured under the same umbrella as chronic limb-threatening ischaemia or lost within procedure coding. If we cannot measure the mode of presentation, time to presentation, time to revascularisation, fasciotomy rates, amputation rates, mortality and functional outcomes nationally, we cannot benchmark or improve outcomes for ALI patients equitably.

From report to revolution

The NCEPOD findings are not unique to ALI. They mirror past lessons from stroke and myocardial infarction: late recognition, disjointed pathways, regional variation, that all lead to delays which worsen the ALI injury. Stroke and myocardial infarction underwent transformation through a national strategy, public campaigns, data sharing and pathway redesign.[8] ALI requires the same level of ambition.

The report outlines five clear achievable priorities:

1. Raise public and professional awareness.
2. Risk-stratify (by Rutherford) and transfer high-risk patients directly to vascular hubs.
3. Organise networks for timely specialist access.
4. Develop a national guideline (beyond simply the interventions).
5. Capture registry data to push quality improvement.

Do or do not. There is no try . . .

ALI is an unforgiving emergency with catastrophic consequences. The NCEPOD report demonstrates that outcomes could be enhanced not just by improvements in technical skill but by reducing lost time and variation. The vascular community, commissioners, emergency services and public health bodies must now respond with the urgency that the condition deserves. We have centralised services. We have advanced endovascular and surgical techniques. There is growing clinical evidence, including an imminent national randomised controlled trial.[9] What is required now is an ALI pathway that moves at the pace of ischaemia. The clock is already ticking.

Conflict of Interest: SN has received NIHR funding for ALI RCT.
No others to declare.

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EDITORIAL

Mentorship in practice: what being a mentor really involves

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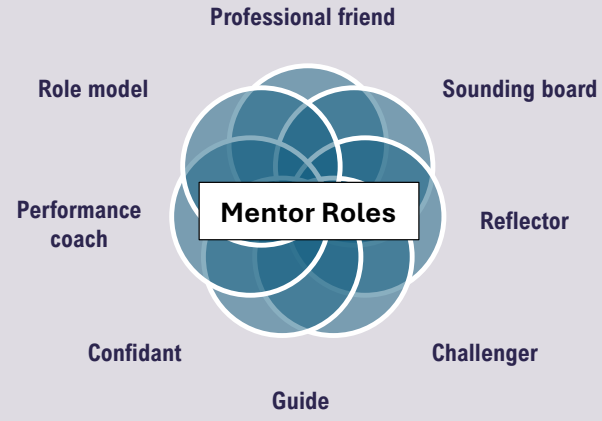
Introduction

Across previous editorials, we have explored mentorship from several perspectives. We outlined the rationale for mentorship within UK vascular surgery,[1] discussed how to build effective relationships,[2] and highlighted the core principles that underpin a meaningful mentoring journey.[3]

What we have not yet examined in detail is one key practical question: what does a mentor actually do? In practice, mentorship is not defined by a single function but by a range of roles that are adopted in response to the evolving needs of the mentee (Figure 1). This editorial therefore focuses on these roles, exploring how mentors operate in practice, how they adapt across different contexts and how this flexibility underpins effective and impactful mentorship.

Figure 1 Summary roles of the mentor.



The core responsibilities of a mentor

Mentorship in vascular surgery extends beyond technical teaching alone. Effective mentorship should support the development of professional identity, clinical judgement, confidence and resilience alongside clinical expertise. Table 1 outlines key domains of support in which mentorship can contribute meaningfully to the development of individuals within the vascular specialty. These domains are rarely addressed in isolation. Instead, mentorship functions as an ongoing developmental relationship that evolves alongside the mentee's experience, confidence and stage of training.

Within vascular surgery, mentoring relationships may begin with practical guidance and support but gradually evolve towards reflection, challenge, career development and professional growth. It is throughout this journey that the different roles of the mentor become most visible and influential.

The roles of a mentor

The role of a mentor is dynamic, shaped by both the context of the relationship and the evolving needs of the mentee over time. While the responsibilities of mentorship may be broad, the way in which mentors deliver this support is equally important. Effective mentors do not operate within a single fixed role, they adapt their approach according to the situation and the nature of the discussion.

Table 2 summarises eight commonly described mentor roles, synthesised from established frameworks in a variety of contexts,

Key words: early-career consultants, mentorship, professional development

Table 1 Summary of typical areas of mentoring support, adapted from the VSGBI Mentorship Programme Orientation Training Slides.

Key domains of support	Impact on mentees
Competence development	Mentoring positively impacts on mentees' ability to see and understand their development areas.
Performance and reflection	Mentoring positively impacts on mentees' ability to unravel and interpret their thoughts and feelings.
Wellbeing and resilience	Mentoring positively impacts on mentees' wellbeing, resilience, ability to bounce back and cope with challenges.
Learning and understanding	Mentoring positively impacts on mentees' ability to understand context and culture; learning from the past.
Self-confidence and empowerment	Mentoring positively impacts on mentees' self-esteem, giving a sense of empowerment.

Table 2 Summary of eight commonly described mentoring roles in clinical and educational practice, adapted from the VSGBI Mentorship Programme Orientation Training Slides.

Mentor roles	Description
Professional friend	Provides a safe, non-judgemental space to talk openly, reducing isolation and restoring perspective.
Sounding board	Helps to test ideas, decisions and approaches, broadening thinking and supporting career strategy.
Reflector	Helps mentees to gain insight into their own behaviours and decisions.
Challenger	Introduces constructive discomfort to promote growth and self-awareness.
Confidant	Offers unconditional support for vulnerability and personal reflection.
Performance coach	Focuses on specific skills or areas for improvement through structured questioning.
Role model	Demonstrates through lived experience what professional growth, resilience and success can look like.
Guide	Helps navigate systems, opportunities and professional networks.

including healthcare and professional education. These roles are underpinned by adaptability as mentees require different forms of support at different stages of their development. Effective mentors recognise and respond to these evolving needs, often moving fluidly between roles (sometimes even within the same mentoring session) to provide appropriate guidance, challenge, reflection or support.

At the first Vascular Society of Great Britain and Ireland (VSGBI) Mentorship Orientation Day last November, led by Professor Julie Haddock-Miller, participants were introduced to the different roles that a mentor may adopt within a mentoring relationship. The following section revisits these roles in greater depth, exploring the defining characteristics of each and how they contribute to effective mentorship in practice.

Mentor roles

The professional friend

One of the most immediately important roles is that of the professional friend. In this space, the mentor provides a safe and confidential environment where the mentee can speak openly about concerns, frustrations or uncertainties that may not be typically shared elsewhere. This role is not focused on instruction or correction, but on reassurance, normalisation and support. It helps mentees to feel heard and less isolated, and is a valuable space to vent. This role sometimes crosses over into the role of cheerleader.

The sounding board

Alongside the role of professional friend, the sounding board creates a space in which ideas, decisions and uncertainties can be explored openly and constructively. Rather than simply providing answers, the mentor supports the mentee in testing their thinking, considering consequences and refining their judgement. This is particularly valuable in the development of clinical reasoning and strategic career planning, where uncertainty is inevitable and reflective discussion is essential. Through this process, the mentor helps the mentee to develop a more strategic approach to their professional life, encouraging thoughtful decision-making, prioritisation and an understanding of when to accept opportunities and when to decline them.

The reflector

Closely linked to the role of sounding board is the role of the reflector. In this capacity, the mentor helps the mentee to step back and make sense of their experiences. By holding up a metaphorical mirror, the mentor enables greater self-awareness, helping the mentee to recognise patterns in behaviour, responses and decision-making. Over time, this deepens insight and supports more intentional professional development.

The challenger

At times, mentorship requires challenge. The challenger role is deliberately more direct, encouraging critical thinking and pushing the mentee beyond their comfort zone. While this may introduce discomfort, it is often where the most significant learning occurs. Constructive challenge helps to refine judgement, expose assumptions and build resilience in decision-making. By encouraging the mentee to consider alternative perspectives and question established patterns of thinking, the mentor promotes deeper reflection and greater self-awareness. The mentor may also help the mentee to recognise the language of self-doubt and imposter syndrome, supporting them to develop confidence and a more balanced perception of their abilities.

The confidant

Equally important is the confidant role. In this space, the mentor offers unconditional support, allowing the mentee to express vulnerabilities, doubts and fears without judgement. This aspect of mentorship is often understated but is essential, particularly in high-pressure clinical environments where emotional load is significant. It provides validation and reassurance at moments when they are most needed.

The performance coach

More structured support is provided through the performance coach role. Here, the focus narrows to specific skills or areas for development. The mentor uses questioning and guided reflection to help the mentee to identify solutions and improve performance. This role is especially relevant in technical or procedural specialties, where incremental improvement and targeted feedback are key to progression. At times, a non-directive coaching approach is most effective, enabling the mentee to generate their own solutions.

The role model

The mentor may also serve as a role model, one of the most recognisable and valued roles within mentorship. In this capacity, the mentee learns not only through direct advice but also through observing how the mentor navigates challenges, balances competing demands and responds to setbacks. Importantly, this includes hearing about the mentor's own experiences of failure, uncertainty and recovery, which often provide some of the most meaningful learning opportunities. Seeing success as an evolving process rather than a fixed endpoint can be highly transformative for mentees. Role models often embody qualities, behaviours and professional values that the mentees admire and aspire to develop within themselves. Learning about the mentor's personal and professional journey can provide reassurance, perspective and practical insight from someone who has faced similar challenges and is willing to share what they learned along the way.

The guide

Finally, the mentor acts as a guide. This involves helping the mentee to navigate systems, identify opportunities and build professional networks. It may include signposting, facilitating connections, or helping the mentee understand how to access resources and progress within the specialty. In many ways, this role situates the mentor within the broader professional landscape, supporting not just individual development but integration into the wider community.

What makes mentorship effective is not the presence of any single role, but the ability to move between these roles fluidly. A single conversation may involve support, reflection, challenge and guidance all at once. The skill lies in recognising what is needed at a given moment and responding appropriately. From the mentee's perspective, it is equally valuable to understand these roles and consider which are most helpful at different stages of development.

The value of being a mentor

Stepping into a mentoring role can be transformative in itself. Although mentorship requires time, emotional investment and thoughtful engagement, it also offers considerable personal and professional rewards. There is deep professional satisfaction in supporting the development of others, watching confidence grow, skills mature and careers evolve over time.

Mentorship also enhances the mentor's own development. It strengthens communication skills, encourages self-reflection and often challenges mentors to examine their own clinical reasoning, leadership style and decision-making processes more clearly. Many mentors find that guiding others enhances their own understanding and perspective.

Importantly, mentorship is also a way of giving back to the specialty. Through the mentor role, experienced surgeons play a vital part in developing the next generation of clinicians, while also strengthening the quality, continuity and long-term resilience of the vascular specialty as a whole.

Conclusion

Effective mentorship is defined not by a single approach but by adaptability and the ability to move fluidly between roles in response to the evolving needs of the mentee. For those already in vascular surgical practice, this editorial has hopefully encouraged reflection on the value of becoming a mentor. The specialty relies on experienced surgeons willing to share not only their technical expertise but also their judgement, perspectives and lived experience.

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ORIGINAL RESEARCH

Calculating and reducing the environmental impact of hybrid endovascular surgery

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Plain English Summary

Why we undertook the work: Healthcare creates lots of greenhouse gases and surgery plays a big role in this. Surgical cases require a lot of disposable single-use equipment, anaesthetic gases and high-energy systems like ventilation, lighting and temperature control. This study measured the carbon footprint of common arterial vascular surgeries and explored ways to reduce their environmental impact.

What we did: At one vascular surgery centre we studied four types of vascular surgery procedures: simple endovascular (keyhole) aneurysm repair (EVAR); complex EVAR (involving custom-made devices and extra branches for arteries to the internal organs); percutaneous (keyhole) lower limb procedures for circulation like angioplasty and stents; and hybrid lower limb revascularisation involving a combination of open surgery and keyhole procedures. For each operation we recorded in real time the devices, disposable items and waste produced. We then estimated the carbon emissions associated with each item by considering its full journey from producing the raw materials and manufacturing the product through to packaging and transport and finally disposal. This approach, known as a life-cycle assessment, looks at the environmental impact of a product from when it is made to when it is thrown away.

What we found: The amount of carbon emissions varied depending on the type of procedure. Complex EVAR had the highest average carbon emissions since it uses more resources and is more complicated. This was about the same as driving 418 miles in a petrol-driven car. We also saw that more people in the operating theatre resulted in a greater number of single-use wearable items such as hats and gowns being used, adding to the waste produced. Ways to reduce the emissions could include using more keyhole techniques, reusable surgical fabrics, ecofriendly packaging and more efficient imaging methods.

What this means: This study is the first to look at the carbon footprint of common arterial vascular surgeries and identifies where changes could be made to make these procedures more environmentally friendly. As this study is an early exploratory investigation, further research involving multiple hospitals and a wider range of procedures is needed to confirm these findings and to see whether these changes really make surgery more environmentally friendly.

Abstract

Background: The healthcare sector is a substantial contributor to global greenhouse gas emissions, with surgical services accounting for a significant proportion. This is driven by the extensive use of single-use consumables, volatile anaesthetic agents and energy-intensive infrastructure including ventilation, lighting and climate control systems. This study quantified the carbon footprint of commonly performed arterial vascular procedures and identified modifiable drivers to reduce their environmental impact.

Methods: A prospective observational study was carried out at a single vascular surgery centre, focusing on four procedure types: simple endovascular aneurysm repair (EVAR); complex EVAR; percutaneous lower limb revascularisation; and hybrid lower limb revascularisation. Real-time data were collected to capture devices, consumables and waste associated with each intervention. A life-cycle assessment approach was used to estimate carbon emissions across the product pathway including raw material extraction, manufacturing, packaging, transportation and disposal.

Results: A total of 24 procedures were analysed (6 simple EVAR, 8 complex EVAR, 5 percutaneous lower limb revascularisations and 5 hybrid lower limb revascularisations). Carbon emissions varied significantly between procedure types (Kruskal–Wallis test, H=11.53,

p<0.05), with complex EVAR associated with the highest median emissions, reflecting greater resource intensity and procedural complexity. Median emissions for complex EVAR were equivalent to driving approximately 418 miles in a standard petrol vehicle. A strong positive correlation was seen between the number of theatre personnel and the volume of single-use wearable items (Spearman's ρ=0.878, p<0.001), suggesting staffing levels contribute meaningfully to procedural waste. Opportunities to reduce emissions were identified, including use of percutaneous techniques, reusable surgical textiles, sustainable packaging strategies and imaging optimisation.

Conclusion: This pilot study represents the first observational quantification of the carbon footprint associated with common arterial vascular procedures and identifies targets for sustainability interventions within vascular surgery. Given the procedural heterogeneity and single-centre design, further multicentre studies with larger sample sizes and standardised methodologies are required to better quantify emissions and evaluate the effectiveness of sustainability interventions.

Key words: CO_2 emissions, hybrid vascular surgery, environmental impact

Introduction

Background

Climate change refers to long-term shifts in global temperatures and weather patterns, driven predominantly over the past two centuries by human activity, particularly the combustion of fossil fuels. The release of greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) traps heat within the atmosphere, raising global temperatures,[1] which is known as global warming. This represents one of the prime manifestations of climate change, alongside air pollution, increase in prevalence of human diseases, food insecurity and other socioeconomic impacts. Climate change has escalated into a global emergency, affecting ecosystems, economies and public health worldwide.

The Paris Agreement, signed in 2016, aimed to limit the global mean temperature rise to below 2°C and to achieve net negative emissions by 2100. However, current projections suggest that, even with immediate action, global temperatures are expected to continue rising by an additional 0.2–0.5°C over the next decade, potentially reaching a 1°C increase by the end of the 21st century. The World Health Organization (WHO) has projected that climate change will cause 250,000 additional deaths between 2030 and 2050, with the burden of climate change not being distributed equally. Vulnerable communities face disproportionate health risks due to limited access to well-resourced healthcare and food security systems.[2] This highlights the critical need for stronger and more unified global mitigation efforts to effectively combat climate change.[3]

Climate change and healthcare

The increasing contribution of healthcare systems[4] to the global climate emergency is now widely recognised. The global health sector was estimated to generate 2.6 billion metric tonnes of carbon dioxide equivalent (CO_2e) in 2011, and in 2014 the global health climate footprint accounted for approximately 4.4% of total global emissions, equivalent to the greenhouse gas emissions from 514 coal-fired power plants.[5]

The increase in greenhouse gas emissions and the resulting intensification of the climate crisis presents both direct and indirect risks to public health. These risks include injury, illness from changes to vector ecology, air pollution and natural disasters (Figure 1). This creates a cycle in which worsening climate-related health outcomes increase healthcare demand, further amplifying healthcare-related emissions. As this cycle continues the burden on healthcare systems grows, making it increasingly challenging to mitigate both climate-related health issues and the environmental impact of healthcare systems.[4]

Recognising the environmental responsibility, the NHS set an aim to become the world's first net zero national health service. The plan outlines two key targets: achieving net zero for the NHS Carbon Footprint by 2040 (covering emissions under direct control) and net zero for the NHS Carbon Footprint Plus by 2045, which includes emissions from the supply chain, patient and staff travel, and commissioned services.[6]

Surgery and sustainability

Within healthcare, surgical care has been identified as a significant contributor to the global climate emergency due to the extensive use of energy, medical devices and consumables and generation of waste. The energy performance of the surgical suite at John Radcliffe Hospital was shown to be 12.61 GJ/m^2 compared with 2.14 GJ/m^2 for the building as a whole, demonstrating the increased energy intensity of operating theatres.[7] A systematic review which aimed to determine the reported carbon footprints of surgical operations in hospitals worldwide identified medical devices and consumables to be the greatest contributor to their carbon footprints (Figure 2), most likely due to their increased requirement in surgery to ensure sterility and efficiency.

Figure 1 Impacts of climate change on human health.[4]

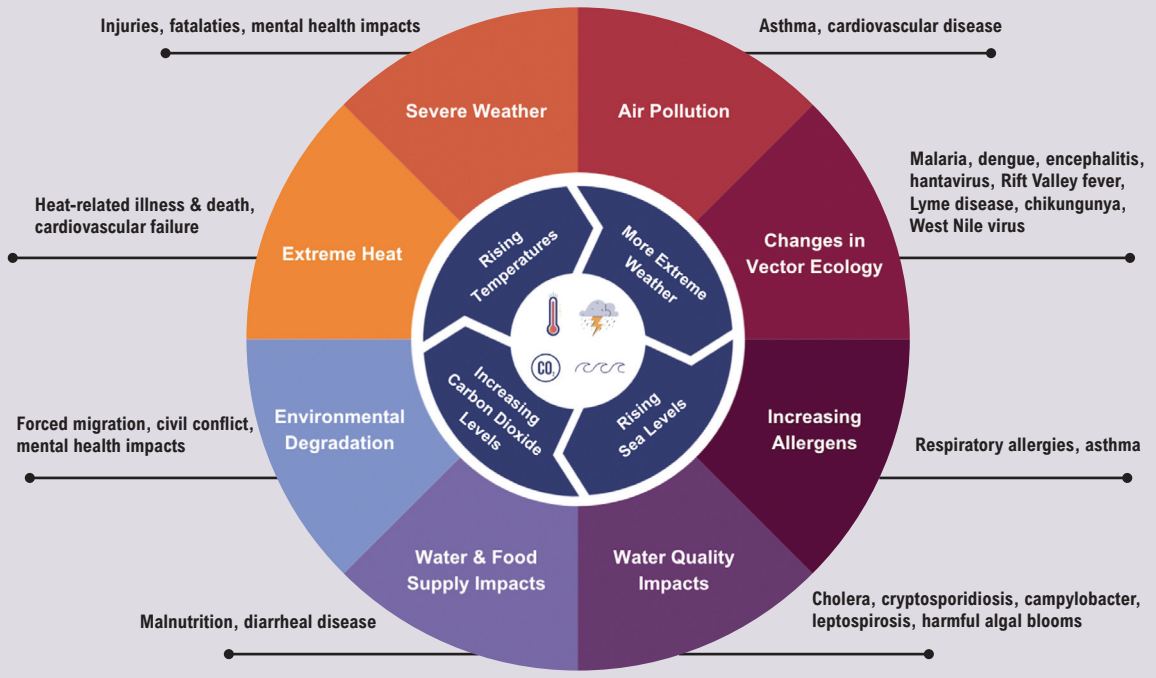
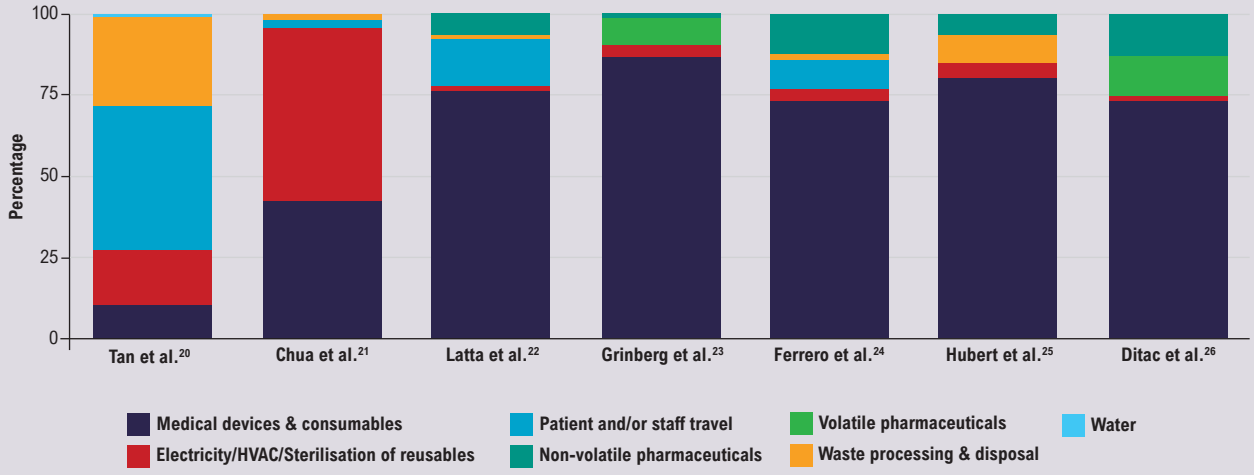


Figure 2 Carbon hotspots across a range of surgical procedures. HVAC, heating, ventilation and air conditioning.[8]



Carbon footprint contribution deriving from transportation of these medical devices and consumables makes up only a small proportion of the total carbon footprint, therefore attempts at reducing the carbon footprint should be focused on other areas. The material production and manufacture of medical devices and consumables was the greatest contributor of their emissions and highlights an area in which more sustainable alternatives could be used, such as through the substitution of single-use items with reusable types. An essential detail which emerges from systematic reviews conducted to determine the reported carbon footprint of surgical operations is that there are no specific guidelines for calculating the carbon footprint of surgical operations, causing diverse results between studies. Standardisation of methods will provide better quality data in order to guide more sustainable surgical practice.[8]

Vascular surgery and sustainability

Vascular surgery is a unique surgical specialty in that open surgery,

endovascular interventions and hybrid techniques are all used in the management of life- and limb-threatening conditions. Endovascular surgery has evolved rapidly over the last 50 years as evidence of reduced periprocedural morbidity and mortality compared with open surgery emerged.[9] Hybrid techniques incorporating elements of both open and endovascular surgery are now common. These procedures have become the standard of care for many patients with life- and limb-threatening ischaemia, and guidelines from major clinical bodies such as the National Institute for Health and Care Excellence (NICE) and the European Society for Vascular Surgery (ESVS) increasingly recommend endovascular interventions as the preferred approach for treating abdominal aortic aneurysms.[10,11]

Endovascular surgical techniques call for specialised equipment such as guidewires, angiographic catheters, balloons and stents, all of which are composed of complex synthetic materials such as polytetrafluoroethylene (PTFE), teflon, stainless steel and nitinol, which increase their cost and environmental impact (polyethylene is more affordable and more environmentally friendly than PTFE, yet PTFE is still more commonly used[12]).[13] The packaging associated with these devices is also extensive. One study on packaging materials associated with equipment used in endovascular aneurysm repair (EVAR), a common vascular surgical procedure, found that typical equipment packaging contained between four and seven elements to hold one device, such as cardboard or plastic inserts, foam and sterility packaging. Some of these packaging items lack the universal recyclable symbol, causing uncertainty of their disposable methods even though the majority of materials were classed as recyclable when discussed with company representatives. The shift towards minimally invasive procedures has led to greater reliance on these disposable devices in vascular surgery, and a formal framework to mitigate the environmental impact of vascular surgery is needed.[14]

A few studies have quantified the carbon footprint of vascular procedures, Gu *et al*[15] showed that the median amount of carbon produced over 59 vascular procedures was 15.2 kg CO_2e, roughly equivalent to driving a car for 108 km.[16] Many vascular and endovascular procedures are difficult to fully standardise and therefore few studies have attempted to assess arterial interventions. Notably, a recent study by Sénémaud *et al*[17] evaluated the carbon footprint associated with a single EVAR, estimating it to generate a median of 108 kg of CO_2e and identifying consumables to be one of the most emissive factors. More specific evidence on the environmental impact of vascular surgery remains limited and, as endovascular techniques continue to grow, their collective environmental impact will likely increase, highlighting the need for robust data in order to develop effective tools to reduce their environmental impact.

Aims and objectives

The primary aim of this study was to describe the environmental impact of commonly performed arterial vascular procedures. With a particular focus on carbon emissions generated through the use of disposable medical devices and consumables and waste management, the study sought to address a critical gap in the existing literature.

The secondary aim was to assess the potential for carbon footprint reduction through changes in clinical practice, such as the adoption of reusable surgical textiles and reusable instrument sets. By assessing the environmental implications of such changes, this study aims to provide practical recommendations for transitioning towards more sustainable surgical practices.

The specific objectives guiding the study to achieve these aims are:

1. To systematically identify and document the equipment used in common arterial vascular procedures and to analyse the associated waste disposal practices, including the classification and management of different waste streams.
2. To calculate the carbon footprint of commonly performed arterial vascular procedures by integrating observational data with life-cycle methodology, published manufacturer-derived data, online sources and published emission factors.
3. To estimate the potential environmental cost savings associated with change in clinical practice, with a particular focus on substitution of single-use surgical textiles with reusable textiles.

Methods

Study design

In this observational exploratory pilot study, prospective data collection methods were employed to assess the environmental impact of commonly performed vascular surgical procedures. A life-cycle assessment (LCA) was used to estimate the carbon footprint associated with disposable medical devices and equipment used.

The LCA focused on per-procedure resource use rather than top-down economic input-output modelling, allowing attribution of emissions to specific items and waste streams used during individual cases. An LCA is a standardised approach used to evaluate the environmental impact of a product or process across its entire life-cycle, from raw material extraction and manufacturing, use, their associated packaging and disposal practices, measured in kilograms of CO_2 equivalent (kg CO_2e). In this context, it enables the identification of carbon intensive components and supports evidence-based changes to more sustainable clinical practice.[18] This study primarily employed a bottom-up, process-based LCA using per-procedure resource use data collected in real time. Where item-specific life-cycle data were unavailable, top-down published emission factors were applied for material production, transport and waste processing.

This study was conducted with local audit approval (project no. 16785).

Procedure selection

Four procedures were selected as follows:

1. Standard endovascular aneurysm repair (EVAR), which is

defined as any EVAR procedure using a standard infrarenal device (stent graft) following the manufacturer's instructions, without the use of any adjunctive procedures.
2. Complex endovascular aneurysm repair (complex EVAR), defined as any EVAR procedure that includes fenestrated, branched, customised or internal iliac branch devices.
3. Percutaneous lower limb intervention, referring to a range of minimally invasive procedures performed to manage peripheral arterial disease, particularly in cases of chronic limb-threatening ischaemia. The procedures aim to revascularise occluded or stenotic arteries (ie, percutaneous transluminal angioplasty (PTA) and stenting).
4. Hybrid lower limb revascularisation, a combined approach which integrates both open and endovascular techniques to revascularise in patients with complex peripheral arterial disease (eg, common femoral endarterectomy alongside endovascular treatment of the iliac, superficial femoral or tibial arteries).

The four selected procedures are among the most commonly performed vascular procedures in the UK, with approximately 43,000 vascular surgery procedures being carried out in England each year and more than 28,000 of those cases relating to aortic aneurysm repair and lower limb revascularisation. There has been an increase in endovascular procedures in recent years as techniques such as EVAR have been established,[19] with lower patient mortality and morbidity,[20] increasing the patient population eligible for treatment.

These procedures are widely recognised and recommended for treatment for different manifestations of arterial disease and chronic limb-threatening ischaemia by various guidelines such as the NICE, the ESVS and the Trans-Atlantic Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II).[10,20,21]

As such, they are being increasingly favoured over purely open strategies and will remain highly relevant in clinical practice. As these procedures become more common, and the complexity of interventions achievable with endovascular and hybrid techniques increases, the collective carbon footprint will also increase, making it essential to understand and reduce environmental impacts through developing sustainable practices.

Four operative groups were included in this study as described above, with consecutive cases being recorded where a data collector was available. There were no specific exclusion criteria, although the hybrid peripheral revascularisation group referred specifically to the hybrid nature of the revascularisation, rather than a purely endovascular procedure combined with adjunctive minor amputation.

Data collection

Data collection was performed by a single operator (YS) over a two-month period, during which 28 cases were selected and observed. A case was observed from the time the patient entered the operating room from the anaesthetic room, until the patient exited for the recovery ward. Data regarding the following were recorded: personal protective equipment (such as gloves and masks), surgical fabrics (such as drapes and gowns), implantable and single-use devices and consumables, all packaging materials associated with devices and consumables, waste produced from the procedure, and data on reusable items. A database of all medical devices, disposables, reusable items, packaging and waste of observed cases was constructed.

Data regarding devices such as catheters, guidewires, stent grafts and consumables, such as gloves and gowns, included the product type, the total weight of the item and the weight of the corresponding packaging, the quantity used, the manufacturing location of the item and the main material composition of the product and its packaging. Data regarding devices and consumables that had been opened but not used would also be recorded. The category 'miscellaneous disposables' included individual single-use items not captured within predefined device categories including syringes, labels, caps, connectors and other small ancillary materials used during routine procedural workflow. The waste produced from each procedure was categorised as recycling – which itself comprised white recycling bag waste and hard plastic and paper kept aside separately for recycling – and clinical waste, which was then weighed. Methods of waste management such as incineration and recycling were also recorded. Data regarding reusable items and laundry recorded the quantity, category (eg, reusable scrub gowns, reusable instrument sets/kits) and weight, referring to sterile instrument sets assembled and packaged locally within the hospital sterile services department, containing reusable procedural instruments prepared for specific vascular interventions. These sets did not include disposable consumables and were recorded separately from single-use items (Table 1).

All weights were recorded using a DIGI® DS-502 weighing scale (maximum capacity 6 kg) to the nearest gram, with no individual item exceeding this limit, and the database for data collection was constructed on Microsoft Excel™. Data on manufacturing location and material composition of disposable medical equipment were gathered by examining the labelling and manufacturing details printed on the product packaging where available, but when such details were not clearly specified, data were gathered through online searches including manufacturing websites, product brochures and other publicly available online sources. The data on identifying waste streams and their associated carbon emissions with their respective disposal methods were obtained through direct correspondence with the trust waste manager of Guy's and St Thomas' NHS Foundation Trust. All the data were collected through direct observation in the hybrid theatre at St Thomas' Hospital, and all appropriate cases during the time period were to be observed, accepting limitations around time commitments for a single data observer.

Table 1 Data capture categories.

Category	Variable	Description	Examples	Data collected
Waste – recycling	White recycling bag	White recycling bag containing the packaging of equipment used during the procedure	White recycling waste bag	Weight (g), method of disposal
Waste – recycling	Hard paper	Hard paper packaging	Packaging from stent/grafts	Weight (g), method of disposal
Waste – recycling	Hard plastic	Hard plastic packaging from stent/grafts	Packaging from stent/grafts	Weight (g), method of disposal
Waste – clinical waste	Clinical waste bag	Orange bags containing infectious or potentially infectious waste	Orange clinical waste bag	Weight (g), method of disposal
Disposables	Kits	Pre-packed kits containing disposable items used during the procedure	St Thomas' Hybrid Angiopack	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Access	Equipment used to gain vascular access for percutaneous devices	Brite Tip Sheath 4F introducer 11 cm 0.035"	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Sheaths	Equipment used to maintain vascular access	Terumo peripheral guiding sheath 8F 90cm straight	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Catheters	Angiographic catheters for injection of contrast media	Cordis BER II 4F 100 cm catheter	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Balloon catheters	Catheters used to dilate vessels during angioplasty procedures	Charger OTW PTA balloon 5F 3×40 mm 135 cm	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Guidewires	Wires used to aid in percutaneous navigation of stents/grafts	Lunderquist extra stiff guidewire 300 cm 0.035"	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Grafts/stents	Mesh or fabric devices used to reinforce vessels	GORE Excluder AAA EP 16x27x14 mm 15Fr 0.035"	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Drapes/covers	Sterile barriers used to maintain an aseptic field	3M ioban 2 56 x 60 cm antimicrobial incise drape	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Gauze/dressings	Materials applied to clean and cover surgical wounds	3M Tegaderm film 15 x 20 cm	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Closure devices	Devices used to achieve haemostasis at vascular access sites	Prostyle Perclose suture system	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Instruments	Manual tools used during procedure	Disposable mosquito clip	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Catheterisation	Equipment used when catheterisation patient	Foley catheter ch 12 4 mm x 10 mL	Weight (g), quantity (n), material composition, manufacturing location.
Disposables	Suture/clips	Materials used to close wounds and incisions	Ethicon Ligaclip large	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Wearables	Materials worn by staff to maintain aseptic field	Disposable blue gloves	Weight (g), quantity (n), material composition, manufacturing location
Disposables	Misc.	All other items which were used throughout the procedure	Baxter heparin solution in NaCl 500 mL	Weight (g), quantity (n), material composition, manufacturing location
Reusables	Instrument sets	Preassembled instrument sets	Vascular fine access set	Quantity (n)
Reusables	Reusable scrub caps	Personal reusable scrub caps		Quantity (n)
Reusables	Laundry	Surgical scrub gowns		Weight (g), quantity (n)

Data analysis and LCA calculations

Categorical data, such as quantity of disposables were presented as numbers and percentages, and continuous data such as the total carbon footprint per type of procedure were described using inclusive median and interquartile range (IQR). Planned statistical analyses included non-parametric comparisons between procedure groups (Kruksall–Wallis tests) and correlation analyses (Spearman's rank correlation). The clinical-to-recycling waste ratio was calculated for each case by dividing the weight of clinical waste by the weight of the recyclable waste produced. The total carbon footprint for each case was quantified using Formula 1 (see Appendix 1 online at www.jvsgbi.com).

The CO_2e associated with disposable items was estimated using a process-based LCA approach, combining measured item weights with emission factors to account for raw material production, manufacturing, packaging, transport, and end-of-life waste processing, allowing the contribution of each stage to the total carbon footprint to be understood, meaning that carbon saving

strategies can easily be applied to stages which contribute the most. The LCA calculator used for this study is shown in Formula 2 (see Appendix 1 online at www.jvsgbi.com).

The CO_2e from raw material processing of disposables was quantified by identifying the main material components and using respective emission factors obtained from online sources, discussed in (see Appendix 2 online at www.jvsgbi.com). Transport CO_2e was calculated by identifying the manufacturing location, and then using a publicly available online sea shipping route calculator[22] to obtain the distance to St Thomas' Hospital, London, in kilometres, covering both sea and road distances. Subsequently, the emission factors for shipping through general sea and road freight obtained from the greenhouse gas reporting conversion factors 2024 spreadsheet from the Department for Energy Security and Net Zero were used to calculate the CO_2e.[23] The contribution of CO_2e from end-of-life treatment was obtained by using emission factors provided by the trust waste manager of Guy's and St Thomas' NHS Foundation Trust, with the emission factors for waste processing differing between recycling and clinical waste with 359 kg CO_2e produced for processing one tonne of clinical waste compared with 21 kg CO_2e /tonne for recycling processes (Guy's and St Thomas' NHS Foundation Trust Waste Management Team).

In the absence of published item-specific life-cycle data for manufacturing and packaging stages, a simplified mass-based emission factor of 0.001 kg CO_2e per gram (equivalent to 1 kg CO_2e per kg of material) was applied. This value was selected as a screening-level approximation and applied consistently across all items to enable comparative analysis between procedures within this exploratory pilot study. Mass-based proxy emission factors were used where item-specific data were unavailable, consistent with ISO 14040 guidance permitting the use of representative secondary data within life-cycle inventory analysis provided assumptions and limitations are transparently reported. Published LCAs of plastics manufacturing report supply chain emission intensities typically within the order of approximately 1–5 kg CO_2e per kg of material, placing the selected value within the lower range of empirically reported estimates for polymer manufacturing.[24]

More granular proportional attribution using material-specific emission factors (eg, DEFRA conversion factors for plastics, paper, and cardboard packaging) was not undertaken in this pilot analysis in order to maintain methodological consistency across heterogeneous devices and packaging types. Introducing variable material-specific factors without complete component standardisation may have introduced additional uncertainty and reduced comparability between procedures. However, incorporation of such approaches represents an important refinement for future work.

Maintaining a uniform modelling approach across all procedures ensured internal consistency of emission estimates, allowing relative differences between procedure types to be interpreted with greater confidence within this exploratory pilot framework.

The CO_2e from laundry is relevant due to the use of reusable surgical gowns. However, it should be noted that centre-specific emission factors were not obtainable, so instead emission factors deriving from a LCA of items commonly reprocessed by a large hospital laundry service were used.[25]

In each case the 'St Thomas' Hybrid Angio Pack' refers to a pre-packaged set of disposable items consisting of 44 individual items including drapes, hypodermic needles, disposable plastic kidney dishes, galley pots, etc. The above carbon emissions calculator formula has been applied to these items, resulting in a total CO_2e per 'St Thomas' Hybrid Angio Pack' of 46.1 kg CO_2e (see Appendix 3 online at www.jvsgbi.com). This has then been included as a single item for subsequent descriptive statistics.

For each case, pre-filled bags of heparinised saline solution (heparin sodium 1000 units/500 mL infusion Viaflex bags) were utilised.[26] The CO_2e calculations for this were generated based on the above LCA calculator, by taking the heparin additive into account for the carbon emissions deriving from raw material processing, which is not synthetic but extracted from animal-based materials (porcine intestinal mucosa).[26] To estimate the carbon emissions, published data were used which indicated that the rearing of a single pig produces approximately 670 kg CO_2e, and each pig yields approximately 65,000 IU of heparin,[27] therefore the carbon emissions deriving from a 1000 IU dose was able to be calculated by substituting the following variable into Formula 3 (see Appendix 1 online at www.jvsgbi.com).

Assumptions

Several assumptions were made during the data analysis process, due to lack of data being publicly available and to ensure consistency. Medical devices and equipment are made of several individual components, using a variety of materials. The use of patents and trademarks by manufacturers limits the data available in the public domain, and therefore material composition was limited to the two most predominant materials, estimated using publicly available online resources and through the use of open-source AI.

The use of a simplified mass-based emission factor for manufacturing and packaging and attribution based on dominant material compositions represents a screening- level approximation. Incorporation of material-specific emission factors and full component inventories may refine absolute emission estimates but is unlikely to substantially alter relative comparisons between procedure groups.

For CO_2e relating to transport, once the manufacturing location was identified (once again estimates had to be made when specific details were not available, such as if a country of manufacture was provided, the capital city of that country was used as the manufacturing location), it was entered into an online shipping route calculator, using St Thomas' Hospital as the destination in order to calculate the total distance by road and sea shipping, with sea shipping routes that use the London Gateway Port as the point of

entry into the UK for consistency across data. It was assumed that container ships with an average TEU and diesel HGV trucks which where average laden were used for sea and road transport.

Centre-specific emission factors for the sterilisation of reusable instrument kits were not able to be obtained and therefore were excluded from the total carbon footprint. However, the contribution of sterilisation of single-use items has previously been estimated at <1%.[28] Similarly, for the purposes of this study, anaesthetic components of care, which have been well described in the existing literature,[29] were excluded as were staff and patient travel, hospital infrastructure and out of theatre patient care components. These elements have all been previously studied[30] and fall outside the remit of this study, given the time limitations. There is unlikely to be significant variation in these elements for this study compared with the previously published data.

Table 2 Summary of disposable items used by procedure type.

Disposables	Simple EVAR (n=6) Median (IQR)	Complex EVAR (n=8) Median (IQR)	Percutaneous LL (n=5) Median (IQR)	Hybrid LL (n=5) Median (IQR)
Sets	2 (0)	2 (0)	1 (0)	2 (0)
Access	5.5 (2.75–6)	6.5 (5–10)	3 (0)	3 (2–5)
Sheaths	0.5 (0–1)	1 (0.5–1.5)	0 (0)	0 (0)
Catheters	5.5 (4.25–6)	6 (5–6.5)	3 (3–3)	2 (0)
Balloon catheters	1.5 (1–2.75)	2.5 (1–3.75)	3 (2–4)	2 (0)
Guidewires	3.5 (2.25–4)	9 (6.5–11)	4 (2–5)	4 (2–6)
Grafts/stents	2.5 (1–4)	9 (7.25–9.5)	1 (0–1)	2 (2–3)
Drapes/covers	1 (0.25–1.75)	0 (0–1)	1 (1–2)	3 (1–3)
Swabs, gauze, dressings	3.5 (3–4.75)	2.5 (1.75–5)	4 (3–4)	6 (0)
Closure	4 (4–4.75)	4 (2.75–4.25)	1 (1–1)	0 (0)
Instruments	0.5 (0–1)	0 (0–1.25)	6 (1–9)	6 (5–9)
Catheterisation	4 (0)	4 (0)	0 (0)	4 (0)
Suture clip	0 (0)	0 (0)	0 (0)	9 (6–11)
Wearables	18 (16.2–25)	31.5 (17–34)	20 (16–21)	25 (23–28)
Miscellaneous	8.5 (7.25–11.25)	13 (12–15.25)	11 (10–11)	19 (17–22)
TOTAL	**60.5 (53.5–66)**	**91 (75.5–103.75)**	**52 (52–59)**	**99 (84–105)**

EVAR, endovascular aneurysm repair; LL, lower limb.

Results

A total of 28 cases were observed, with the previously mentioned data analysis methodologies only being applied to 24 of them. The flowchart in Figure 3 illustrates the process. These consisted of simple EVAR (n=6), complex EVAR (n=8), percutaneous lower limb revascularisation (n=5) and hybrid lower limb revascularisation (n=5).

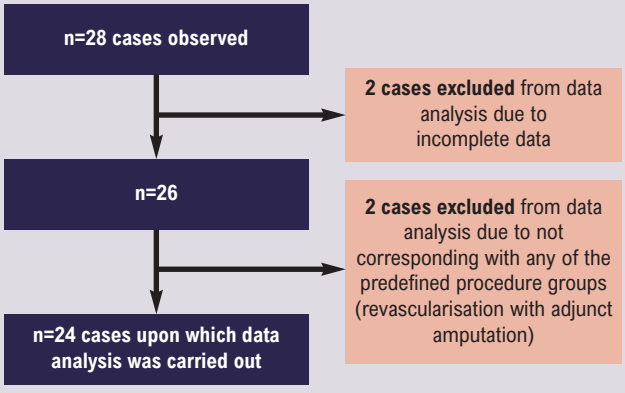
Disposable item analysis

For each of the procedure types studied the number of disposable items used is shown in Table 2, giving the median (IQR) number of items for each procedure type due to the small sample sizes and non-normal distributions observed across procedure groups.

The data showed variation between cases and groups, with the complexity of the case having a direct correlation with the number of disposables. The median (IQR) number of disposable items used per procedure was 70.5 (58.5–97). When stratified by procedure type, hybrid lower limb revascularisation procedures showed the highest number of disposables used (99 (84–105)), followed by complex EVAR procedures (91 (75.5–103.75)), simple EVAR (60.5 (53.5–66)) and percutaneous lower limb interventions (52 (52–59)).

More personnel were present during complex procedures, which correlated with a greater number of wearable disposable items used during the case (Figure 4). Spearman's rank correlation coefficient was selected as a non-parametric method to assess the association between these two variables. The analysis confirmed a strong positive correlation between the two variables (Spearman's $\rho=0.878$, $p<0.001$). These findings are consistent with expectations, as each theatre personnel requires disposable items to maintain sterility, and the significance of the observed relationship emphasises the impact that personnel numbers may have on the overall carbon footprint.

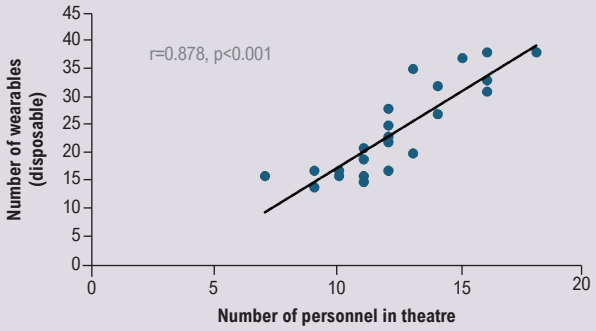
Figure 3 Study flowchart.



Waste generation analysis

The median waste generated per case also varied between procedure types. The weight of waste is given to the nearest gram.

Figure 4 Correlation between number of personnel and disposable wearable items. Scatter graph with line of best fit illustrating the relationship between the number of personnel in the theatre (x-axis) and the number of wearables (disposable) (y-axis). Spearman's rank correlation coeffecient ρ=0.878, p<0.001.



Separate analysis of recyclable waste and clinical waste is given in Figures 5 and 6.

Differences in both clinical waste and recyclable waste were noted across groups with the complex EVAR and hybrid lower limb revascularisation groups again representing the greater waste generation.

A Kruskal–Wallis test was performed to determine if there were statistically significant differences in the clinical-to-recycling waste ratios across procedure types. This statistical test was selected as it is a non-parametric method for comparing continuous non-normally distributed data across multiple independent groups. The analysis showed a significant difference between groups (H=18.09, p=0.00042), indicating that the proportion of clinical waste to recycled waste differed between procedure types. The median clinical-to-recycling waste ratios varied between procedure types (Table 3), suggesting that hybrid and percutaneous lower limb procedures tended to generate proportionally greater amounts of clinical waste relative to recycling waste.

LCA results

LCA of carbon emissions of disposable items was conducted for each case. The full data tables are given in Appendix 3 (online at www.jvsgbi.com). Similar to the disposable items and waste analysis, the complex EVAR (median (IQR) 110.59 (100.77–121.87) kg CO_2e) and hybrid lower limb revascularisation groups (median (IQR) 86.59 (70.56–94.70) kg CO_2e) were the procedure groups generating the most carbon waste, and the complex EVAR group generated significantly greater CO_2e than the hybrid lower limb revascularisation group (Figure 7).

Another Kruskal–Wallis analysis demonstrated a significant difference in carbon emissions across the four procedure groups (H=11.53, p=0.0092), indicating that the environmental impact varied depending on the procedure type. It is likely that this relates to the greater complexity of the implantable devices used across

Figure 5 Recycling waste generated by procedure type. Box and whisker plot of recycling waste produced per procedure type in grams. Values shown are median (IQR). Simple EVAR: 3192.5 (2950.75–3455.25) g; complex EVAR: 8612 (5103.5–9366.5) g; percutaneous lower limb procedures: 2561 (2430–2585) g; hybrid lower limb procedures: 2838 (2050–3057) g. EVAR, endovascular aneurysm repair; LL, lower limb.

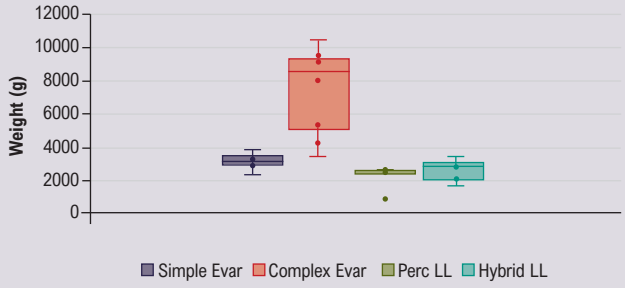


Figure 6 Clinical waste generated by procedure type. Box and whisker plot of clinical waste produced per procedure type in grams. Values shown are median (IQR). Simple EVAR: 6047.5 (5637.5–6494.25) g; complex EVAR: 7323 (5682.5–8293) g; percutaneous lower limb procedures: 5881 (5143–6604) g; hybrid lower limb procedures: 7380 (6038–8703) g. EVAR, endovascular aneurysm repair; LL, lower limb.

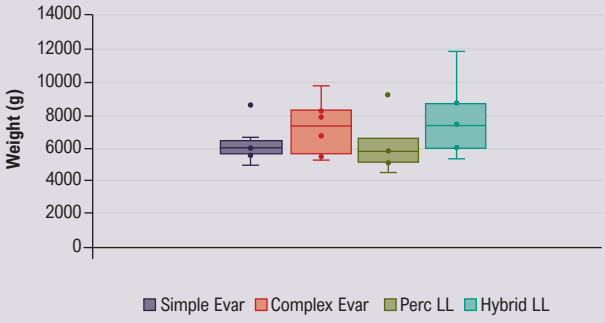
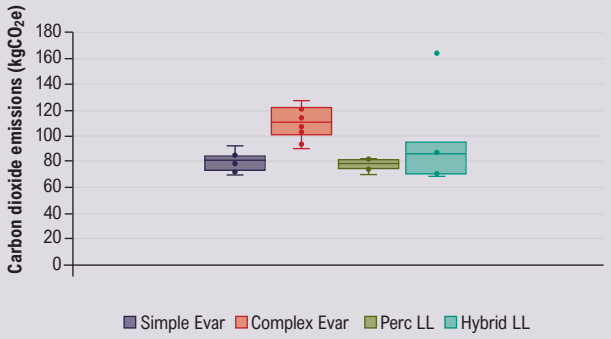


Table 3 Clinical-to-recycling waste ratios

Procedure type	Median clinical-to-recycling ratio	IQR
Simple EVAR	1.94	(1.74–2.34)
Complex EVAR	0.97	(0.83–1.12)
Percutaneous lower limb	2.50	(2.28–3.82)
Hybrid lower limb	2.95	(2.60–3.23)

EVAR, endovascular aneurysm repair

Figure 7 Carbon dioxide emissions by procedure type. Box and whisker plot of carbon emissions produced per procedure type ($kgCO_2e$). Values shown are median (IQR). Simple EVAR: 80.83 (73.70–84.04); complex EVAR: 110.59 (100.77–121.87); percutaneous lower limb procedures: 78.20 (74.69–81.21); hybrid lower limb procedures: 86.59 (70.56–94.70). EVAR, endovascular aneurysm repair.



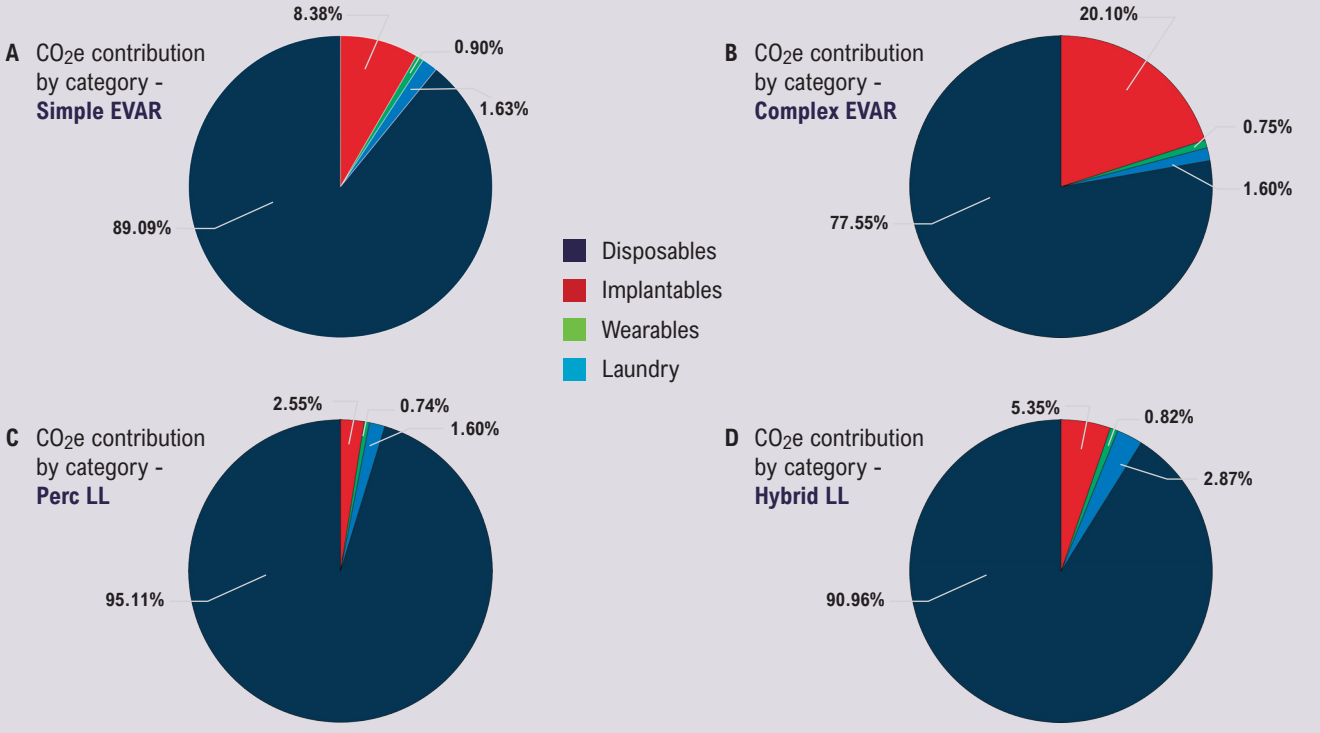
groups, with complex EVAR cases requiring custom-made stent grafts and other specialised equipment, often involving more complex manufacturing processes and potentially greater shipping distances, although this subgroup analysis was beyond the scope of the current project.

The emission factor for laundry processing was obtained from published results from an LCA which aimed to estimate the environmental impact of linen items reprocessed by a large hospital laundry unit and was 0.508 kg CO_2e per kg of laundry.[25]

In order to investigate the contributors to CO_2e generation, all emission-generating components which were used in the LCA calculations were further categorised into four categories: single-use disposables (sheaths, guidewires, catheters, balloon catheters, swabs/gauze/dressings, instruments, kits, drapes/covers, access and closure devices, equipment used when catheterising patients, suture/clips), implantable devices (stent/grafts), wearables (hats, masks, gloves, gowns) and laundry.

Analysis of CO_2e contributions by components across the four procedure types revealed that single-use disposables were the predominant source of emissions in all cases, accounting for 77.55–95.11% of total procedure-related CO_2e (Figure 8). The proportion attributable to disposables was highest in percutaneous lower limb interventions (95.11%) and lowest in complex EVAR cases (77.55%), in which a greater reliance on stents and grafts resulted in a higher relative contribution from implantables (20.10%). Implantables contributed minimally in simple EVAR (8.38%), hybrid lower limb (5.35%) and percutaneous lower limb (2.55%) procedures. Wearables and laundry represented minor emission sources overall, each contributing minimally across all procedure types. These findings indicate that disposables and

Figure 8 Contributors to CO_2e on LCA by procedure type. Pie charts illustrating the contribution to total procedural CO_2e by procedure type (%). (A) Simple EVAR: n=479.69 $kgCO_2e$; (B) complex EVAR: n=880.55 $kgCO_2e$; (C) percutaneous lower limb (LL) procedures: n=386.36 $kgCO_2e$; (D) hybrid lower limb procedures: n=484.81 $kgCO_2e$. EVAR, endovascular aneurysm repair; LCA, life-cycle assessment.



implantable devices are the primary contributors to procedural carbon emissions, and targeted carbon-saving strategies should prioritise these domains to optimise sustainability in vascular surgical practice.

Discussion

This exploratory study aimed to estimate the carbon footprint associated with four common arterial endovascular surgical procedures. Through understanding the main procedural components to the environmental impact from surgery, it may be possible to reduce emissions through targeted system change. The main findings are that procedural carbon emissions varied by procedure type, with higher emissions observed in more complex endovascular and hybrid procedures, and that disposable medical devices and consumables accounted for the largest proportion of total emissions across all procedure types. Given the pilot nature of this study, these findings should be interpreted as descriptive. The study was designed to provide baseline data that may inform future sustainability research within vascular surgery.

The carbon emission data obtained from this study are likely to underestimate the actual carbon emissions for the procedures, as certain contributing factors were not included in the analysis such as energy use of the theatre as a whole, carbon emissions from anaesthesia and transport of staff and patients, based on existing literature and the pragmatic constraints of a pilot design. Operating theatres and hybrid suites vary widely in size, ventilation requirements, imaging capabilities and procedural duration is likely to differ between simple and complex interventions as well as between operators. These factors may meaningfully influence energy consumption and could vary by procedure type. Incorporating direct measurement or estimation of theatre energy use represents an important area for future research.

The total carbon footprint of a procedure would comprise all the emission-generating components, such as anaesthesia, for which there is also published literature. The anaesthetic team at Guy's and St Thomas' NHS Foundation Trust have moved away from inhaled volatile gas-based anaesthesia to total intravenous anaesthetic techniques, known to confer reduced carbon emissions.[29] This is standard practice across all vascular anaesthetists and all procedure types, and therefore would have been unlikely to impact the results discussed in this study focusing on vascular surgery.

The study highlights differences in environmental impacts with each different procedure type. In particular, the clinical waste generation and total carbon emissions generated through complex hybrid lower limb revascularisations were high, and significantly greater than for percutaneous lower limb revascularisations. This is expected, given the hybrid nature of the intervention involving open common femoral surgery in addition to the endovascular components of the procedure.

Interestingly, although the complex EVAR group was the greatest contributor to overall carbon emissions, the clinical waste generation was low and emissions seemed to relate largely to graft manufacture and transport. Recyclable waste was high in this group, reflecting the large number of disposable and implantable items which are packaged in paper and plastic-based materials.

The findings of this study align with and expand upon previous work quantifying the environmental impact of surgical procedures. The study supports the findings of Rizan *et al*[31] who identified single-use consumables and textiles as major contributors to surgical emissions. In particular, the high carbon emissions generated in complex endovascular and hybrid revascularisation procedures in this analysis reflect the intensive use of disposable equipment. While prior research has focused on general surgery, orthopaedics or anaesthetic-related emissions, this study adds to a growing body of evidence highlighting the high carbon intensity of device-heavy specialties such as vascular surgery. The waste generated per procedure observed here are consistent with ranges reported in studies of comparable surgical complexity such as arthroscopic procedures,[32] and the carbon emissions generated and quantity of disposables are consistent with ranges reported from a previous study quantifying the carbon footprint of EVAR procedures.[17]

The data were collected through real-time observation of procedures, which allowed for a highly accurate documentation of devices and consumables used and waste produced. The direct observation allowed for the identification of different categories of waste like recycling and clinical waste and, by distinguishing between different waste streams, this study provides a greater understanding of their individual contributions to total carbon emissions. The prospective nature of the study meant that all data were documented accurately from the moment the patient entered the operating theatre to the moment of exit, including data on items which may not be listed on procedure logs or in inventory records, improving the accuracy of the dataset.

The use of a single observer for data collection allowed for a greater understanding of procedural practices. The nuances between theatre staff in their practices when setting up for procedures and waste management was able to be observed, ensuring that a standardised method was consistently applied when collecting data.

To the team's knowledge, this is also the first study to explore the environmental impact of different vascular and endovascular arterial procedures and therefore generates new knowledge which may equip clinical teams with information necessary to consider systematic change towards greener vascular practice.

In capturing 'real world' complex cases rather than those more standardised and easily protocolised cases (eg, endovenous ablation), the study results are relevant and valid in relation to the varied and complex vascular cases which require operative intervention, providing information on which decisions can be made to reduce environmental impact.

Despite the strengths of this study, several limitations must be acknowledged when interpreting the findings. The heterogeneity within the dataset was a primary challenge. Variability arising from

differences in procedure type and complexity and also the surgical practices of individual surgeons resulted in a wide variety in the quantity of consumables, which limits the generalisability of the findings. A larger dataset incorporating a broader range of procedures would be necessary to draw more statistically robust conclusions.

The study was conducted in a single centre, introducing further limitations due to variability in surgical practices across vascular units, waste management and procurement choices of equipment between trusts in the UK. A multicentre study would therefore be required to validate the findings and to ensure the results have a broader applicability across different geographic sites. The relatively small sample size also limits the conclusions which may be drawn from the results. The limited number of cases reduces statistical power to detect meaningful differences in CO_2e.

Operator experience, procedural complexity and case duration are likely to influence resource utilisation and emissions; however, the sample size was insufficient to permit stratified analysis by operator type or experience. Future studies with larger cohorts may allow exploration of whether emissions vary systematically according to operator factors or procedural efficiency.

Manufacturers were not directly consulted regarding device transport pathways and shipment modes were estimated using standard assumptions. Variability in transport logistics, including potential use of air freight, may influence absolute emission estimates and represent an area for refinement in future analyses through industry collaboration.

Although having a single observer ensured a consistent approach to data collection, it also introduces the potential for bias. The presence of one observer may have influenced the behaviour of theatre staff, and the subjective judgement of the single observer may have caused data to be incorrectly categorised or recorded.

Opportunities to reduce environmental impact

Several opportunities to reduce the environmental impact of vascular surgical practice have been identified through this study and in the wider literature. A key intervention applicable across all procedure types is the transition from disposable to reusable surgical fabrics. Adoption of reusable textiles represents a simplified practical change, requiring minimal alteration to clinical workflows or staff training. A 2018 study by Vozzola *et al*[33] showed that the use of reusable isolation gowns over disposable isolation gowns resulted in a 30% reduction in greenhouse gas emissions (kg CO_2e). This reduction was largely attributed to decreased clinical waste generation and the elimination of repeated manufacturing processes associated with single-use gowns. The study also noted that reusable gowns could offer additional environmental benefits such as lower water and energy usage when processed through modern industrial-scale laundering systems, which often incorporate wastewater treatment facilities to reduce the environmental impact of water output from the cleaning process.

A more comprehensive follow-up study by the same group in 2020 focused specifically on surgical gowns and reported an even greater reduction in carbon emissions, up to 66% (kg CO_2e), when using reusable gowns compared with disposables.[34] This larger reduction compared with the 30% seen in the earlier isolation gown study is primarily attributable to differences in the type of gown assessed and the inclusion of more detailed life-cycle components in the analysis. Unlike the previous study, which focused on isolation gowns with limited packaging and fewer handling steps, the 2020 study evaluated surgical gowns which typically require more robust manufacturing, sterility controls and packaging. The analysis accounted for all stages from raw material extraction through to end-of-life disposal and included emissions from packaging production, the full energy demands of repeated laundering cycles and the role of wastewater treatment plants used in modern laundry systems. By incorporating these additional factors, particularly transport, industrial-scale cleaning infrastructure and textile processing, the study offered a more accurate estimation of the emissions associated with each gown type, thereby highlighting the substantial carbon savings achievable through reusable systems.

The findings from both studies reinforce the role of textile-related choices as a key area of opportunity for carbon emission reduction within surgical care. Although the exact scale of savings may vary depending on gown type, laundering system and hospital infrastructure, the consistent finding across multiple analyses is that reusable gowns lead to substantial and repeatable reductions in carbon emissions. At St Thomas' Hospital reusable surgical gowns are already standard practice, representing a strong commitment to sustainable procurement. However, further environmental gains could be achieved by optimising elements of the laundering system, particularly through investment in more efficient wastewater treatment infrastructure to reduce the footprint of repeated washes. Additionally, while life cycle models often assume a defined reuse limit, typically 75 uses per gown, based on manufacturers' advice, in practice, gowns at St Thomas' are washed and reused indefinitely until failure, which may in fact amplify the carbon savings beyond those reported in the literature. This study did not assess infection risk or barrier performance associated with reusable surgical textiles, and conclusions regarding clinical safety cannot be drawn. The results reinforce the potential of reusable surgical textiles as a practical and impactful intervention to reduce the carbon footprint of routine surgical care.

The paradigm shift towards prioritising percutaneous lower limb revascularisation over hybrid lower limb procedures highlights a key clinical strategy in reducing the carbon footprint of vascular procedures. Full percutaneous techniques such as interventions at the common femoral artery have been shown to be increasingly effective, with low rates of periprocedural complications and mortality and better patency.[35] By minimising the need for open surgical exposure, percutaneous approaches can decrease operative time, reduce consumable use and lower waste generation, all contributing to a lower procedural carbon footprint. However, it is essential that environmental consideration does not

override clinical judgement. Decisions regarding revascularisation strategy should remain grounded in patient selection, anatomical suitability, risk stratification and multidisciplinary team discussion to ensure optimal clinical outcomes. Sustainability consideration may complement – but should not replace – established decision-making frameworks.

Packaging waste also represents a significant contributor to the total carbon footprint of surgical procedures, with medical consumables and devices being packaged in multiple layers to ensure sterility and prevent damage to fragile components. The widespread use of virgin plastics and complex composite materials – which are often trademarked and patented – reduce the recycling opportunities. Switching to biodegradable or recycled plastics offers a sustainable solution to this problem, but collaboration between healthcare institutes and industry partners is needed to encourage greener packaging practices and is a complex and time-consuming process.

A further opportunity identified for reducing procedural carbon emissions relates to imaging modality choices during vascular interventions. Digital subtraction angiography is commonly used in vascular procedures for its enhanced imaging quality; however, recent research has shown that this technique contributes significantly more to procedural carbon emissions compared with standard fluoroscopic imaging runs.[36] Considering minimising the number of digital subtraction angiograms and using fluoroscopy where possible could potentially contribute to overall reduced CO_2e per procedure without compromising patient safety, in addition to reducing procedural radiation exposure.

Conclusion

This exploratory study aimed to estimate the carbon footprint associated with four vascular surgical procedures, demonstrating that emissions vary by procedure type and are largely driven by disposable medical devices and consumables.

The findings from this study represent a small pilot single-centre investigation, but at the time of writing it is the first study to describe the environmental impacts of arterial vascular procedures commonly performed for life- and limb-threatening pathologies. The procedures represent a common subset of procedures used in clinical practice due to their minimally invasive nature and favourable patient outcomes, but their dependence on disposable devices and consumables presents a difficult environmental challenge.[19]

To address this environmental challenge, a multifaceted approach will be required, involving reduced reliance on disposables through increasing use of reusable textiles and instruments where possible, implementing better waste management protocols and collaborating with industry partners to promote the development of more sustainable devices and packaging.

Despite the limited scope of this study, the results highlight the significant carbon footprint generated by endovascular and hybrid techniques. These findings provide us with essential baseline data to build upon for future efforts aimed at reducing the environmental impact of vascular surgery, and future work is required to validate and consolidate the findings through larger multicentre studies with more comprehensive data collection.

KEY MESSAGES

- Hybrid and endovascular arterial procedures generate a substantial carbon footprint.
- Carbon emissions varied significantly by procedure type, and disposable medical devices accounted for the largest share of total emissions across all procedure types.
- The study identified practical and implantable sustainability interventions such as switching to reusable surgical textiles, use of percutaneous techniques and imaging optimisation to meaningfully reduce emissions.

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ORIGINAL RESEARCH

The ulcer with no fixed abode: barriers in accessing venous healthcare for individuals experiencing homelessness and using intravenous drugs in Bristol, UK

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Plain English Summary

Why we undertook the work: People who are homeless and inject drugs have higher rates of cardiovascular (heart and artery) disease. There are currently no reported studies focused on venous (vein-related) disease, despite the risk of blood clots (deep vein thrombosis or DVT). DVTs can be deadly if left untreated. Damage to the veins is common in this patient group and can lead to chronic leg ulcers, pain, infection and swelling, which can be life-limiting and life-threatening. This is a health inequality and overstretching finite NHS resources. Diagnosis requires outpatient ultrasound scans prior to treatment (eg, blood thinning medication and/or surgery). These patients often do not attend these appointments, instead presenting at A&E with more critical health. This can result in delayed treatment, higher risk and greater NHS expense. Known barriers exist to accessing healthcare; however, the relevance of these to venous healthcare has not been explored previously.

What we did: 15 individuals were recruited and interviewed in drop-in clinics in a charity and homeless GP practice in Bristol. Staff in these organisations have built rapport and are known to the participants so directed potential participants. Eligible participants had a history of venous disease, homelessness and injecting drugs. Semi-structured interviews were used to explore the barriers faced, which were then analysed into themes.

What we found: Five separate themes emerged: (1) competing priorities; (2) stigma; (3) practical barriers; (4) treatment limited to anticoagulation and/or compression stockings only; and (5) knowledge and understanding of own health. Barriers previously reported to healthcare utilisation also apply to venous healthcare including stigma, practical barriers and competing priorities to healthcare (eg, drugs or housing). Appropriate opioid substitution treatment (used to help individuals cope with withdrawal symptoms) reduces the need to earn money for drugs, which readjusts priorities towards healthcare. Specific barriers exist related to venous healthcare including: (1) venous ulceration and associated odour cause stigma and embarrassment; (2) treatment for chronic venous conditions is limited to compression with inherent barriers from required compliance; (3) harm reduction and homeless health services cannot refer individuals for specialist vascular review/imaging; and (4) poor knowledge in the target population of groin-related pathologies such as DVT contributes to delayed presentation.

What this means: Barriers exist to accessing venous healthcare with both acute (eg, DVT) and chronic (eg, ulceration) disease for individuals experiencing homelessness and using intravenous drugs. These barriers are exacerbated by poorly managed opioid substitution treatment. Venous ulceration causes stigma and embarrassment contributing to untimely healthcare utilisation. Treatment can be limited to compression and/or anticoagulation only and specialist vascular review/imaging cannot be requested directly by harm reduction and homeless health services. Vascular services need to consider how best to engage and serve this patient demographic to challenge this health inequality.

Abstract

Background: Individuals experiencing homelessness and using intravenous drugs are high risk for acute (eg, venous thrombosis) and chronic (eg post-thrombotic syndrome, ulceration, venous insufficiency) venous disease. Healthcare utilisation is erratic with known access barriers. This study sought to understand the relevance of these barriers in accessing venous healthcare by exploring lived experiences in Bristol, UK.

Methods: Participants with a history of homelessness, intravenous drug use and venous disease (n=15) completed a one-to-one semi-structured interview focused on lived

experiences of accessing venous healthcare. Thematic analysis was undertaken, applying an interpretivist research paradigm.

Results: Five distinct themes were identified: competing priorities, stigma, practical barriers, anticoagulation/compression treatment only and knowledge of own health. Withdrawal symptoms present a daily burden, skewing priorities towards earning money for illicit drugs. Combined with previous stigmatising experiences, this results in delayed presentation until health is critical. The transient lifestyle of street homelessness conflicts with the traditional UK healthcare model of arranging/attending appointments. With this challenge of accessing primary healthcare, chronic venous conditions rarely result in referrals for specialist vascular review/imaging. Treatment instead focuses on anticoagulation for thrombosis and compression therapy for ulcers; both have inherent barriers from long-term compliance requirements. Acute and chronic venous disease are poorly understood by this population.

Conclusion: Participants described inequitable access to venous healthcare. The barriers faced are comparable to general healthcare utilisation, but with specific barriers to venous healthcare. Individuals are heavily reliant on community-based homeless health and harm reduction services and face challenges accessing specialist vascular services.

Key words: homeless, intravenous drug user, venous disease, deep vein thrombosis, barriers to healthcare

Introduction

Unstable housing is a growing UK issue with 178,000 households assessed as homeless in 2023–24.[1] Health inequalities exist for this population,[2] with untimely healthcare utilisation often via Accident and Emergency (A&E) when health is critical resulting in long periods of inpatient care,[3–5] higher mortality,[2] National Health Service (NHS) financial strain[6] and 'tri-morbidity' (poor physical and mental health with substance abuse).[7]

Intravenous drug use (IVDU) has a higher prevalence in homeless individuals,[8–10] reported in one study in 78% of individuals with a life history of homelessness.[11] Groin injection is the most common access site,[12] with long-term injection leading to sinus formation – a hole in the skin and subcutaneous tissue allowing direct venous access.[13] This reduces the risk of 'missing a hit',[14] but also allows discretion from the public, family members or police,[12] perhaps explaining higher rates of groin injection with individuals experiencing homelessness.[15]

Femoral vein damage occurs in the vast majority of individuals who groin inject[13] due to various mechanisms detailed elsewhere.[11,15–17] Deep vein thrombosis (DVT) is reported to be three times more common with femoral injection,[12] and long-term damage results in venous insufficiency[13,18] and leg ulcers.[3] A general lack of uniformity is reported in treating longstanding venous disease in this population.[19]

Improved prevention and/or treatment of chronic conditions such as ulceration may save individual suffering and costs to the NHS;[20] however, barriers to accessing diagnostic/treatment pathways need to be established. There are currently no qualitative studies focused on the barriers for this population accessing venous healthcare. Venous healthcare is multifaceted, with diagnostic and treatment pathways including but not limited to duplex assessment for acute DVT, ulcer assessment, prescription of compression hosiery, duplex assessment for venous incompetence/insufficiency and venous intervention (eg, deep venous recanalisation, foam sclerotherapy, radiofrequency ablation). The barriers to accessing healthcare in general have been explored in previous qualitative research based in Australia,[8,21] Canada,[22,23] Ireland,[24–26] the Netherlands,[27] the UK[28] and the USA.[5,29,30] A range of themes have been described including stigma,[5,6,21–23,25,28,30] practical barriers,[21,24] poor adherence to treatment[6,8,26] and chronic pain being a low priority concern.[22] The aim of this research is to explore the relevance of these and other barriers in accessing venous healthcare (diagnostics and/or treatment) from service users' perspective.

Methods

Research methods

This qualitative research used interviews and thematic analysis applying an interpretivist research paradigm.[31] The Principal Investigator was in-post locally as a Trainee Vascular Scientist, thus arriving at the research with biases based on interacting with the target population in an acute hospital setting for vascular ultrasound investigations.

Ethics

Health Research Authority (HRA) and Research Ethics Committee (REC) approval was obtained via the Integrated Research Application System (IRAS) (ID 342033). Newcastle University approved and sponsored the project.

Recruitment

Recruitment used non-probability sampling methods. Convenience and purposive sampling were used as defined by Stratton.[32] This approach was adopted due to transient nature of the individuals

using intravenous drugs and experiencing homelessness. Traditional recruitment methods of contacting via post and telephone were not viable with this population due to the challenge of having no fixed abode or telephone number. Recruitment took place at Bristol Drugs Project (BDP), a charity providing harm reduction services, and The Compass Centre, a BrisDoc Homeless Health GP practice. These venues were used for ease of participant access with specialist staff available on site for medical, emotional, social and safeguarding support if required. The Principal Investigator was based in these venues for a two-week period in November 2024. Local staff in these venues acted as gatekeepers and directed potential participants from drop-in clinics to the research team. The Principal Investigator explained the study using a Participant Information Sheet and potential participants who met the inclusion criteria were consented by the Principal Investigator who obtained informed written consent using a consent form. Participants were renumerated with a £10 cash stipend. Light refreshments were provided during the interview. A research grant was awarded by The College and Society for Clinical Vascular Science (CSVS) to cover transcription and stipend costs.

Sample size

An initial sample size of 10 was planned for and was extended to 15 due to early success with recruitment, at which point data saturation was reached and recruitment ceased. It is not normal practice to complete a power calculation for qualitative research, so this sample size was chosen in line with other similar qualitative studies as well as pragmatic considerations of the time scale of the project as it was completed between September 2024 and May 2025. The inclusion and exclusion criteria used in the research project are shown in Box 1 and the demographics of the participants are shown in Table 1.

Box 1 Inclusion and exclusion criteria used in the research project.

Inclusion criteria:

People with a history (or current status) of:
- Venous disease (acute and or chronic DVT, venous insufficiency, venous ulcers, post-thrombotic syndrome)
- Homelessness
- Intravenous drug use

Exclusion criteria:

People who were:
- Unable to give informed consent due to being drug-induced or cognitively challenged (eg, difficulty with processing information or reasoning).
- Unable to communicate in the interview setting due to drug use as these people may not be able to recall an account of their experience accurately.
- Unable to recount their experience accurately due to a mental health issue or dementia.
- Unable to speak fluent English.
- In a high state of anxiety or distress as the interview contains topics that are potentially upsetting and, due to socioeconomic status, the population can be regarded as vulnerable.

Table 1 Participant demographics.

Variable	Frequency (no. of participants)
Gender characteristics	
Male	67% (n=10)
Female	33% (n=5)
Age at time of interview	
18–29 years	0% (n=0)
30–39 years	13% (n=2)
40–49 years	60% (n=9)
>50 years	27% (n=4)
People with lived experience of homelessness	100% (n=15)
People with lived experience of intravenous drug use	100% (n=15)
Active ulceration at time of interview	33% (n=5)
History of venous thromboembolism (VTE)	87% (n=13)

Data gathering

Participants completed a one-to-one face-to-face semi-structured interview about their experiences (mean length of time 32 minutes). Interviews occurred in the host venues concurrently with drop-in clinics for participant convenience. An interview schedule was used with open-ended questions in a semi-structured manner, allowing for discussion to emerge. The questions were written and refined based on themes explored within the literature review, casual conversations with host venue staff and consultation with the Bristol Drug and Alcohol Health Integration Leadership Team. Follow-up questions were asked as required to expand/elaborate on points, opinions, thoughts and/or feelings. The interview schedule evolved throughout the interviews influenced by the interactions of the researcher with the participants and casual conversations with staff in the host venues. Interviews were audio-recorded and outsourced for transcription (UK Transcription).

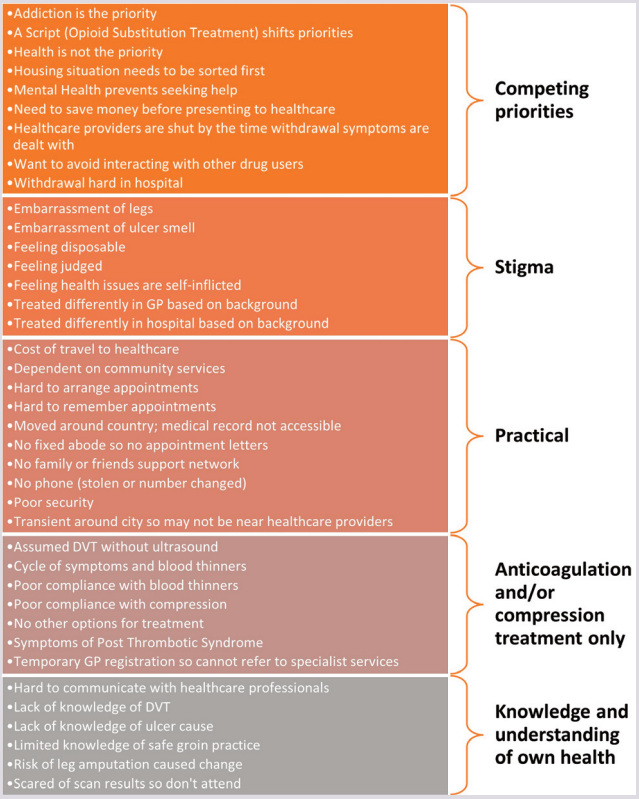
Data analysis

The data were handled using NVivo 15 software[33] and thematic analysis was undertaken applying the Braun and Clarke method (Table 2).[34] The coding method was data-driven with codes systematically assigned by the researcher, which were then formulated into sub-themes. Reflexivity was practised throughout the coding which took place over several weeks and the content was discussed with members of the research team experienced in quantitative research. Over time the codes were grouped into sub-themes and commonality was established to name the overall themes. These were further refined to ensure the name of the theme accurately reflected the sub-themes assigned. The assignment of themes would have been influenced by the biases of the Principal Investigator working in post within a diagnostic vascular laboratory and reflected on throughout the process.

Table 2 Thematic analysis method used in the study (Braun and Clarke)[34]

Stage of analysis	Name	Description
1	Familiarisation	The entire interview data were read with notes of preliminary ideas made for codes that can describe the content. This was also used to check the accuracy of the transcription.
2	Generating initial codes	The entire dataset was coded systematically. Each time something of interest was said, it was coded with a description of what was said, not an interpretation.
3	Searching for themes	Codes were collated into themes. Themes are broader than codes and involved active interpretation of the codes and the data.
4	Reviewing themes	Themes were checked to ensure they reflected the attributed data. All extracts were read through to check that all data within the themes cohered. All themes are distinct from one another.
5	Defining and naming themes	Themes were refined and named. Theme names are descriptive of the data within that theme.
6	Producing the report	Write-up of results. This added a further level of reflection on the themes, the data and the examples used to illustrate themes.

Figure 1 Summary of sub-themes (left) developed by the researcher grouped into the themes (right) derived from the thematic analysis of the interviews detailing the barriers to accessing venous healthcare.



Unfortunately, it was not possible to undertake triangulation validation as analysis was undertaken solely by the Principal Investigator as part of an MSc level award. Participant validation was attempted but was not possible given project time constraints and the transient nature of individuals experiencing street homelessness.

Results

Sub-themes were grouped in commonality by the Principal Investigator to form five separate themes. These themes are distinct from one another and centre around the research question. The overall thematic analysis findings are shown in Figure 1 with a more detailed breakdown below.

Competing priorities

Competing priorities describes the need for individuals to deal with other daily concerns deemed more important than health concerns. This centres around the need to earn money for a variety of needs including food and drugs as well as gain stable housing.

Competing priorities was a significant barrier to presenting to healthcare, particularly as addiction was always the main priority:

"When you're in that addiction state, that's the only thing that matters."

To serve this addiction, all participants described waking up each morning with a focus to 'get well' – a common expression used for alleviating withdrawal symptoms:

"That was the main priority of the day (getting well). Once I'd dealt with that, then I'd deal with my health and everything comes later."

Getting well required working to earn money for drugs including begging, shoplifting, prostitution or dealing. This commonly took all day to earn enough money meaning health was the last priority and could often only be dealt with once primary healthcare was closed:

"Your time just gets consumed when you're homeless … you're going out and begging for money and stuff … you need to get well before you do anything …. So, you spend the whole day trying to get well. By the time you've done it, everything's shut."

This situation is made worse when struggling with venous ulcers:

*"Wake up in the morning, sheer panic … you're getting the usual withdrawal symptoms … you're broke and you're sore, you can't move, and especially when you've got f****** ulcers because that makes the pain twice because your pain threshold has gone … Then, all of a sudden, you wake up and think, "Oh, I need help … it's all shut, I can't do it. I'll do it tomorrow" and, of course, it gets worse and worse and worse."*

One participant described an extreme experience of this with reduced sensitivity to pain from opioid use resulting in their venous ulceration progressing down to the bone before presenting to healthcare. Multiple participants talked about peers who had lost limbs or lives due to delayed healthcare presentation caused by this daily cycle. Even when health became critical, some participants would still wait to attend A&E:

"I'd always try to hold out until it was my payday because I never wanted to go in there with no money, with no cigarettes and stuff like that, and rely on people."

Several participants explained the severity of withdrawal symptoms as an inpatient leading to self-discharge before completion of treatment or forcing discharge by refusing treatment to deal with their addiction.

Symptoms of post-thrombotic syndrome (PTS) were described with chronic intermittent lower limb pain and swelling following DVT. PTS occurs due to the associated damage to the valves and veins caused by a thrombotic event in the affected limb resulting in chronic venous insufficiency. The daily need to 'get well' meant there was no time to alleviate these symptoms through rest, exacerbated by the transient nature of street homelessness:

"You're not able to settle in a place or be settled long enough yourself, because you need rest, you need nutrition, you need to have to sit down and be able to heal, you need to be able to elevate your legs."

All participants talked about 'a script' referencing prescribed opioid substitution treatment (OST). OST includes prescribed replacement opioids such as methadone and buprenorphine, which are used to support withdrawal from opioids such as heroin. With appropriate OST, health could be addressed during primary care opening hours and reinstated as a priority from the reduced need to 'get well'.

Housing was an area of significant concern for many and particularly those living on the street at the time of the interview. Attending housing meetings, applying for housing or securing a hostel for the night were all described as higher priority than health. There was a perception by those in this situation that, if their housing situation were improved, health could then be prioritised

"I'm bidding on Home Choice. I'm really close to … getting my own council property, and when that happens, my life's going to change massively because … with a home … I can look after myself better."

However, housing comes with the financial pressure of rent that can trap individuals in a cycle due to unsustainable rental costs. This can result in healthcare remaining a low priority concern:

"I'm a qualified chef … I've always had opportunities. If you go and get a job, if you're at Salvation Army, they let you have four weeks free … but after that you're then liable for the £330 a week rent and the £125 a month service charge. So that's £1445 … without paying for food."

Mental health (including low self-esteem, depression, bipolar disorder, psychosis and ADHD) was also described as a competing priority over physical health, with participants associating this with an ability to engage with healthcare professionals. This made it challenging to attend outpatient appointments as well, with several individuals describing situations where they feared leg amputation if they presented to healthcare.

Stigma

Stigma relates to the treatment participants received based on their background as an individual experiencing homelessness and using intravenous drugs. This feeling and fear of stigma can be due to previous interactions with healthcare providers and a general feeling of embarrassment for presenting to healthcare with self-inflicted concerns. Individuals described severe stigma in society ranging from parents shielding children from this population in the street, abusive language/behaviour and, in some instances, this was so extreme with being woken up on the street, being urinated on or set on fire. Participants spoke passionately about healthcare being a place of safety and this makes stigmatising behaviour in healthcare providers even more degrading.

Stigma was referenced by all participants commonly manifesting in different treatment based on background:

"They don't treat you the same (if you're an addict) … as a normal person."

Stigmatising attitudes can be overtly apparent as soon as healthcare staff realise IVDU status:

"I've gone into the hospital … and they're talking to me … and they're all chirpy and that … then the tone of voice just completely changes and the whole demeanour changes. It's almost like they've taken it to a personal level to basically deflate you by saying certain things that are quite hurtful and painful."

Late presentation to healthcare results in being seen in A&E with lower limb venous symptoms and the stigma of IVDU often results in long A&E waits:

"You're sat six hours waiting to be seen by the triage, when someone else would come after you and you're still waiting … and they talk about you in the back … but we can hear … it's like they've got no time for people that do drugs, to be honest."

While appreciation of systemic long A&E wait times was mentioned, many associated their treatment with their background:

"And I do believe, I've got absolutely no evidence that it's intentional, but when you're going into A&E and you're waiting seven hours, and just about everybody else is coming in and getting seen in four … Your head's going to tell you it's intentional and there's a judgement being made on you because of what you're in for and because of your status as a homeless person."

Participants described giving up after several hours and walking out. The experiences of individuals who waited were quite negative including stigma during an ultrasound scan for DVT:

"As soon as I mentioned that it's through an old drug addiction, like I just saw the lady's face (who was completing the ultrasound scan) go from a smile to upside down to a frown. She just wanted me out of there."

Stigmatising behaviour could be so overt that participants could be refused a same-day diagnostic ultrasound scan for DVT:

" 'Yeah, it could be a clot', and this is no word of a lie, you can ask my keyworker, the doctor turned round and said … 'But you're a drug user, you have to come back tomorrow'."

Multiple participants described lack of privacy in hospital – for example, when showering or toileting due to perceived staff suspicion of opioid use. One participant described how curtains needed to remain open with visitors requiring identification. An overriding sense of not being listened to and feeling worthless was portrayed, shown in this extreme situation a week prior to the interviews:

"I pressed the buzzer. In the time that I'd pressed the buzzer, I managed to hang myself, snap the sheet, and still it was about an hour and a half from the time I pressed the buzzer to the time they answered it."

Participants explained that, when an individual attends hospital, they are desperate for help but then feel judged. Individuals perceive staff are trying to oust them. However, focused efforts are needed to give as much help as possible before discharge:

*"And when you're in hospital, it's that situation, I think there's a lot of people that think what they've done is just such a shock that they've ended up in hospital because of it, they're like, 'S***, now I've got to stop'. And that's when you need to get them."*

Treatment pathways were often described as different due to individual background. One participant described how staff thought they were lying about pain scores to be given opioid pain therapy while another described waiting for several hours in A&E before receiving any pain relief. Stigma can remain when using healthcare despite being clean for several years:

"You're looking at my records and you're judging me because I was an addict. I see you looking at my notes, I see the alerts, I know what they mean. If you're not willing to offer me the same pain pathways that you would offer to a regular person, then I need to speak to your practice manager, because you're discriminating against me because of my past."

Stigma of using intravenous drugs also then combines with embarrassment, which was a commonly used term particularly associated with chronic leg changes: sinus formation, oedema, discolouration and varicose veins. Individuals felt judged entering general practitioner (GP) practices or using public transport for appointments with the smell of venous ulceration. One participant detailed an extreme example of not leaving their hostel for four years in the longest stretch due to embarrassment, eventually presenting with whole leg, maggot-infested ulceration. Several participants explained how this stigma linked with a feeling of issues being self-inflicted:

"It's the embarrassment side of it as well because I hate going to hospitals when it's drug related because I feel so ashamed. This is my fault. I've done this and I've found it hard taking up a hospital bed that could be used for someone, you know, like a pensioner with COVID or childhood cancer, you know, whatever."

Practical

Practical barriers relate to the logistical aspects linked with arranging and attending healthcare appointments as an outpatient. These include barriers such as lack of fixed telephone number, no fixed address to receive appointment letters and unknown distance to healthcare providers due to transient movement around the city.

All participants referenced a variety of practical barriers. Lack of family and/or friends support network was most referenced linked with attending outpatient appointments or having encouragement to seek medical attention. Consequently, participants relied on support workers to schedule, remind and physically take them to outpatient appointments. The situation would be different without a support worker:

*"I'd be f*****. But now, because … I've got a mental health worker, I've got people behind me, they're ringing me up every day, make sure I know about this appointment."*

There was a reliance on community services explained, including but not limited to the interview host venues. Individuals with active venous ulcers explained how community nurses linked with the Homeless Health Service visited them regularly in temporary accommodation for wound cleaning and dressing. Participants often had multiple concurrent appointments at the time of interview to collect OST, blood thinning medication, ulcer assessment/redressing and/or have compression bandaging fitted. This was also coupled with appointments regarding housing and safeguarding. Hospital and GP outpatient appointments were described as more challenging due to set time/date requirements, focus on only one aspect of health and lateness resulting in refused consultation/treatment. Flexible appointment structures comparable to drop-in services in the host venues were valued by participants:

"They advise you. They give you information that you never knew … Same day scripts and stuff like that. They help with benefits here … They even help with housing. They've got nurses here, doctors here … I would say this place is a lot better for people living on the streets because they've got everything here that you require. Even sleeping

bags ... and they don't turn you away ... Whereas if it was the doctors', it would be like you have to ring up and make another appointment, which could be in a week's time."

Wider practical barriers included not being contactable via telephone due to poor security and numbers frequently changing. This presented challenges for arranging appointments and/or receiving letters/results (sent via Short Message Service (SMS)). Physical letters often do not arrive due to temporary, absent or inaccurate address records resulting in missed appointments. Individuals can move around the country, and one participant explained how their medical records were inaccessible to local services leading to a breakdown in the continuity of care. Some participants mentioned how the transient movement around the city when experiencing homelessness gave uncertainty of distance to healthcare providers, exacerbated by difficulties walking with pain, swelling and ulceration.

Anticoagulation and/or compression treatment only

This theme related to treatment for participant's venous disease and how this was limited to anticoagulation for episodes of acute DVT and compression hosiery for ulceration. Both require long-term compliance to have effectiveness, which brings inherent challenges for this population.

Participants described anticoagulation for DVT treatment, which is usually diagnosed on ultrasound. Diagnosis for this population was sometimes based on medical history alone, therefore acute DVT was assumed without ultrasound confirmation:

"Like, it would be because I've been IV using recently so, "Oh, it must be that so we'll just whack you back on blood thinners."

Even with ultrasound diagnosis, treatment often focused on a cycle of resolving acute DVT alone, which participants had frustration over.

*"It's always, like, scan, 'No blood clot, blood clot, blood thinners, f*** off', and that's it."*

PTS symptoms were described yet none could recall discussion or investigation into this. Anticoagulation varied with some individuals on lifelong prescription and others on 6–12-month cycles based on symptoms.

It was clear that participants found long-term anticoagulation a burden as it was challenging to remember to collect prescriptions and, even if they were collected, individuals would just accumulate them and not take them. Individuals struggled to articulate why, but it was a recurring scenario. Some individuals showed a lack of understanding of why they were on long-term anticoagulation if the blood clot had resolved. Poor compliance led to resurgence of symptoms, which may warrant appointments and ultrasound scans starting the cycle over again. There were some more emotive reasons for not taking anticoagulation including self-harm bleeding risk and continued IVDU bleeding risk:

*"When I was still f****** banging up [injecting] in my groin, I didn't want to take them then, as well, because I am a bleeder anyway."*

Those with chronic symptoms such as venous ulcers described similar frustration with the compliance required for compression hosiery. Some of the participants in this study were engaging in healthcare by attending the host venues for compression and dressing changes yet arrived with their legs wrapped in plastic bags. Compression was described as cumbersome and uncomfortable so would often be cut off by the individual before the next appointment. Compression was generally described as effective, with individuals adamant that it would help their ulcers but having to attend regular appointments (2–3 times a week) for over a year provides a significant barrier to individuals who already struggle to attend appointments. This compression treatment was provided in the host venues and associated nurses who visited hostels daily to perform wound cleaning and dressing.

Knowledge and understanding of own health

This theme relates to a lack of understanding to identity key symptoms, which can result in delayed presentation. Most health knowledge in this population is shared on the street and gathered through experience. Several participants explained how there was a general lack of DVT knowledge resulting in delayed presentation:

"I didn't think it was that bad, because I didn't really know much about it. I don't know much about DVT. I'd never really heard about it. So I never really knew about it."

Only following initial diagnosis did individuals better understand DVT symptoms and when to seek medical help:

"I know, more, what to look out for now as well, like any sort of swelling, any sort of redness, any sort of pain, any uncomfortability [sic]."

It was suggested more drop-in services focused solely on groin/leg health including DVT would raise awareness:

"No, leaflets are no good … There should be some form of drop-in advice centre. Just somewhere that you can go."

Several participants talked about safe groin injecting practice due to the proximity of the artery, nerve and vein. A lack of knowledge of the key symptoms linked with different pathologies (eg, DVT versus false aneurysm versus abscess) provided uncertainty of when/where to seek help:

"There's no handbook written like say, 'If this happens go to this, if this happens do this, if this happens do this'."

Limited knowledge of ulcer causes was also found even if the individual had been suffering for several years, with none of the participants asked able to explain why they had an ulcer. Some were obviously perplexed that their ulcer had appeared years after

groin injection. Many participants (n=5) mentioned the risk of leg amputation acting as a catalyst for healthcare utilisation:

> *"I didn't want to lose my leg because of running around playing with her and stuff like that. I didn't want to be the daddy that was crawling around to see my daughter."*

An inability to communicate with healthcare professionals was described with support workers relied upon to explain medical conditions/notes:

> *"They [healthcare staff] wouldn't really sit down with me and explain what this meant … The only person who'd do it was … the drugs workers. I'd say to them, 'Do you know what this means or that means?' … I'm not from a medical background so I don't really understand a lot of like … I've got dyslexia as well, so reading writing can be quite difficult."*

Discussion

Individuals experiencing homelessness and using intravenous drugs face barriers in accessing venous healthcare. Some of these are comparable to general healthcare utilisation including stigma, competing priorities and practical barriers. There are barriers specific to venous healthcare – notably, the embarrassment of ulcers, the inability to refer patients for specialist vascular review/imaging, a lack of treatment options available for chronic venous conditions (ulcers, PTS and venous insufficiency) and a lack of DVT knowledge prior to diagnosis.

Competing priorities

Competing priorities provide a significant barrier to accessing venous healthcare, with participants describing how addiction takes priority. Harris[35] describes this as a 'cyclic dynamic' to obtain illicit drugs. Whilst other studies draw attention to different daily priorities akin to Maslow's Hierarchy of Needs,[8] this sample focused solely on the concept of 'getting well'. Klop *et al*[27] describe a daily survival mode, which participants recounted during times of severe addiction. Consequently, multiple participants attend A&E when health is critical – a common pattern of healthcare utilisation in this population.[24]

PTS does not feature in the wider literature; however, these symptoms were described by most participants. PTS-associated pain and ulceration increased the risk of further damage through IVDU for pain relief purposes. O'Carroll and Wainwright[24] describe continued injection around ulcers, as mentioned by several participants. Comparable with previous findings, participants conveyed that repeated groin injection is due to ease of access, public discretion[12,15] or lack of other access sites.[14]

Mental health featured heavily as a competing priority to venous health, with equally harrowing suicide attempts detailed by Harris.[35] Cornford *et al*[3] and Harris[35] both describe how fear of leg amputation prevents presentation; however, this sample described the risk of acute limb loss as a catalyst for behaviour change.

OST reduced the pressure to 'get well' resulting in readjusted priorities towards healthcare. Lewer *et al*[4] found that appropriate OST significantly reduces the likelihood of A&E presentation. Multiple participants described ineffective inpatient OST management, as previously reported;[3,24,35] presentation would be delayed by waiting for payday to serve addiction whilst admitted, as found by Harris.[35] Harris *et al*[36] highlight the national inpatient OST inconsistencies, with severe bureaucracy limiting timely intervention. This contextualises participant descriptions of leaving A&E after waiting hours for pain relief or OST.

Attempts have been made to standardise hospital OST approaches and reduce this barrier; however, strategies can exacerbate feelings of stigma and mistrust – for example, point-of-care urine testing.[37] Stigma has been described in relation to OST status due to the implication of addiction.[5,30] Participants did not mention this, perhaps due to a degree of acceptance embedded from long-standing IVDU history.

Stigma

Stigma towards participants featured heavily and provided a significant barrier to presentation. Participants described being treated differently in healthcare based on IVDU status even if this was historic, which is widely reported.[5,24–26] Stigmatising healthcare language is often used in medical notes rather than neutral person-first language,[37] thus influencing staff preconceptions.[30] Gilmer and Buccieri[22] highlight how staff demeanour changes upon realisation of IDVU; comparable examples feature in this sample. Participants suggested this treatment was worse in the city centre hospital than in suburban hospitals. This may be linked to compassion fatigue as described Dowdell *et al*[29] following years of dealing with acute withdrawal cases due to the comparative ease of access to the city centre hospital. As the skewed priorities of this population do not conform with norms of self-care,[35] perhaps staff cannot relate to the individuals' situation resulting in compassion fatigue. Subsequent care is not trauma-informed, and participants spoke about being made to feel their venous health issues were self-inflicted. Trauma-informed harm reduction techniques should consider the reasons for IVDU, emphasising that substance abuse is a health issue, not a moral failure.[23–25,28] Ultimately, individuals are presenting to A&E in times of desperation and then negative stigmatising experiences with poor continuity of care degrade trust.[21,25,28]

Poor continuity of care was described by the participants, especially those in unstable housing. For some participants housing was a higher priority than health, as described by Harris.[35] O'Donnell *et al*[26] associate this situation with current homelessness or sex workers. Due to bed shortages, UK hospitals are pressurised to discharge medically fit individuals with inadequate provision for continuity of care such as OST.[37] Participants describe lack of continuity in anticoagulation when diagnosed with acute DVT, and Harris[35] highlights the lack of holistic support provided on discharge. Anticoagulation treatment pathways for DVT lack uniformity,[19] concurring with this sample. Unsurprisingly, these factors lead to erratic compliance with medication,[38] especially in instances of repeated PTS-like symptoms.[3]

Anticoagulation and/or compression treatment only

Gilmer and Buccieri[22] report overemphasis on prescribing medication compared with other treatments. Similarly, this sample reported prescribed anticoagulation without appropriate ultrasound investigations to diagnose DVT. The long-term compliance requirements of anticoagulation and/or compression treatments present inherent barriers for this population.[6,8,26,39]

Participants struggle to be referred to specialist vascular services; a comparable finding with oncology[35] and cardiology.[6] Permanent GP registration is required. However, this sample described how they are ostracised in GP practices, a view in agreement with Armstrong *et al*[28] who detail instances of refused registration.

Venous health has associated embarrassment that acts as a barrier.[3] The most intense feelings of embarrassment are reserved for the smell of leg ulceration and abscesses,[35] debilitating daily life. This shame and embarrassment has been reported in studies involving district nurses visiting hostels[28] and pharmacy-based needle exchanges.[5] In contrast, participants spoke highly of the host venues and associated nurses who visited hostels for wound cleaning and dressing. Care provided in these community settings was always described as non-judgmental, in keeping with Armstrong *et al*.[28]

Practical

Practical barriers corresponded with previous studies including time poverty due to other commitments,[35] transient movement causing geographical access issues[21] and difficulties accessing medical records with address changes.[6] Purkey and Mackenzie[23] suggest that the presence of an advocating support worker significantly improves the quality of healthcare delivered, although this was not specifically mentioned in this sample. Participants instead emphasised the necessity of a support worker in scheduling, reminding and physically escorting individuals to appointments. Participants were extremely complimentary of the care provided by the host venues, reiterating the need for drop-in services in community settings8 with suitably trained professionals who are easily approachable to build trusting relationships.[27]

Knowledge and understanding of own health

Previous studies have shown the value of access to diagnostic ultrasound scans in familiar community settings.[13] While not directly described by participants, the inherent barriers of attending appointments in hospital have already been discussed. Consistent with Cornford *et al*,[3] participant knowledge of DVT symptoms was limited prior to initial diagnosis. O'Carroll and Wainwright provide comparable examples of delayed presentation caused by uncertainty of DVT symptoms.[24] Participants described self-care of groin-related issues until symptoms were unbearable, which Robertson *et al*[40] associate with progressive and cumulative damage. Participants lacked knowledge of ulcer causes, which may link with Coull *et al*[20] who relate misdiagnosis with inappropriate use of antibiotics due to assumed infection rather than addressing underlying venous issues. This is despite venous insufficiency reported in 55% of one sample of groin injectors.[13] Consistent with Coull *et al*,[20] this sample described how chronic venous issues occurred long after ceasing IVDU. Doran *et al*[39] positively associate venous insufficiency with >15 years of IVDU.

Strengths and limitations

This is the first study to focus solely and directly on the barriers to venous healthcare from the perspective of individuals experiencing homelessness and using intravenous drugs in the UK. The findings may be transferable to similarly marginalised individuals in the UK and globally.

The findings are not generalisable as typical with qualitative research design and are limited to a specific social context of select individuals experiencing homelessness and using intravenous drugs in Bristol, UK. The findings may have reduced validity due to lack of analysis triangulation or participant validation. The findings represent solely one perspective and further insight would have been gained by interviewing healthcare or other independent professionals (eg, support workers), but this was beyond the scope of this research. The individuals recruited in this study were actively interacting with healthcare and/or harm reduction and therefore the views of individuals not interacting with these services may differ.

Conclusion

Individuals experiencing homelessness and using intravenous drugs in Bristol, UK are a marginalised group with unequitable access to venous healthcare compared with the wider population. The barriers faced are comparable to general healthcare utilisation. Some of these barriers are very specific to venous healthcare, such as the daily life-limiting stigma of venous ulceration, the lack of care consideration for chronic venous conditions and poor knowledge and understanding of groin-related pathologies. Individuals depend on the specialised harm reduction, homeless health and support worker services due to the barriers faced in accessing the traditional UK healthcare model. This study provides a useful insight into how these barriers present for individuals, albeit in a small study specific to one particular geographical area and is therefore not generalisable. Further research in this underrepresented area is required, with larger studies to establish the transferability of these findings and in doing so should consider how these barriers can be addressed. The inability of local harm reduction and homeless health services to refer individuals to specialist services such as Vascular is particularly concerning and would be a meaningful future research or service improvement area of focus. Equally, no studies exist to date that document the extent of chronic venous disease in this population, and quantifying these may serve useful in understanding the scale of this issue in a very underrepresented and underserved group suffering blatant health inequalities.

KEY MESSAGES

- Individuals experiencing homelessness and using intravenous drugs have unequitable access to venous healthcare
- Barriers to accessing venous healthcare exist including stigma, competing priorities, practical barriers, treatment being limited to anticoagulation/compression hosiery and limited knowledge of their own health
- Individuals in this population are highly dependent on harm reduction and homeless health services. These services are unable to refer to specialist vascular services for diagnostics or review as this requires the individual to be fully registered with a permanent GP practice.

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ORIGINAL RESEARCH

Embedding lived experience into the development of a rehabilitation programme for individuals with chronic limb-threatening ischaemia

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Plain English Summary

Why we undertook the work: Peripheral artery disease (PAD) affects millions of people worldwide and in its most severe form chronic limb-threatening ischaemia (CLTI) individuals face a number of health challenges. Although surgery can help restore blood flow to the leg/s, patients have highlighted the need for better education and additional support to live a healthier life. We therefore aimed to develop a programme that includes exercise and education to help them achieve this. Importantly, we wanted individuals with CLTI and their carers to help guide our research so that the programme reflects what matters most to patients.

What we did: We involved patients and their carers throughout our research project. Some helped with the study design and funding application, and others helped to prepare our questionnaires. Patients, carers and health professionals were invited to complete the questionnaires and attend an online workshop so they could share their views on exercise and education. Their responses helped identify the components that should be included in a rehabilitation programme. As part of the education aspect we created information sheets and presentations. Some patients and carers reviewed them and gave feedback. We also used the information in the questionnaires to understand what stops individuals from exercising and what we could put into place to help.

What we found: Involving patients and their carers helped shape our study in several ways. Their input improved the relevance and clarity of the study questions and ensured that the programme addressed real-world concerns. The questionnaires and workshop helped to identify the challenges that patients face after surgery and what is needed to support them. Patient feedback also helped improve the layout, language, images and overall clarity of the educational resources. However, as fewer people participated in this part of the research, it highlighted the importance of communicating with participants and offering different ways for them to provide feedback.

What this means: This work shows that involving people with lived experience of a condition can strengthen health research. By working together with patients and carers we were able to design a rehabilitation programme that is based on patient priorities and lived experience. The next step is to test the programme in a future study to see whether it is feasible and beneficial. Continued involvement of patients and their carers will remain central to this work.

Abstract

Background: Public and patient involvement and engagement (PPIE) is essential to improving the relevance, quality and impact of health research, while also offering potential benefits for those involved. Guided by the GRIPP-2 framework, this paper reports how PPIE was embedded throughout the development of a vascular rehabilitation programme for individuals with chronic limb-threatening ischaemia (CLTI) post revascularisation.

Method: Patient priorities identified in a James Lind Alliance (JLA) priority setting partnership initiated the study; individuals with lived experience supported the study design and funding application. A pre-study advisory group contributed to the protocol and development of the modified Delphi study. Alongside healthcare professionals, patients and carers participated in the Delphi activity which directly informed the structure and content of the rehabilitation intervention. Subsequent PPIE activity focused on refining educational materials and intervention components.

Results: Patient feedback improved accessibility, clarity and acceptability of programme resources, while behavioural barriers identified during the Delphi process informed the inclusion of structured behaviour-change tools.

Conclusion: Overall, embedding PPIE throughout strengthened the methodological rigour and applied relevance of the study. Continued commitment to meaningful PPIE will guide future feasibility testing of the rehabilitation programme.

Key words: public and patient involvement, GRIPP-2, chronic limb-threatening ischaemia, Delphi study, rehabilitation, patient engagement

Introduction

Public and patient involvement and engagement

There is increasing recognition that involving individuals with lived experience of a health condition in public and patient involvement and engagement (PPIE) activities enhances the overall quality of the research.[1-3] Beyond strengthening the research itself, evidence suggests that patient participation may benefit the individual directly, by developing their skills and knowledge and increasing their self-confidence and self-satisfaction.[4-6] Defining PPIE as research conducted with or by individuals with lived experience, rather than to, about or for them,[7] and guided by the GRIPP-2 long form,[8] this paper presents an overview of how the involvement of individuals with lived experience of peripheral artery disease (PAD) and their carers has been embedded throughout the research project, from priority setting through to the creation and refinement of a rehabilitation programme. In reporting this work, we aim to highlight the methodological importance and applied impact of integrating PPIE expertise in vascular rehabilitation research.

Peripheral artery disease

Peripheral artery disease (PAD) affects more than 236 million people globally, with prevalence continuing to rise.[9] Its most severe form, chronic limb-threatening ischaemia (CLTI), affects around 11% of PAD patients,[10] and is associated with poor mobility, frailty and reduced quality of life.[11,12] Even after successful revascularisation, reported mortality rates approach 50% within one to three years, 42% of patients experience major adverse cardiovascular events (MACE) such as myocardial infarction and stroke, and major amputation occurs in up to 20% of cases within the same time frame.[13-15] Whilst the benefits of a supervised exercise programme post revascularisation are established in those with the less severe manifestation of the disease (intermittent claudication),[16] there is a notable absence of studies evaluating whether similar benefits are observed in those with CLTI post revascularisation.

Research priorities

Individuals who live with a medical condition are encouraged to participate in establishing research priorities,[17] therefore priority setting partnerships (PSPs) such as those facilitated by the James Lind Alliance (JLA) bring patients and healthcare professionals together on an equal footing to identify evidence uncertainties and prioritise them.[18] Recently 373 patients and carers helped to identify the top 10 research priorities for PAD.[19] Three of them included: how can we reduce cardiovascular risk in PAD patients; how can we help educate better those patients who have poor circulation to their legs; and what can be done to improve outcomes in patients with severe circulation problems to their legs? In the absence of guidance specific to those with CLTI post revascularisation,[20] we conducted a modified Delphi study to inform the development of a rehabilitation programme specifically for this population.[21] This process represents an initial step toward addressing several of the identified research priorities and ensuring that subsequent programme development is firmly grounded in patient identified needs and priorities (Figure 1). The subsequent stages in the research project will involve a feasibility study to assess the acceptability and practicality of the intervention, followed by (if progression criteria are achieved) a randomised controlled trial to evaluate its effectiveness.

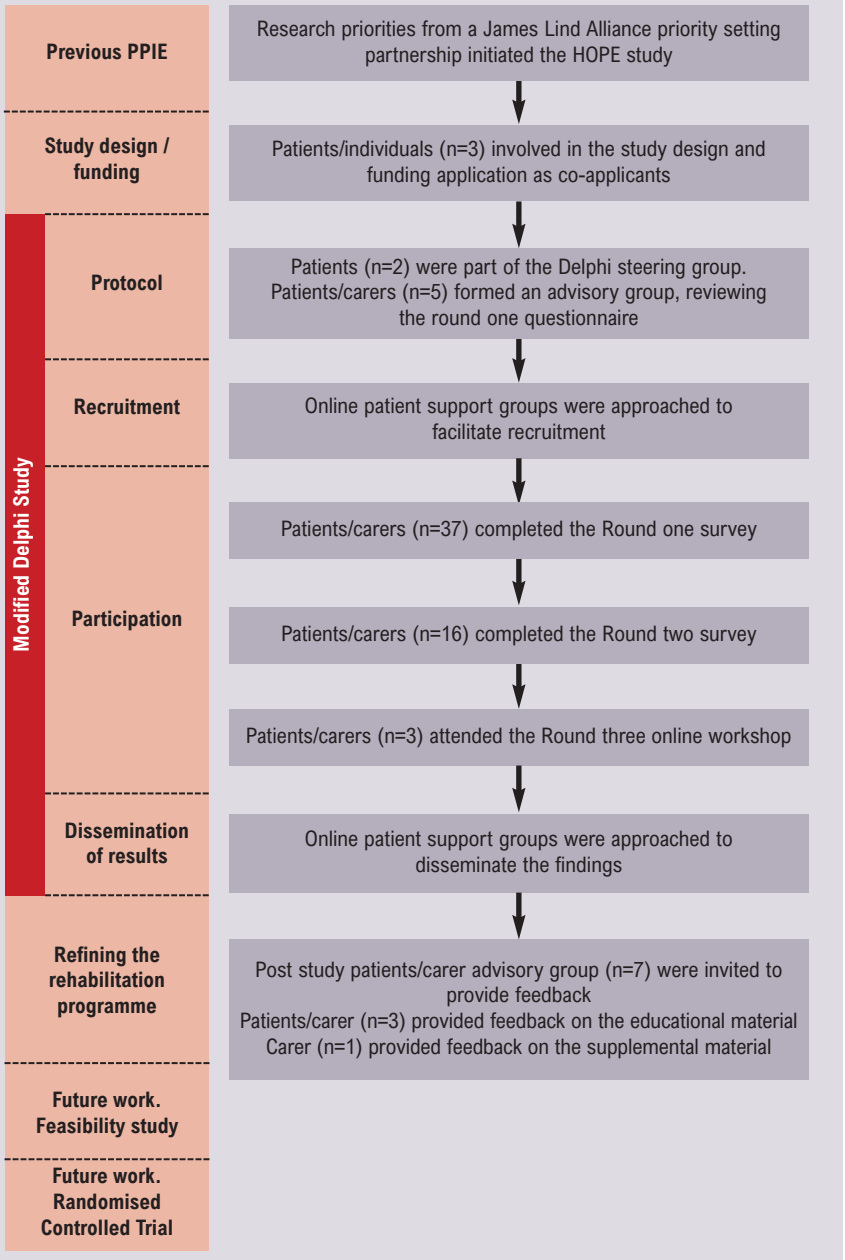
Study protocols and funding application

PPIE was embedded from the earliest stages of the research cycle, with three PPIE co-applicants supporting the National Institute for Health and care Research (NIHR) for patient benefit funding application, and development of the Delphi study and feasibility study protocols. The first co-applicant who lives with CLTI has completed training modules provided by the NIHR, has represented patient perspectives across multiple PPIE focus groups, and has involvement in several research studies as a patient participant. The second, who is a double amputee as a consequence of CLTI, has participated in two previous research studies as a patient. The third, who is a health and wellbeing professional, actively works within minoritised ethnic communities. All three reviewed the study protocols and the lay summaries to ensure equality, diversity and inclusivity. Suggestions included provision of a chaperone, a translation service, and changing the word “arteries” in the lay summary to “blood vessels”. All contributors were treated in accordance with ethical research principles,[22] and will receive funding for their time and commitment in accordance to the NIHR. All three were invited to join the modified Delphi study steering group. Whilst formal training was not provided, ongoing communication from the research team was offered throughout to facilitate meaningful engagement.

Modified Delphi study

Delphi is a consensus-driven technique, widely adopted in health services research, to harness the insights of healthcare

Figure 1 Flowchart demonstrating the involvement of individuals with lived experience in our research to date



professionals and individuals with lived experience of health conditions.[23] The purpose of this report is to describe how PPIE was embedded throughout our work. The full methodology and findings can be found in the published study.[21]

Steering group and advisory group

The research team brings together expertise spanning health psychology, clinical exercise physiology, cardiovascular rehabilitation and vascular surgery. Collectively, the team has extensive experience in the co-design, delivery and evaluation of complex rehabilitation interventions using mixed-methods and consensus-based approaches, including Delphi studies that integrate patient and clinician perspectives. Following the death of one of the PPIE contributors as a result of their condition, two of the three contributors joined the research team to form a steering group and coordinate the study activity. Additionally, alongside two other individuals with CLTI and a carer of an individual with CLTI (n=5), an advisory group was formed. As initial data for Delphi studies are collected via participant questionnaires, the advisory group reviewed the patient/carer questionnaire that had been designed by the research team. It was important to ensure that the questions pertaining to rehabilitation, exercise and educational needs were understandable, meaningful and aligned with patient priorities. Responses from the group included "maybe reword, have you/the person with CLTI had surgery?", "include some examples (of rehabilitation)" and "add the question, do you think it is necessary? (rehabilitation)" The feedback led to several refinements, including rewording items, additional questions, and the inclusion of illustrative examples to improve clarity and relevance.

Recruitment and participation

The study took place from November 2024 until June 2025. As social media provide an effective platform for connecting and engaging with patients within a condition- specific population,[24,25] patient and carer participants were recruited through patient- and public-led PAD Facebook groups. A member of the research team engaged with patients and carers via a webinar hosted by the Global PAD Association to support participation. In the initial round of the modified Delphi study, 20 healthcare professionals and 37 patients/carers responded to open-ended questions pertaining to rehabilitation, exercise and education. Demographics of the patient/carer group collected in round one are provided in Table 1.

In the second-round questionnaire 13 healthcare professionals and 16 patients/carers evaluated the inclusion of items that had been identified in round one, by indicating their level of agreement. Consensus was pre-defined as ≥70% agreement. The final round ran as an online workshop, attended by six healthcare professionals and three patients/carers. All findings were presented to

Table 1 Demographics of the patient/carer group in round one.[21]

Data gathered in round 1	n (%)
Individuals with CLTI/carers	**37**
Sex	
Male	6 (16%)
Female	31 (84%)
Age (years)	
40-59	8 (22%)
60-79	27 (73%)
80+	2 (5%)
Ethnicity	
White	27 (73%)
Black	1 (3%)
Mixed ethnicity	1 (3%)
Unknown/unclear	8 (22%)
Location	
United Kingdom	20 (54%)
Canada	2 (5%)
America	7 (19%)
Australia	1 (3%)
Unknown/unclear	7 (19%)
Surgery	
Stent	14 (38%)
Bypass	13 (35%)
Neither/unsure	10 (27%)

participants, and topics that had not achieved consensus were subjected to further review, discussion and re-evaluation through a voting process. The modified Delphi process successfully produced a final data set that informed the structure and content of the rehabilitation programme (Figure 2).

Reporting and dissemination of results

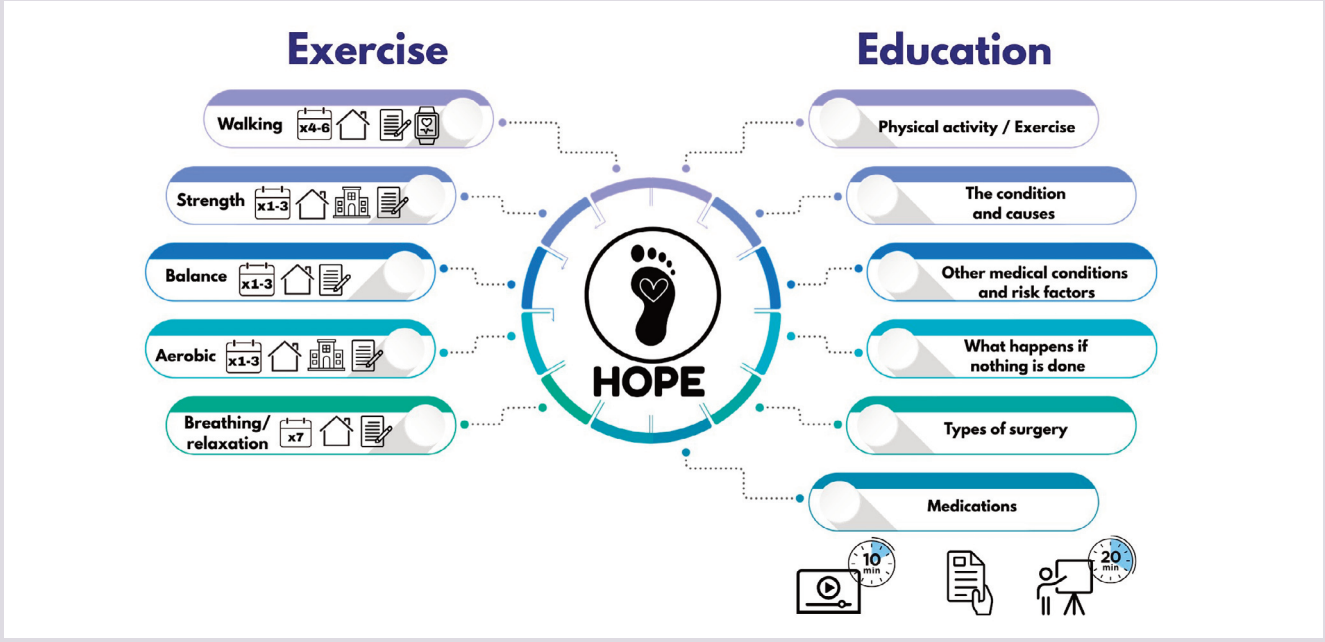
The Delphi study was reported in accordance with CREDES guidance,[26] and the GRIPP-2 short form was utilised, as both ensure thorough and transparent reporting of PPIE throughout the process.[7,27]

In addition to publication in a peer-reviewed journal,[21] and presentation at a scientific conference, the results were disseminated via the patient- and public-led Facebook groups that facilitated study recruitment. Evidence suggests that sharing the findings with the community that contributed to the initial stages of the research reinforces trust, demonstrates the impact of involvement and helps to sustain ongoing engagement in research activities.[28]

Refining the rehabilitation programme after the Delphi study

The Delphi activity established that the rehabilitation programme post revascularisation should include education on the condition and its causes, physical activity and exercise, other medical conditions and risk factors, what happens if nothing is done, types of surgery, and medications. Written educational material is only effective if it can be read, understood and remembered,[29] so patients with lived experience are ideally positioned to assess the comprehensibility, acceptability and actionability of such material.[30]

Figure 2 Infographic of the HOPE rehabilitation programme.[21]



Therefore, during the Delphi study participants were invited to indicate their interest in contributing to the development of the educational material (PowerPoint presentations and information sheets) which would take place after the Delphi activity itself. Once the material had been created by the research team it was emailed to the seven patients and carers who had expressed interest. Three contributors responded, offering comments such as "the educational material contains too much information and is crowded" and "some images are a bit drab," alongside suggestions including "images could be a bit brighter" and "font size could be bigger." The feedback received led to refinement of the layout, imagery, content and tone. The revised material was emailed back to the contributors and one responded, commenting "this material is far better presented", "the layout is somewhat more understandable" and "the pictures are far more relatable".

Adhering to clinical recommendations such as increasing physical activity is often challenging, as many find it difficult to adopt and maintain changes.[31] Therefore barriers to exercise that had been reported by participants during the Delphi process were categorised by members of the research team using the COM-B model (Capability Opportunity Motivation – Behaviour).[32] This helped the research team to understand what would need to change for the behaviour (exercising) to take place, and furthermore facilitated identification of potential interventions that might support this change.[32] Mapping barriers such as the weather (opportunity), co-morbidities (capability) and mental health (motivation) directly informed refinement of the programme. This included the incorporation of volitional help sheets[33] and action planning tools,[34] which participants can utilise in conjunction with the educational sessions. Seven patient/carers were invited to provide feedback and one responded, expressing strong advocation for the additional resources.

Reflection and future research

Via mixed methods, PPIE meaningfully influenced multiple stages of the research cycle, with the most substantial impact occurring during the Delphi exercise itself. This was attributed to context and process factors such as targeting a specific audience and disseminating the questionnaires online. Attrition rates are recognised as a limitation of the Delphi technique;[35] whilst attrition was high across successive rounds, representation from both individuals with CLTI/carers and healthcare professionals was maintained throughout. The final workshop included significantly fewer patients/carers (n=3) than healthcare professionals (n=6) which may have influenced the findings. However, throughout the workshop we experienced effective and meaningful patient participation. Notably, a patient contributor highlighted that although information on physical activity and exercise would be referenced within the broader category of risk factors, its significance warranted recognition as a separate topic. This prompted further group discussion and a unanimous decision to include it as a standalone topic. Evidence suggests that active patient participation is due to adequate preparation, facilitator guidance and a trusting, supportive atmosphere.[36] We achieved this through the advanced distribution of workshop invitations, providing detailed information regarding the workshop content and schedule, and by following up with reminder emails. During the workshop, all facilitators introduced themselves and emphasised that all contributions were valued and considered important.

KEY MESSAGES

- Lived experience strengthens research quality and relevance
- Patients and carers can shape every stage of the research cycle
- Building relationships and sustaining engagement is essential

Feedback from those with lived experience strengthens confidence in the perceived need and acceptability of the educational material, but engagement during our refinement stage was poor. This highlights the importance of investing in relationships and support mechanisms to ensure long-term and meaningful participation. Whilst there is no evidence that alternative methods such as interviews and focus groups would have encouraged additional participants to provide feedback on the educational material,[37] offering multiple channels for feedback such as anonymous submission might have done.[38] Furthermore, as low participation rates are often due to uncertainty about what is required, or feeling overburdened by what is expected,[39] we will provide additional support, clearer guidance and flexible feedback options to encourage participation in future.

Conclusion

To enhance the quality of healthcare research it is essential to involve those who have lived experience of the health condition being researched. Involving individuals with lived experience of PAD and CLTI has proved valuable in the context of our study conception, design, recruitment, insights, dissemination and refinement of the intervention, and the research team remains committed to harness the insights of patients and carers as the project progresses. To strengthen relationships with patient and carer contributors in the forthcoming feasibility trial additional support and improved communication pathways will be implemented, including regular updates, clear guidance on tasks and additional channels for feedback. These measures aim to enable deeper and sustained engagement and ensure that those with lived experience continue to shape the research process.

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Ethics: This study was reviewed by the Science and Engineering Research Ethics and Governance Committee at Manchester Metropolitan University and was given a favourable ethical opinion on 02/01/2024. Reference Number: 55518.

Data sharing: All data relevant to the study are included in the article or uploaded as supplementary information. Other data if required are available on reasonable request.

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PROTOCOL

Decisional regret in vascular surgery: a scoping review protocol

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Plain English Summary

Why we are undertaking this research: 'Decisional regret' is a negative emotion associated with a decision, its outcome or how it was made. Decisions about vascular surgery can feel rushed, frightening or confusing. Some patients regret the decision to have vascular surgery. Understanding why some patients regret surgery is important. It can help clinicians develop ways to support future patients in making decisions about surgery. We aim to design a future study to investigate regret after vascular surgery. To do this we need to understand what research has already been done on this topic. We also need to understand if this research topic is important to patients.

What we aim to do: The aim of this study is to do a more detailed search for research about regret after vascular surgery. We will do a broad search of a large number of articles from two online medical libraries. After we filter and exclude irrelevant results, we will read and summarise the findings of the relevant articles. We will present these findings to patients with experience of vascular surgery and work together to describe what research already exists. Patients can identify gaps that are important to study further that researchers may miss. We will describe areas where research is missing. For example, decisional regret may have been investigated after some operations more than others. We will decide which aspects of regret we should research further and how best to do this. Ideas from patients and the research will be combined to design a future study about regret after vascular surgery. A future study could help make conversations before surgery better and more supportive. Work from this project will ensure that this future study is both necessary and important to patients.

Abstract

Background: Decisional regret describes negative emotions relating to a decision. Some patients regret the decision to have surgery, causing emotional distress and mistrust of healthcare providers. Understanding decisional regret could improve communication and help clinicians support future patients in making decisions about surgery. Vascular surgery can have significant complications, yet research into decisional regret after vascular surgery is limited. No reviews on this topic are currently registered.

Methods: In this report we present a protocol for a scoping review to characterise the literature about decisional regret in patients following vascular surgery. It will be conducted with reference to the Joanna Briggs Institute guidelines. Two academic databases (MEDLINE and CINAHL) will be searched for terms relating to "decisional regret" and "vascular surgery". A specialist librarian will develop the database searches. Additional literature and citation searches will be conducted using Google Scholar. The results will be screened against predefined inclusion criteria. Data will be extracted to produce a descriptive summary. The summary will be shared with patient co-investigators whose interpretations will inform the review conclusions.

Discussion: Describing the current available literature about decisional regret in vascular surgery will help identify knowledge gaps that should be prioritised for further investigation. An accessible infographic of the review findings will be produced to support future patient and public involvement work.

Key words: vascular surgical procedures; decision making; review literature as topic

Introduction

Decisional regret describes significant negative emotions such as distress or remorse following a decision.[1] Some patients may regret decisions made about their treatments including whether to have surgery. A decision may be regretted because of the option chosen, the outcome or how it was made. A decision with a 'good' outcome may still be regretted if the process is perceived as rushed or pressured. Decisional regret can result in negative experiences of healthcare systems and poor patient satisfaction.[2] Developing and implementing interventions that minimise the incidence of decisional regret is a priority for perioperative patients and researchers.[3] Communication, patient understanding and shared decision-making have been identified as research priorities for vascular surgery.[4] Understanding decisional regret in vascular surgery may contribute towards addressing these.

Previous research has measured decisional regret after surgery using a variety of tools. Some studies asked patients directly about regret following surgery using open-ended or yes/no type questions. Other studies evaluated regret using surveys involving the Decision Regret Scale and/or other Likert-type questions.[1] Decisional regret may differ between surgical contexts.[3] It has been investigated in some surgical contexts more than others; for example, prostate and breast cancer surgery appear to have attracted more attention from researchers than vascular surgery, despite vascular surgery carrying a relatively high risk of complications.[1]

A preliminary search for relevant literature about decisional regret in vascular surgery was conducted by a team of clinicians, academics and a specialist librarian with literature review experience. We searched PubMed and Google Scholar in September 2025 using terms including "decision* regret" and "vascular surg*". Approximately 10 relevant studies were retrieved. These included one survey from the USA of 572 patients which estimated the prevalence of decisional regret following four common vascular surgery procedures as 14.2%.[5] This was related to procedure type, being more common among patients undergoing lower extremity procedures (amputation or revascularisation) than other vascular procedures.[5] A 2017 systematic review of 79 studies about decisional regret in surgery included only one study involving patients who underwent vascular surgery.[1,6] Of the 54 patients who underwent great saphenous vein surgery in this study, two (4%) regretted the procedure at 12 months.[6]

The limited available research suggests that some patients may experience decisional regret following vascular surgery. However, the prevalence of decisional regret following certain vascular procedures is not fully understood. Patient-, procedure- or decision-related risk factors for experiencing regret after vascular surgery have not been identified and understanding why patients regret certain operations has not been explored. No reviews on this topic are currently registered on PROSPERO or the Joanna Briggs Institute websites.[7,8]

This scoping review will characterise the existing research about decisional regret in patients following vascular surgery. Specifically, it will describe how decisional regret has been evaluated and the surgical contexts in which it has been studied. It aims to identify gaps in the literature and inform potential areas for future research.

Patient and public involvement

We undertook a patient and public involvement activity to explore whether patients valued decisional regret as a research topic and whether the proposed role for patient co-researchers was acceptable. A presentation of the research topic and proposed study was delivered to a group of eight patients organised through Vocal (an organisation hosted by Manchester University NHS Foundation Trust in partnership with The University of Manchester). Discussions about the research topic were positive. Patients described the topic as under-researched and not obvious, yet still important. Patients felt it was also important to understand decisional regret amongst family members and caregivers in addition to patients. As a result, the inclusion criteria were expanded to include studies involving the relatives or carers of adult patients. The focus group supported the role of patient researchers and suggested that a brief lay summary of the included studies (plus access to the original abstracts) would support this role. Some members felt it was important to present the findings of the scoping review back to a larger group to gather a wider range of opinions on the research before designing a future study. We have planned to do this.

Methods

This scoping review will be conducted by a team of clinical, academic and patient researchers with reference to the Joanna Briggs Institute methodological guidelines.[9]

Search strategy

Two online databases (Ovid MEDLINE and CINAHL) will be searched initially. The reference lists of included sources will then be searched manually. Google Scholar will be used to facilitate forward and backward citation searching of relevant articles. Finally, a search will be conducted using Google Scholar to capture additional literature (eg, abstracts and theses).

Database searches will be developed with the support of a specialist librarian (author OS). The population of interest is adult patients who have had vascular surgery. Synonyms for "vascular surgery" and specific procedures (eg, abdominal aortic aneurysm repair, angioplasty, bypass or stenting procedures, lower limb amputation and carotid endarterectomy) will be included in the search terms. The concept of interest is "decisional regret" and synonyms for this term will also be searched. A proposed search strategy for Ovid MEDLINE is provided in Appendix 1 (online at www.jvsgbi.com). Search results will be limited to English language only because this is the only language spoken fluently by the whole review team. Results will not be restricted by geographical location or publication date.

Table 1 Inclusion criteria.

	Include	Exclude
Population (who is being studied)	Adult patients or their relatives or carers	Clinicians, children
Concept (what is being investigated)	Decisional regret	Decisional conflict
Context (the setting for this investigation)	Vascular surgery and named specific procedures (including but not limited to abdominal aortic aneurysm repair, revascularisation, amputation, carotid endarterectomy and varicose vein surgery)	Cardiac or neurovascular surgery Interventional radiology procedures
Types of evidence source (how the research was done)	Quantitative or qualitative research, reviews (systematic or scoping), editorials, opinion pieces, abstracts	

Table 2 Draft table to illustrate the potential groupings and presentation of results. The final table headings will depend on the literature retrieved and researcher perspectives. The number of studies (and associated references) will be provided for each category with additional data as stated in italics.

Location of study			
e.g. UK	Sweden	USA	
Study design			
e.g. Survey	Interview	Interventional	
Participants			
e.g. Vascular surgery only	Mixed surgical population		
Number of participants			
e.g. <10	10–50	>50	
Primary objective			
e.g. Decisional regret	Decision making experiences	Quality of life	
Tool for measuring decisional regret			
e.g. Decision regret scale	Open-ended questions	Other Likert-type questions	
Vascular surgical procedure and urgency			
e.g. Immediate/Urgent	Expedited	Elective	
	e.g. Carotid endarterectomy	Abdominal aortic aneurysm repair	
Decisional regret at 0–1 month	*Quote rates of regret if given*		
Decisional regret at 1–6 months			
Decisional regret at 6–12 months			
Decisional regret at >12 months			
Associations investigated			
	e.g. Age	Sex	Frailty
Significant			
Non-significant			
Quotes describing experiences of decisional regret			
Provide quotation			

Screening and data extraction

Titles and abstracts will be screened against predefined inclusion criteria (Table 1). The full texts of potentially relevant resources will be subsequently reviewed against the same criteria for inclusion. Primary research (qualitative or quantitative study designs) and review articles (systematic or otherwise) will be eligible for inclusion. Studies involving patients undergoing any vascular surgery procedure will be eligible for inclusion even if studied with other surgical populations. Based on the limited research identified by our preliminary search, the inclusion criteria will be kept intentionally broad. Screening will be performed by one review team member (author SS) using the Rayyan online platform.[10] Inclusion decisions will be reviewed by a second reviewer with disagreements resolved by consultation with a third. Data from included sources will be extracted using the Joanna Briggs Institute data extraction form (Appendix 2 (online at www.jvsgbi.com)) with modifications made to ensure relevance to the aims of the scoping review.[9] Extracted data will include evidence source details and characteristics (eg, citation details, context, country and participant information) and details or results extracted from the source of evidence specific to the scoping review concept (eg, tool used to measure decisional regret, rate of decisional regret, timing of decisional regret measurement and factors associated with decisional regret). The modified form will be trialled on a sample and amended, if necessary, before being applied to all included sources.

Analysis and presentation of results

Clinical and patient researchers will analyse the included resources. Capturing the meaning of the research landscape from both perspectives aims to ensure that future research meets the needs of the people it is intended to benefit. Included sources will be collated and a descriptive summary of each will be generated by a clinician researcher. Summaries will be presented to the patient reviewers and their interpretations of the research landscape sought. Interpretations will be recorded as field notes and will inform the final review conclusions. Patient and clinician researchers will work together to group and organise the resources in a way that highlights the key findings within the research landscape. The final groupings will be determined by the available literature and researcher perspectives. Potential groups could describe study characteristics (eg, study design or measurement tools used), clinical context (eg, type of vascular procedure) or features of decisional regret (eg, measured values, associations or impact). The review findings will be presented in a tabular format to highlight potential areas for future research (Table 2). Reports of the scoping review will follow the PRISMA-ScR checklist.[11] A lay summary and infographic will be used to present the review findings in an

KEY MESSAGES

- Research into decisional regret after vascular surgery is limited. No reviews on this topic are currently registered.
- We present a protocol for a scoping review to characterise the literature about decisional regret following vascular surgery.
- The scoping review will be conducted with patient co-investigators. Describing the current available literature with patients will help identify knowledge gaps that should be prioritised for further investigation.

accessible format to support future patient and public involvement work.

Conclusion

This scoping review will identify and characterise gaps in the literature and outline potential areas for future research. It will inform the focus and value of a future study into decisional regret in vascular surgery. Decisional regret is emotionally distressing for patients and their relatives. A future study may contribute towards improving communication and support for patients who are making decisions about vascular surgery. Joint investigation between clinical researchers and patients aims to ensure that any future studies are informed by the people they intend to benefit.

Conflict of Interest: None.

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CASE REPORT

Giant aneurysm of the dorsalis pedis artery: a rare pathology

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Abstract

True aneurysms of the dorsalis pedis artery are extremely rare. This case report describes a 53-year-old male patient who presented with a rapidly enlarging pulsatile lump at the dorsum of his right foot. Imaging studies confirmed this to be a true aneurysm of the dorsalis pedis artery. As the large lesion was causing functional impairment, operative repair was offered. The aneurysm was excised and the arterial continuity was restored with a saphenous vein interposition graft. This case report aims to highlight this rare pathology and management considerations.

Introduction

Aneurysms of the foot arteries are rare.[1,2] The majority of such lesions are post-traumatic false aneurysms. In contrast, true aneurysms that contain all three layers of the arterial wall are less frequently encountered.[2–4] Such aneurysms have the potential for complications due to thrombosis or embolism.[5] Unlike true aneurysms of the abdominal aorta, popliteal artery or major visceral arteries which have clearly established management guidelines, there is no consensus on when to intervene for these lesions.[1] Here we report a patient who underwent open repair of a true dorsalis pedis artery (DPA) aneurysm with a reversed greater saphenous vein (GSV) interposition graft.

Case report

A 53-year-old previously well male presented with a painless but rapidly enlarging lump over the dorsal aspect of his right foot for 3 months causing functional disturbance. He was a heavy smoker and a bus driver by profession. There was no preceding history of trauma and no associated sensory or motor impairment of the foot. On examination there was a 5 x 3 cm pulsatile mass over the dorsum of the right foot without overlying skin changes (Figure 1A). The dorsalis pedis pulse was palpable immediately distal to the mass. The rest of his peripheral pulse examination was unremarkable. A duplex ultrasound scan demonstrated a true right DPA aneurysm (Figure 1B), confirmed by a subsequent computed tomographic angiogram (Figure 1C) with dimensions 40.5 x 25.6 mm. Other investigations, which included a complete blood count, C-reactive protein level, erythrocyte sedimentation rate and a 2D echocardiogram, were unremarkable.

Under spinal anaesthesia, surgical repair of the right DPA aneurysm was undertaken. After proximal and distal control of the DPA, the mass was completely mobilised (Figure 2A) and the ipsilateral thigh GSV was harvested. Following systemic heparinisation and clamping of the DPA, the aneurysm was excised. The vessel was reconstructed using a reversed GSV graft (Figure 2B), with anastomoses using 7/0 polypropylene interrupted sutures.

Bacteriological culture of aneurysm tissue samples was negative. The patient's postoperative recovery was uneventful apart from a minor superficial wound breakdown. Six months after surgery he remains well with a patent graft.

Discussion

True DPA aneurysms are rare, with the first case documented by Archibald Cuff in 1907.[6] The majority of reported DPA aneurysms are false aneurysms related to trauma.[2–4] True aneurysms,

Key words: foot aneurysm, dorsalis pedis artery, true aneurysm

Figure 1 (A) The lump over the dorsal foot. (B) Duplex ultrasound showing the aneurysm. (C) 3D reconstruction of the aneurysm on computed tomographic angiography.

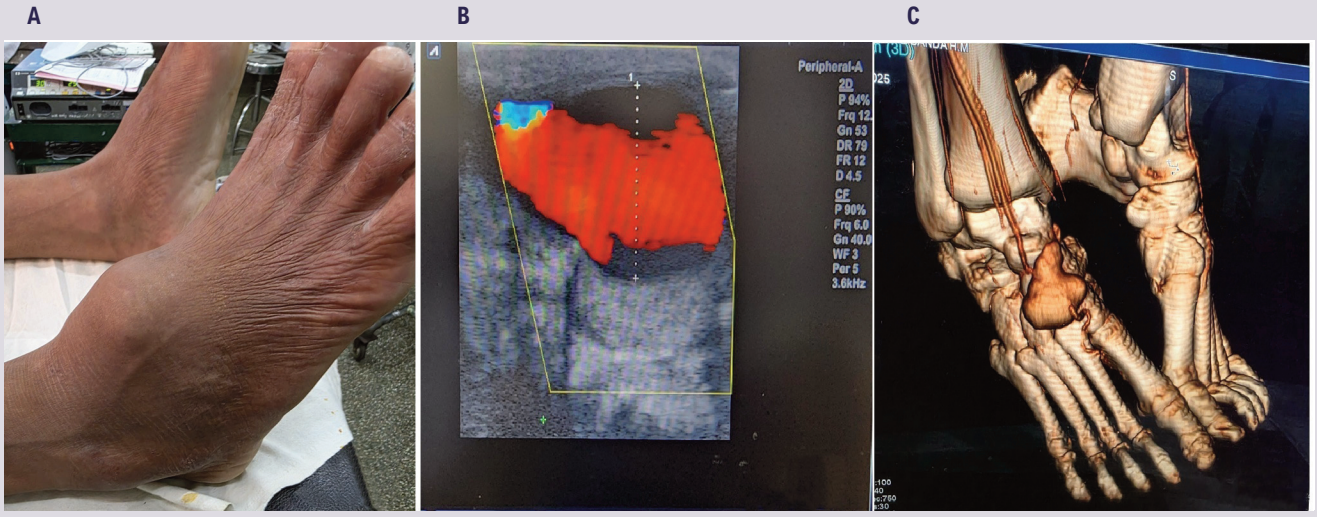
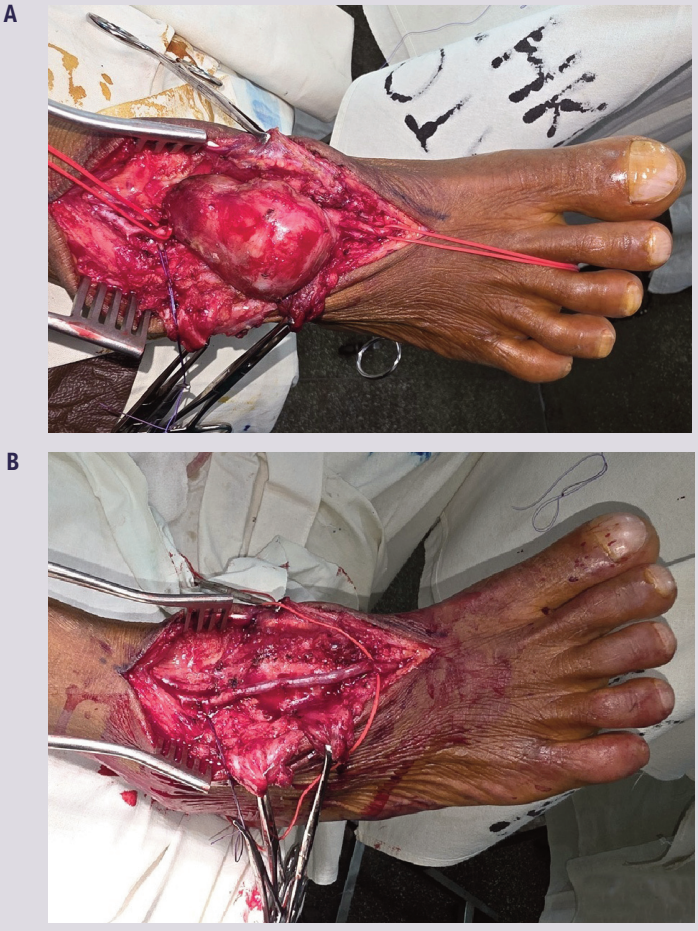


Figure 2 (A) The mobilised aneurysm. (B) After vein graft reconstruction of the dorsalis pedis artery.



which are much rarer, have been associated with atherosclerosis, hypertension, smoking and minor repetitive trauma.[2,3,7,8]

The majority of DPA aneurysms present as a progressively enlarging pulsatile mass.[2] Pain can result from pressure on the adjacent nerves.[8] Functional impairment from the mass on the dorsal foot often prompts medical attention and subsequent intervention.[9] This was also the case in our patient. Rarely, patients with these lesions can present with ischaemic complications due to thrombosis or embolism.[5] Rupture is extremely uncommon.[10]

The diagnosis of DPA aneurysms involves clinical examination, supplemented by imaging studies. Duplex ultrasound is the preferred initial imaging modality. Angiography, whether non-invasive or invasive, offers additional details such as the presence of synchronous aneurysms and the adequacy of collateral circulation.[1,4,10]

Intervention is generally recommended for true DPA aneurysms. Due to the rare nature of these lesions, no size cut-off for intervention has been established but conservative management with follow-up may be an option for asymptomatic small aneurysms.[3,8] Proponents of intervention, regardless of size or absence of symptoms, argue that early intervention can prevent future complications.[1] Surgical resection of the aneurysm, with or without vascular reconstruction, can be performed with minimal morbidity. Ligation of the DPA without restoring vascular continuity should only be done after confirming adequate collateral circulation. Preoperative digital subtraction angiography to verify the patency of the foot arch, intraoperative Doppler assessment of the digital arteries after clamping the DPA and

KEY MESSAGES

- True aneurysms of the dorsalis pedis artery are rare, but they can be associated with complications such as thrombosis, embolism and rupture.
- Their diagnosis is mainly clinical, supported by imaging for confirmation and operative planning.
- Surgical repair with reconstruction is preferred, with ligation of the dorsalis pedis artery reserved for selected patients.

good back bleeding from the distal end of the DPA are indicators of good collaterals.[2,4,8,10] Comparing the distal DPA stump pressure with radial artery pressure is another method used by Kato and colleagues to confirm sufficient foot perfusion after DPA ligation.[11] For patients with risk factors for occlusive arterial disease such as diabetes and smoking and in children, where a ligated foot artery could affect growth, reconstruction is preferred.[8,10] Options for reconstruction include end-to-end repair, vein patch repair or interposition grafting.[8] Anastomosis with interrupted sutures may reduce the risk of luminal compromise in small vessels.

Conclusion

True aneurysms of the DPA are rare and primarily dealt with by open surgery. Excision of the aneurysm and reconstruction of the artery is the preferred technique. Ligation of the DPA can be performed in selected patients who have robust evidence of adequate collateral circulation.

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Patient consent to publication: We confirm that informed consent has been obtained from the patient before data collection and writing of the article.

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