Vein size and demographics: Is there a correlation?

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Submitted in fulfilment of the requirements with regards to the Master of Medicine Degree, (MMed Surgery), in the Department of Surgery, School of Clinical Medicine in the Faculty of Health Sciences at the University of the Free State

06/12/2019

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Declaration of authorship

I, Nadia Roberts, declare that the coursework Master's Degree mini-dissertation that I herewith submit in a publishable manuscript format for the Master's Degree in Surgery (MMed Surgery) at the University of the Free State is my independent work, and that I have not previously submitted it for a qualification at another institution of higher education.

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Abstract

Peripheral arterial occlusive disease has a high prevalence worldwide, as well as in our population, and contributes to an immense burden of morbidity and mortality. Due to the systemic nature of especially atherosclerotic vascular disease, most patients also have cardiovascular and cerebrovascular involvement at the time of presentation, adding to the huge impact on the patient and the economy. Lower limb amputation is associated with a 50% 5-year mortality rate, thus peripheral arterial disease itself is also responsible for considerable mortality rates. Attempting to re-establish perfusion to an ischaemic limb is crucial in saving the limb and the life of the patient.

Options for revascularisation of patients with limb-threatening ischaemia include open and endovascular approaches, each with its own indications and shortcomings. In the case of open infra-inguinal bypass grafting, the great saphenous vein is the preferred conduit used to replace the diseased segment. It has been proven to perform superiorly to synthetic grafts with respect to long-term patency, adequate length, and swift harvesting. This vein is also used in other autogenous bypass procedures, including coronary bypass graft surgery and arterio-venous fistula grafts for access in renal replacement therapy.

Occlusion of the graft, or graft-failure, is one of the dreaded complications of any bypass procedure, and can be divided into primary or secondary failure, according to the time from procedure to the establishment of the diagnosis. Both scenarios are detrimental to the salvage rate of the limb, and can also indirectly contribute to the demise of the patient. Many factors have been associated with primary graft failure, particularly the size of the conduit graft, which was the main focus of our study.

Our primary aim was to determine the average great saphenous vein size in our study population, and our secondary aim was to demonstrate a relationship between vein size and demographic variables like race, age and gender. The study was a cross-sectional retrospective study, using data over 10 years from January 2006 to December 2015. All patients underwent vein mapping with ultrasound pre-operatively prior to a lower limb bypass procedure in Universitas Academic Hospital, and the demographics of these patients were then analysed. A total of 811 patients were included and the meteorological season was used as a surrogate indication of the average temperature in the vascular suite to account for the influence of ambient temperature on vaso-action and vein size.

The average size of the great saphenous vein in our study population was found to be 4.08 mm. After analysis, it was found that black patients had smaller veins than white patients ($p < 0.0001$) and men had smaller veins than women ($p = 0.0217$). Vein measurements were smaller during summer months, and there was no significant difference between vein sizes in different age groups.

Owing to the existing risk of small conduit size for graft failure, vein size plays an important role in the choice of procedure used to revascularize limbs in patients with critical ischaemia, whether acute or chronic. The results from our study may assist in improving selection of patients suitable for open surgery based on demographic parameters, thus decreasing poor outcomes of revascularisation procedures and decreasing complications associated with graft failure.

Key words

- Peripheral vascular occlusive disease
- Great saphenous vein
- Vein size
- Infra-inguinal bypass graft
- Vein mapping

List of Abbreviations

- PAOD: Peripheral Arterial Occlusive Disease
- CLTI: Chronic Limb Threatening Ischaemia
- CTA: Computer Tomography Angiogram
- MRA: Magnetic Resonance Angiogram
- GSV: Great Saphenous Vein
- HIV: Human Immunodeficiency Virus
- BMI: Body Mass Index
- SFJ: Saphenofemoral Junction

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Chapter 1

Literature Review

Introduction

Vascular disease manifests in a vast array of clinical presentations. Vessels of many kinds and sizes are located throughout the body, ranging from small arterioles entirely covering all mucosal surfaces, lymphatic channels draining every tissue, veins that dilate and contract to accommodate massive amounts of blood, to the aorta from which every supplying artery originates. All these channels lend themselves to opportunity for illness to set in, of which the causes can be divided into congenital and acquired. Broadly speaking, vascular disease is divided into arterial, venous and lymphatic disease. The surgeon encounters patients with various vascular complaints on a daily basis.

The focus of this paper will centre on arterial ischaemia, which occurs when a segment of the arterial tree is partially or completely occluded, leading to ischaemic consequences in the area it supplies.[1] Although arterial disease may affect any body part, and in many cases multiple body parts, much of this paper will discuss peripheral limb arterial occlusive disease (PAOD). Ischemia causes increasing degrees of pain as well as loss of motor and sensory function. Beyond a critical value of arterial stenosis, where the degree of luminal narrowing produces a significant reduction in distal pressure and flow into a vascular bed, the tissue becomes necrotic.[2] Necrotic tissue is at risk of ultimately becoming infected. This local sepsis may give rise to a systemic septic cascade, and together with other systemic consequences of necrotic tissue, death may ensue.

Treatment options for acute as well as chronic arterial occlusion vary considerably according to many factors. In both cases, the anatomical location, severity of the occlusion as well as the time from onset is taken into account. The general condition of the patient and the available expertise and equipment also affects the management strategy.

Acute limb ischaemia

Acute peripheral arterial occlusion is a sudden deterioration in the blood supply to a limb which leads to acute ischaemia and threatened tissue viability, which presents up to two weeks after the occluding event.[1] Causes include the following: (1): thromboembolism, where thrombotic material from a proximal culprit lesion lodges in the narrow distal vessel; (2): thrombosis, where an area of chronic stenosis can undergo plaque rupture to form a sudden thrombotic occlusion. (3): Venous occlusion may also lead to arterial ischaemia when edema causes increased pressure severe enough to overcome arterial pressures. (4): Trauma does not specifically form part of acute limb ischaemia, but may sometimes require bypass procedures, usually with an available GSV as conduit. Here, an arterial injury precludes blood from reaching the distal organ it supplies, and bypass procedure may be used to re-establish perfusion to the affected area, as well as addressing the blood loss to limit the systemic effects hypovolemia.

The most common sites of acute peripheral limb occlusion occur at branching sites of arteries. Examples include the aortic bifurcation, the common femoral artery bifurcation and the crural vessel trifurcation below the knee. Patients present primarily with ischaemic pain that starts suddenly and persists. In patients with existing chronic ischaemia, where collateral supply is present, pain may gradually worsen up to complete occlusion. Clinical findings depend on the degree and time period of the ischaemia. The limb may be pale, mottled, or have an area of necrosis, and might have decreased motor and sensory function. The severity of the ischaemia is classified according to the Fontaine or Rutherford classifications[1,3] and ranges from a limb that is viable, to one with irreversible ischaemia. Investigations to confirm acute occlusion include duplex Doppler ultrasound, computed tomography angiogram (CTA) or magnetic resonance angiogram (MRA), percutaneous catheter-directed arteriogram or an arteriogram on the operating table.

Management of the patient includes fluid and electrolyte resuscitation, analgesia and systemic anticoagulation with heparin in the case of occlusive aetiology to limit the propagation of the thrombus. Revascularisation is achieved according to the classification of the severity. An unsalvageable limb is amputated at a level above the occlusion or demarcation of necrosis. In the case of a salvageable, but threatened limb, revascularisation is done either immediately or urgently. The mode of revascularisation depends on the patient's fitness for open surgery and the available resources. Angio-intervention entails catheter-directed thrombolysis or –thrombectomy. During thrombolysis, an intra-arterial catheter is percutaneously advanced to the site of the thrombus and left in situ to directly infuse a low dose of thrombolytic urokinase or thrombokinase and heparin. During thrombectomy, devices are advanced percutaneously under fluoroscopy to mechanically disrupt and remove the thrombus. Open embolectomy is the gold standard of treatment in a patient that is fit for surgery. Open surgical exploration is done, the involved vessel is exposed, and a balloon-embolectomy (Fogarty) catheter is advanced through an arteriotomy to remove the thrombus. The arteriotomy may be closed with primary suturing or a vein patch.

In the case of acute traumatic injury to a peripheral artery, management depends on the site and nature of the injury. Mechanisms of injury include a penetrating laceration of a vessel with a sharp object; blunt trauma causing shear injury and tearing of vessels; fracture of an adjacent bone with laceration from a bony prominence; and crushing injury with direct damage to both vessels and tissue. Even an impact from a high velocity projectile like a bullet can damage vessels in close proximity to the area due to high energy release. Dislocation of a joint is a mechanism well-known to cause intimal injury by stretching an overlying artery. This leads to thrombosis in that vessel, occluding it, and the popliteal artery is particularly prone to this injury after posterior dislocation of the knee. Iatrogenic injury to arteries may be caused by angiography, cardiac catheterisation, balloon angioplasty, or inadvertent arterial puncture. In the event that the artery is an end-artery solely supplying a critical organ or when continued hemorrhage is compressing surrounding structures or may potentially lead to exsanguinating hemorrhage, surgical intervention is indicated.

The diagnosis of acute vascular injury is clinically suspected after a history of trauma when there is evidence of hard signs like pulsatile bleeding, an expanding hematoma, a palpable thrill, an audible bruit, or when the pulses distal to the injury are absent. Soft signs may also allude to vascular injury, and these include evidence of significant blood loss at the scene, a trajectory of an external wound which runs in close proximity to a large vessel, diminished pulses distal to the injury and a hematoma which is non-pulsatile. In cases of minimal vascular injury, where there is radiological evidence of arterial injury but no hard or soft signs of vascular injury, the management may be non-operatively initially. Although the yield of radiological evidence on angiography or formal arteriography is up to 25% if combined with clinical suspicion, these lesions are often non-occlusive, and 90% of lesions will heal spontaneously.[4] These injuries include focal segmental narrowing of an artery, an intimal flap, and a small pseudoaneurysm. The gold standard for evaluating arterial injury is catheter-directed angiography, but this is invasive and currently, a CTA is done initially, reserving direct angiography for intervention.

Endovascular treatment is employed in selected stable patients with arterial injury, especially when a single vessel is suspected to be involved or if the particular vascular injury is anatomically difficult to reach via open means. Management should never be delayed while waiting for endovascular equipment or expertise. A temporary intraluminal shunt can be inserted in selected patients while awaiting the definitive repair. Open surgery is the preferred approach performed in traumatic injuries, due to concurrent injuries that may need exploration and addressing. It might be possible to restore the anatomical flow by way of a simple primary repair of a small defect in the artery, or anastomosis of the two transected segments. In some cases the vessel may be safely ligated to halt further hemorrhage if there is sufficient collateral arterial supply. Lastly, an interpositional segment may be fashioned from either an autogenous conduit, like a harvested vein, or a synthetic conduit made from various materials to re-establish flow in the severed artery. The GSV is the conduit of choice,[1,3-7] due its long length and superficial location. It has also been proven to have superior patency in the long term. In the case of irreversible ischaemic damage or extensive tissue damage, primary amputation may be indicated. A low threshold of suspicion should be implemented for fasciotomies to prevent or treat compartment syndrome.

Chronic limb-threatening ischaemia

Chronic limb-threatening ischaemia[5] (CLTI) is defined as objectively documented peripheral arterial disease (absolute toe pressures at the ankle of below 50mmHg, or the toe below 30 mmHg; Ankle Brachial Pressure Index below 0.4; Transcutaneous Oxygen Pressure below 30 mmHg, or minimally pulsatile pulse volume recorded on Duplex doppler), as well as any of the following: ischaemic rest pain for more than 2 weeks; any non-healing lower limb ulceration (including diabetic foot ulcer) present for at least 2 weeks; gangrene of any portion of the lower limb. Chronic arterial occlusion can occur due to an array of causes, of which atherosclerosis is the most prevalent.[1,6,7,9] It can also occur due to Human Immunodeficiency Virus (HIV) associated vasculopathy, diabetic vasculopathy, arteriosclerosis and neo-intimal hyperplasia. Systemic hypercoagulable conditions, including malignant hypercoagulopathy, may lead to venous as well as arterial thrombotic occlusion.

Atherosclerotic arterial disease, although systemic, principally affects the large and medium-sized arteries. Like acute occlusion, the sites most likely involved in atherosclerosis, are sites of arterial branching. These are the aorta and its branches, including the coronary and carotid arteries, mesenteric arteries and the lower limb arteries. Risk factors for developing atherosclerotic disease can be divided into non-modifiable factors and modifiable factors. The former include increasing age, male gender and African American race. The latter include smoking, dyslipidemia, diabetes mellitus and hypertension. It is important to note that a manifestation of atherosclerotic ischemia in one anatomical region is a surrogate marker for arterial disease in other areas.

Patients may present with different levels of severity of ischaemia, was previously classified according to Rutherford into asymptomatic disease, intermittent claudication (may be mild moderate or severe), critical ischaemia or tissue loss (necrosis which may be infected or non-infected). The Global Vascular Guidelines on the treatment of Chronic Limb-threatening Ischamia[5] uses the WIFI classification to stratify the amputation risk. This is based on the appearance of the Wound, the degree of Ischaemia, and the amount of Foot Infection. This classification predicts the probability of limb salvage and wound healing after revascularisation.

As in acute ischaemia, again the patient is evaluated with respect to the severity of the occlusion or stenosis, and the anatomical site of the arterial segment involved and the organ it supplies. Once a critical threshold is reached, intervention may be required either immediately or within a short period to reverse ischaemic tissue damage. Restoring blood supply can save the limb or the life of the patient, and it may even be necessary to simply restore the inflow blood supply to an already irreversibly necrotic limb, in order to ensure good wound healing when the inevitable amputation is performed. Revascularisation can be endovascular or open, depending on the patient’s general condition and the anatomy of the lesion. The choice of conduits to replace the diseased segment depends on the site and the nature of the occlusion.

Previously, the TASC II working group[1] classified occlusive lesions according to the anatomical location into types A to D. The recommendations of this group stated that type A lesions were best treated with endovascular angioplasty, and type D lesions with open bypass graft surgery. There was insufficient evidence to recommend definitive modalities of treatment for types B and C, but type B lesions may have benefitted more from angioplasty and type C lesions may have benefitted more from open surgery.

The Global Vascular Guidelines[5] states that the optimal revascularisation strategy is determined by the global limb anatomic staging system (GLASS anatomic scheme). It states that successful revascularisation in CLTI nearly always requires restoration of in-line (pulsatile) flow to the foot. The targeted arterial path is decided by the surgeon or interventionist, and is the optimal arterial pathway to restore in-line flow. These guidelines propose that the revascularisation follows evidence-based protocols, considering in order of priority: the patient risk; the limb severity; and the anatomic pattern of disease.

The BASIL trial is a randomised controlled trial comparing clinical outcomes and cost effectiveness of bypass surgery versus balloon angioplasty for infrainguinal revascularisation.[10] The recommendations include that patients who are expected to live beyond two years according to their comorbidities, should be offered bypass surgery first, especially if an autogenous vein is available as a conduit. Patients who are expected to live less than two years should be offered angioplasty first due to the fact that angioplasty is less expensive and associated with less morbidity in the short term. In the case of unavailability of a vein, the BASIL group recommends that angioplasty may be better than open bypass with a synthetic conduit. Again, the great saphenous vein is long enough to be used in most scenarios of segmental occlusion, is harvested easily and has superior long term patency.[1,6-8,10-14] Synthetic conduits are available, but have inferior long-term patency and are avoided in areas which cross joints due to suboptimal compliance after kinking or bending.

Endovascular infrainguinal revascularization is used increasingly and has many advantages over open procedures. Percutaneous access considerably decreases the occurrence of post-procedural pain, surgical site infection and hospital stay. It may also be performed under local anaesthesia, thus eliminating the potential physiologic burden of general anaesthesia. This is especially helpful in patients who are unfit for major open surgery. Endovascular procedures include percutaneous endolumenal balloon angioplasty to alleviate short segments of stenosis, or the deployment of endovascular stents to increase the diameter of the vessel in the long term. Endovascular procedures may also be employed to mechanically macerate and remove an intravascular thrombus or to administer intravascular thrombolytic drugs in cases of acute-on-chronic occlusion.

Open revascularisation for infra-inguinal bypass procedures can be done under regional or general anaesthesia, depending on the anatomical site. The GSV is harvested and secured in situ or in a reverse fashion to offer flow of blood from the proximal site to beyond the occlusion. In lesions involving suprainguinal sites, a bypass procedure from the abdominal aorta may be necessary. This can be performed endovascularly, with the known advantages already mentioned, using synthetic conduits. Open aorta-to infra-inguinal bi-femoral artery bypass is also done using a synthetic conduit. A lesion in the aorta or its bifurcation may also be addressed with a bypass from the axillary artery to the vessels below the bifurcation of the aorta, which can be done using an endogenous conduit like the GSV or a synthetic conduit.

In all cases of arterial occlusion, the underlying cause should be sought and treated, with or without interventional procedures. In the case of atherosclerotic disease, medical therapy is aimed at targeting the many pathways in the pathogenesis of the disease, which is beyond the scope of this paper's content.

Revascularisation

The great saphenous or other veins are harvested for many purposes, mainly for infra-inguinal bypass procedures for PAOD. The GSV can be used in bypass grafting of coronary and other arteries, as well as in the fashioning of arterio-venous fistulae for access in renal replacement therapy. The decision about the mode of intervention is based on the factors discussed above, and importantly includes the availability of a vein.[1,4-8,15-17]

As part of the preparation for lower limb bypass surgery, pre-operative vein mapping (phlebography) measures the diameter of the GSV with colour Doppler ultrasonography at several levels in order to confirm that it offers a suitable conduit for the bypass procedure. These findings closely correlate with in situ vein diameters.[8,9,15,18-20] Veins with chronic phlebitis, calcification, or an existing intraluminal thrombus are also identified and excluded in pursuit of an optimal graft conduit. Varicose veins are unsuitable as conduits, due to their dilated and tortuous nature. Varicose veins are classified and defined according the American venous forum's CEAP classification.[21] It consists of clinical features (C), etiological factors (E), anatomical distribution of the disease (A), as well as pathophysiological features (P). In a study done by Engelhorn et al, reflux of the GSV was predicted with a cut-off diameter value of $\geq$ 7.0 mm, 4.0 mm and 4.0 mm respectively at the saphenofemoral junction (SFJ), thigh and calf.[22] In a study by Navarro et al, a GSV of less than 5.5 mm was found to preclude reflux with a sensitivity of 78% and a specificity of 87%, and a GSV of 7.3 mm or greater predicted reflux with 80% sensitivity and 85% specificity.[23] In a study by Joh and Park, a cut-off value of 5.05 mm was used to predict reflux at the SFJ,[24] which is similar to the cutoff value of 5.0 mm suggested by Karmacharya et al.[25] Alternative conduits are used when endogenous veins are discovered to be unfavourable, either pre-, or intra-operatively.

Factors associated with an increased risk of primary vein graft failure[11,12,14,26,27] (within 30 days post-operatively) consist of patient factors and procedural factors. The former include: female gender, African-American race, small diameter conduit, and non-adherence with post-operative ultrasound surveillance. The latter may include technical aspects causing damage during harvesting of the vein. In a prospective study on 62 patients where infrainguinal bypass grafts were performed, the patency of the graft was followed up for 3 years. Using 3.0 mm as a cutoff, findings indicate that the diameter of the GSV was a major independent factor in the outcome of femoro-distal bypass surgery.[16] Minimum vein diameters recommended for conduits in infrainguinal bypass surgery vary from 2.0 mm and 3.0 mm in diameter, and are illustrated in **table 1**.

The measured vein size may be influenced by the following factors: ambient temperature,[28] human error of the operating ultrasonographer, drugs causing vaso-constriction or –dilatation, cardiac output, contraction of skeletal muscles, hydrostatic forces (gravity), and circulating blood volume. A study of 26 volunteers could not demonstrate a correlation of body mass index (BMI) with the size of the GSV.[29] A study done by Keiler et al on 164 legs of 82 healthy volunteers, attempted to demonstrate a correlation of the femoral vein size with demographic variables, and found that males had a bigger diameter than females, and also a positive correlation between femoral vein diameter and body mass index.[30] These studies were unfortunately small and done on healthy individuals, but in practice, the harvested vein pertains to a patient with known systemic vascular disease.

Existing Studies indicate that African Americans, especially women, are more likely to lose their limbs due to peripheral arterial disease and diabetic foot sepsis complications, compared to Caucasian patients.[10,12,13] Multiple factors may contribute to these findings, including the aetiology of the arterial disease, different demographic variance of comorbidities, the level of access to health care, educational level, and socioeconomic status. In view of the fact that small diameter plays a major role in the patency of the graft, the hypothesis that graft failure in these demographic groups may be a marker for small vein size in the said group, is worthy of inquisition. No studies concerning these differences exist to date in South African literature.

Research question

The Primary aim of the proposed study was to determine the average GSV size in our study population. The secondary objective was to demonstrate a relationship between vein sizes and demographic variables, like race, age, and gender.

A retrospective cross-sectional study was conducted on patients who presented for duplex Doppler ultrasound Phlebography at Universitas Academic Hospital for assessment for potential lower limb bypass surgery over 10 consecutive years.

In light of the known effect of ambient temperature on vein size, the meteorological season during which the imaging was recorded and used as surrogate indication of average temperature in vascular suite.

During phlebography, the diameters of bilateral greater saphenous veins are recorded at some or all of 6 areas, namely: the inguinal area, mid upper leg, above the patella, below the patella, mid lower leg, and ankle. A vein is deemed unusable when: the diameter is less than 2.0 mm or greater than 5.0 mm (likely varicose); the walls of the vein are thickened – suggesting chronic phlebitis; or when a vein has an existing thrombus in the lumen.

A p-value of < 0.05 was considered significant, testing the null hypothesis of similar average vein sizes among people of different ages, races and gender. Age was grouped into 2 groups (older than; and younger than 55 years old). Vein size was correlated to race, age group, gender and meteorological season and the interaction between these variables.

Our hypothesis was that men would have larger veins than women and that white patients would have larger veins than black patients, extrapolating findings from the small studies found in literature. We also hypothesised that veins would be measured larger during summer months when ambient temperature is warmer, causing vasodilatation. We hypothesised that older patients would have smaller veins than their younger counterparts, in view of the effect of muscle activity on vascularity. In the light of the proven correlation of conduit availability and size with the outcome of revascularisation procedures, this study sought to demonstrate demographic parameters that might influence revascularisation using veins as conduits.

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Chapter 2

Manuscript for the South African Journal of Surgery

Cover Letter

Declaration of authorship:

I, Nadia Roberts, declare that the manuscript that I herewith submit is my independent work, and that I have not previously submitted it for review elsewhere. It was also handed in as part of the curriculum for a Masters degree in surgery, MMed Surgery, for marking at the University of the Free State. I approve the publication of the content of the manuscript. The contributions of the authors are divided equally between the researcher and supervisor in terms of intellectual content, concept and design of the proposed study, and the collection and interpretation of data. The authors declare that we have no association with any product or subject that may constitute conflict of interest.

The study protocol was approved by the Ethics Committee of the Faculty of Health Sciences, University of the Free State (HSREC 67/2016), as well as the Department of Health of the Free State (FS_2016RP27_26). Permission for the research was obtained from Dr. NE Pearce, Acting Head of Department of Surgery, University of the Free State and Dr. R. Nathan, Head of Clinical Services, Universitas Academic Hospital.

The department of Biostatistical Analysis at the University of the Free State was involved during the protocol stage to assist with the planning of the proposed study.

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Abstract

Background

In revascularisation of patients with limb-threatening ischaemia, the preferred conduit for an open infra-inguinal bypass graft is the Great Saphenous Vein. This is due to its long-term patency, adequate length, and easy harvesting. Many factors have been associated with primary graft failure, particularly the size of the conduit graft, which was the main focus of our study.

Methods

Our aim was to determine the average vein size and demonstrate a relationship with demographic variables like race, age and gender. A cross-sectional retrospective study was performed, analysing data over 10 years from January 2006 to December 2015. A total of 811 patients who underwent vein mapping with ultrasound pre-operatively prior to a lower limb bypass procedure in Universitas Academic Hospital were included. The meteorological season was used as a surrogate indication of average temperature in the vascular suite to account for the influence of ambient temperature on vaso-action and vein size.

Results

The average greater saphenous vein size was 4.08 mm. Black patients had smaller veins than white patients ($p < 0.0001$) and men had smaller veins than women ($p = 0.0217$). Smaller vein sizes were measured during summer months ($p = 0.0853$). There was no significant difference between vein sizes in different age groups.

Conclusions

Owing to the existing risk of small conduit size for graft failure, the results may be used to improve selection of patients suitable for surgery based on demographic parameters and therefore aim to improve outcomes of revascularisation procedures and decrease complications associated with graft failure.

(250 words)

Introduction

The great saphenous vein (GSV) is harvested and used as a conduit in many arterial bypass procedures. It is particularly used in infra-inguinal bypass procedures in critical limb ischaemia in peripheral arterial occlusive disease (PAOD). Limb-threatening ischaemia has a profound impact on global morbidity, mortality and economy[1]. Lower limb Amputation is also associated with a 50% 5-year mortality rate, emphasising the need to rather reperfuse the limb if possible.

In acute as well as chronic occlusive lesions, revascularisation may be achieved with either endovascular interventions or open surgical procedures. Endogenous or synthetic conduits may be used to bypass the occluded section. All these decisions are based on many factors, including availability of a favourable conduit.[1,2] The TASC II working group[1] classifies occlusive lesions according to the anatomical location into types A to D. They recommend that type A lesions are best treated with endovascular angioplasty, and type D lesions with open bypass graft surgery. The BASIL trial[2] is a randomised controlled trial comparing clinical outcomes and cost effectiveness of bypass surgery versus balloon angioplasty for infrainguinal revascularisation. They recommend that patients, who are expected to live beyond two years according to their comorbidities, should be offered bypass surgery first, especially if an autogenous vein is available as a conduit. Patients who are expected to live less than two years should be offered angioplasty first due to the fact that angioplasty is less expensive and associated with less morbidity in the short term. In case of unavailability of a vein, they recommend that angioplasty may be better than open bypass with a synthetic conduit. According to the Global Vascular Guidelines[3], the optimal revascularisation strategy is determined by (1) the patient's risk; (2) the limb severity and (3) the anatomic pattern of the occlusion (in that order of priority). These guidelines also state that successful revascularisation in CLTI nearly always requires restoration of in-line (pulsatile) flow to the foot. This occurs via the target arterial path, which is decided by the surgeon or interventionist, and is the optimal arterial pathway to resore in-line flow. The preferred endogenous conduit for open infrainguinal revascularization remains the GSV.[1,3-8] It has been proven to provide the best long-term patency, is usually available at the desired length, and is harvested easily in a relatively swift manner.

As part of the preparation for lower limb bypass surgery, pre-operative vein mapping (phlebography) measures the diameter of the GSV at several levels in order to find a suitable conduit for the bypass procedure. These findings closely correlate with in situ vein diameters.[8-11] Veins with chronic phlebitis, calcifications, too many tributaries, or an existing intraluminal thrombus, are also identified and excluded in pursuit of an optimal graft conduit.[12-15] Varicose veins are unsuitable due to their tortuous nature. Different criteria are used to define a vein as varicose. Reflux at the saphenofemoral vein junction causes varicose veins and correlates with GSV diameters ranging between 4.0 mm and 5.0 mm.[16-18] Alternative conduits are used when endogenous veins are discovered to be unfavourable, either pre-, or intra-operatively.

Factors associated with an increased risk of primary vein graft failure[19-24] (within 30 days post-operatively) consist of patient factors and procedural factors. The former includes: female gender, African-American race, small diameter conduit, and non-adherence with post-operative ultrasound surveillance. The latter may include damage during harvesting of the vein. Minimum vein diameters recommended for conduits vary from 2.0 mm to 3.0 mm in diameter, and are illustrated in **table 1**.

Vein size (as measured for preoperative evaluation), may be influenced by the following factors[12,26]: ambient temperature, human error of the operating ultrasonographer, drugs causing vaso-constriction or –dilatation, cardiac output, contraction of skeletal muscles, hydrostatic forces (gravity), and circulating blood volume. A study of 26 volunteers could not demonstrate a correlation of body mass index (BMI) with the size of GSV.[27] A study done by Keiler et al on 164 legs of 82 healthy volunteers, attempted to demonstrate a correlation of the femoral vein size with demographic variables, and found that males had a bigger diameter than females, and also a positive correlation between femoral vein diameter and body mass index.[28] In practice, however, patients are known with vascular disease and mostly have many comorbidities.

Existing Studies indicate that African Americans, especially women, are more likely to lose their limbs due to peripheral arterial disease and diabetic foot sepsis complications, compared to Caucasian patients.[2,20,21] Multiple factors may contribute to these findings, including the aetiology of the arterial disease, different demographic variance of comorbidities, the level of access to health care, educational level, and socioeconomic status. In view of the fact that small diameter plays a major role in the patency of the graft, the hypothesis that graft failure in these demographic groups may be a marker for small vein size in the said group, is worthy of inquisition. No studies concerning these differences exist to date in South African literature.

Aims and Objectives

The Primary aim of the proposed study was to determine the average GSV size in our study population. The secondary objective was to demonstrate a relationship between vein sizes and demographic variables, like race, age, and gender. The effect of ambient temperature on vein size is well-known, therefore the difference in room temperature during different geographical seasons was taken into account in the interpretation of the results.

Methodology

This was a retrospective cross-sectional study. The population consisted of all patients who presented for Duplex Doppler Ultrasound Phlebography at Universitas Academic Hospital for assessment for potential lower limb bypass surgery from January 2006 to December 2015. All patient records meeting the inclusion- and exclusion criteria were used for the study. A count of excluded records and the reason for exclusion was made. Only Lower limb imaging studies were included. All participants were 18 years and older. Patients with multiple vein mappings done on the same limb were excluded, but vein mappings done on different limbs of the same patient were included.

Demographic data on the hospital's electronic data base (Meditech) was matched to the handwritten data forms of vein mappings in the vascular suite. Data recorded was captured on a data sheet (see **appendices**). All vein diameter measurements were recorded, but the most proximal measurement was used to determine the average vein size.

All data and information collected were regarded as confidential. Encryption with new numbers was done to replace the hospital numbers and names of patients. Hospital numbers were recorded on the data sheet, but not coded for, and was used to acquire demographic information from the hospital's electronic record-keeping system. Every precaution was undertaken to ensure the privacy of the research participants and the confidentiality of their personal information. The data files were stored by the researcher in the Department of Surgery in the University of the Free State.

The meteorological season during which the imaging was recorded, was used as surrogate indication of average temperature in vascular suite.

It was presumed that all imaging procedures in the vascular suite were performed in a standardized manner. In our suite, this is as follows: the patient is placed in a room of which the ambient temperature is centrally regulated along with all other rooms in the hospital. Imaging in our suite over the 10 year period of the collected data, was performed by two permanently employed qualified sonographers. The patient is placed first in a supine and then in a standing position. Duplex ultrasound is then performed with a Toshiba® Nemio or Philips® CX50 Ultrasound with a linear probe. The frequency of this probe ranges between 3 and 11 MHz. Bilateral GSV are followed out and the diameter thereof recorded at some or all of 6 areas, namely: the inguinal area, mid upper leg, above the patella, below the patella, mid lower leg, and ankle. A vein may simply be deemed and recorded as unusable when: the diameter is less than 2.0 mm or greater than 5.0 mm (likely varicose); the walls of the vein are thickened – suggesting chronic phlebitis; or when a vein has an existing thrombus in the lumen.

Analysis of data collected was performed by the researchers and the department of Biostatistics at the University of the Free State. Data was captured on an Excel spreadsheet. A p-value of < 0.05 was considered significant, testing the null hypothesis of similar average vein sizes among people of different ages, races and gender. Age was grouped into 2 groups (older than; and younger than 55 years old). Age was then correlated with vein size using Pearson correlation coefficients, and differences in the correlations were determined for race and age via Fisher's r-to-z transformation. Vein size was compared by means of factorial ANOVA including race, age group, gender and meteorological season and the interaction between these variables.

Results

A total of 891 vein mappings were performed over 10 years from January 2006 to December 2015. These were analysed and compared to the demographic data available on the hospital's electronic data system. Two of the hand-written forms were deemed illegible and were excluded. One patient was 16 years of age at the time of phlebography and was excluded. 77 Patients had phlebography repeated on the same limb, and were therefore excluded. Thus a total of 811 vein mappings were included.

In 74 of the 811 mappings, the information concerning race was unavailable. In the remaining 737 mappings, the racial representation, in descending order, was as follows: Black 56% (n = 413), White 33% (n = 240), Coloured 11% (n = 83), Indian 0, 1% (n = 1).

Of all mappings, 65% (n = 527) of the patients were men, and (35% (n = 284) were women. The average age of the men was 59 years and 61 years for women. The mean age of the patients in the study population was 60 years (median = 60). The youngest patient was 18 years old and the oldest was 98 years old. The average age of the men was 59 years and 61 years for the women. Black patients in our study population were an average of 56 years old, and white patients an average of 66 years old.

The vein size measurements found in our study population are illustrated in **table 2**. In men, the GSV sizes (average = 4.07 mm) were statistically significantly smaller than those in women (average = 4.11 mm), with p = 0.00217. Varicose veins are defined as veins of 5 mm or more, and were found to present in 14% (n = 76) of the men and in 17% (n = 48) of the women. After excluding participants with varicose veins from the calculations, the vein sizes in women (average = 3.80 mm) were still significantly larger than those in men (average = 3.70 mm), with p = 0.0233.

The two largest race-groups in our study population were black and white, and therefore these were compared using the Mann-Whitney test and the Fischer's exact test. The GSV sizes in black patients (average = 3.84 mm) were statistically significantly smaller (p = 0.00001) than those of white patients (average = 4.46 mm).

When comparing vein sizes in patients who underwent phlebography done during summer versus winter months, the sizes were smaller during summer-time (average = 3.99 mm) than during winter-time (average = 4.12 mm), with p = 0.0853.

Participants were divided into two age-groups to compare vein sizes in patients younger than 55 years (average = 4.16 mm), and those 55 years and older (average = 3.95 mm). There was no statistical difference in the vein sizes of patients in these two groups (p = 0.72).

The average vein sizes measured in right (average = 4.10 mm) and left (average = 4.10 mm) legs did not differ, and more participants had right (52%) leg (n = 426) than left (48%) leg (n = 388) vein mappings done.

Discussion

In terms of gender, women were found to have statistically larger veins than men. There is an increased prevalence of varicose veins in women, potentially resulting in larger average vein sizes, but even when varicose veins were excluded from calculations, women still had statistically significantly larger vein sizes than men.

In terms of race, the vein sizes in white patients were statistically significantly larger than those of black patients. This may be in keeping with international literature, which found that graft failure occurred more in black patients, thus supporting the increased risk for smaller vein sizes in black patients contributing to the increased risk of graft failure.

There was no statistically significant difference between vein sizes measured during winter or summer months in our institution, but a trend indicating that in summer months, veins were measured smaller than in winter months. In our study, the temperature in the vascular suite is centrally regulated, which might mean that the temperature is constant in the room, but might be set at a higher general temperature during colder months, and therefore contributing to vasodilatation and larger measurements. The implication may be great, if a significant difference could be demonstrated, implying that in summer months, a patient might be deemed unsuitable for bypass procedures simply due to vasoconstriction in artificially cooled-down rooms. There was no significant difference between vein sizes in the two age groups, which might explain why age has not previously been found to be a risk factor for graft failure.

The findings regarding general demographic composition of our patient population is in keeping with national literature.

Limitations and recommendations

Human error may influence sizes of veins measured. The measured diameter by ultrasound may also differ from in situ diameter. Bias is minimised in this study, due to the consistency of measurement by the two permanently employed sonographers, but will be taken into account when interpreting data.

Ambient temperature is not routinely recorded in our vascular suite, therefore dates of the investigations were used to indicate the meteorological season, as a surrogate of average temperature in the room. Our results did not demonstrate a significant difference between warm months and cold months, only a trend. The projected number of participants needed to confirm statistical significance is estimated at twice the current amount and leaves room for future studies to explore this proposal. A prospective study with documented room temperature could also give clarity.

The assumption that race can be purely defined is debatable, but cultural differences in different racial backgrounds are well documented. In this study, race was classified using the electronic data base's self-reported information on admission of the participant.

The population in this study is limited to patients with known or proven arterial disease and extrapolation to the general healthy population should be taken into account when interpreting the results.

The retrospective nature of the study limits the spectrum of patients and possible future studies might include a broader array of demographic details as well as clinical information about patients, which were not included here.

The form requesting the phlebography simply states the main working diagnosis, and does not stipulate whether the intended intervention was executed as proposed or not. The information about the outcome of the said intervention is also not available in our data and can be explored in a prospective study where participants can be followed up.

The weight and the length of the patients in our data series were not available, and this may prompt subsequent studies to include this information in order to further correlate BMI or habitus with vein sizes.

Due to the retrospective nature of the study, missing or incomplete records in the electronic data base, as well as the handwritten sheets containing the imaging results may be problematic in terms of legibility and erroneously entered data. A prospective study might be conducted to ensure that the records are more complete.

Conclusion

Owing to the existing risk of small conduit size for graft failure, a significant association of vein size with race and gender might improve future selection parameters for the choice between prosthetic and autogenous graft, potentially avoiding revision of grafts or overall failure with possible limb amputation or prolonged morbidity and cost implications. The use of endovascular procedures are preferred to open grafts in the presence of unfavourable anatomy and a primary amputation might even be considered if a bypass is not safe or feasible. Although not included in this study, the risks of graft failure due to inadequate conduit may also apply to upper limb bypass surgery, arterio-venous fistulae for access in haemodialysis, and Coronary Artery Bypass Graft surgery.

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Appendices

Table 1: Minimum GSV diameter recommended by authors for infrainguinal bypass

Author	*Date*	*Recommended minimum GSV diameter in mm*
Cruz[17]	2004	2.5 – 3.0
Chew[12]	2005	3.0
Slim[15]	2011	2.0
DeFreitas[7]	2012	3.0
Johnston[14]	2012	2.0
Jah-Kabba[8]	2014	3.0
Oresanya[11]	2014	3.0

Table 2: Average vein sizes

Population	*Average vein size (in mm)*	
	Varices included	**Varices excluded**
Entire Study Population	4.08	3.70
Men	4.07	3.70
Women	4.11	3.80
Black	3.84	-
White	4.46	-
Age below 55 years	4.16	-
Age 55 years and above	3.95	-
Winter	4.12	-
Summer	3.99	-
Right leg	4.10	-
Left leg	4.10	-

Letter of Approval: Ethics committee

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

IRB nr 00006240
REC Reference nr 230408-011
IORG0005187
FWA00012784

01 August 2016

DR N ROBERTS
DEPT SURGERY
FACULTY OF HEALTH SCIENCES
UFS

Dear Dr N Roberts

HSREC 67/2016
PROJECT TITLE: VEIN SIZE AND DEMOGRAPHICS – IS THERE A CORRELATION?

1. You are hereby kindly informed that, at the meeting held on 26 July 2016, the Health Sciences Research Ethics Committee (HSREC) approved the above project after all conditions were met.
2. The Committee must be informed of any serious adverse event and/or termination of the study.
3. Any amendment, extension or other modifications to the protocol must be submitted to the HSREC for approval.
4. A progress report should be submitted within one year of approval and annually for long term studies.
5. A final report should be submitted at the completion of the study.
6. Kindly use the **HSREC NR** as reference in correspondence to the HSREC Secretariat.
7. The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

Yours faithfully

....
PROF WJ STEINBERG
VICE CHAIR: HEALTH SCIENCES RESEARCH ETHICS COMMITTEE

Health Sciences Research Ethics Committee
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Letter of Approval: Department of Health

health
Department of Health
FREE STATE PROVINCE

13 June 2016

Dr N Roberts
Dept. of Surgery
Faculty of Health Science
UFS

Dear Dr N Roberts

Subject: Vein Size and Demographics – is there a correlation?

- Permission is hereby granted for the above – mentioned research on the following conditions:
- Serious adverse events to be reported and/or termination of the study.
- Ascertain that your data collection exercise neither interferes with the day to day running of Universitas Hospital nor the performance of duties by the respondents or health care workers.
- Confidentiality of information will be ensured and no names will be used.
- Research results and a complete report should be made available to the Free State Department of Health on completion of the study (a hard copy plus a soft copy).
- Progress report must be presented not later than one year after approval of the project to the Ethics Committee of the University of the Free State and to Free State Department of Health.
- Any amendments, extension or other modifications to the protocol or investigators must be submitted to the Ethics Committee of the University of the Free State and to Free State Department of Health.
- **Conditions stated in your Ethical Approval letter should be adhered to and a final copy of the Ethics Clearance Certificate should be submitted to** khusemj@fshealth.gov.za or sebeelats@fshealth.gov.za **before you commence with the study**
- No financial liability will be placed on the Free State Department of Health
- Please discuss your study with the institution managers/CEOs on commencement for logistical arrangements
- Department of Health to be fully indemnified from any harm that participants and staff experiences in the study
- Researchers will be required to enter in to a formal agreement with the Free State department of health regulating and formalizing the research relationship (document will follow)
- You are encouraged to present your study findings/results at the Free State Provincial health research day
- Future research will only be granted permission if correct procedures are followed see http://nhrd.hst.org.za

Trust you find the above in order.

Kind Regards

Dr D Motau
HEAD: HEALTH
Date: 15/06/16

Head : Health
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Letter of Approval: Department of Biostatistics

UNIVERSITY OF THE FREE STATE
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UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

22 March 2016

For attention: Ethics Committee
Faculty of Health Sciences

Title of project:

VEIN SIZE AND DEMOGRAPHICS – IS THERE A CORRELATION?

Researcher:

Nadia Robberts

I hereby confirm that I approve of the study design, sampling method, measurement procedures and statistical analysis of the above-mentioned protocol.

Yours faithfully

Dr. Jacques Raubenheimer

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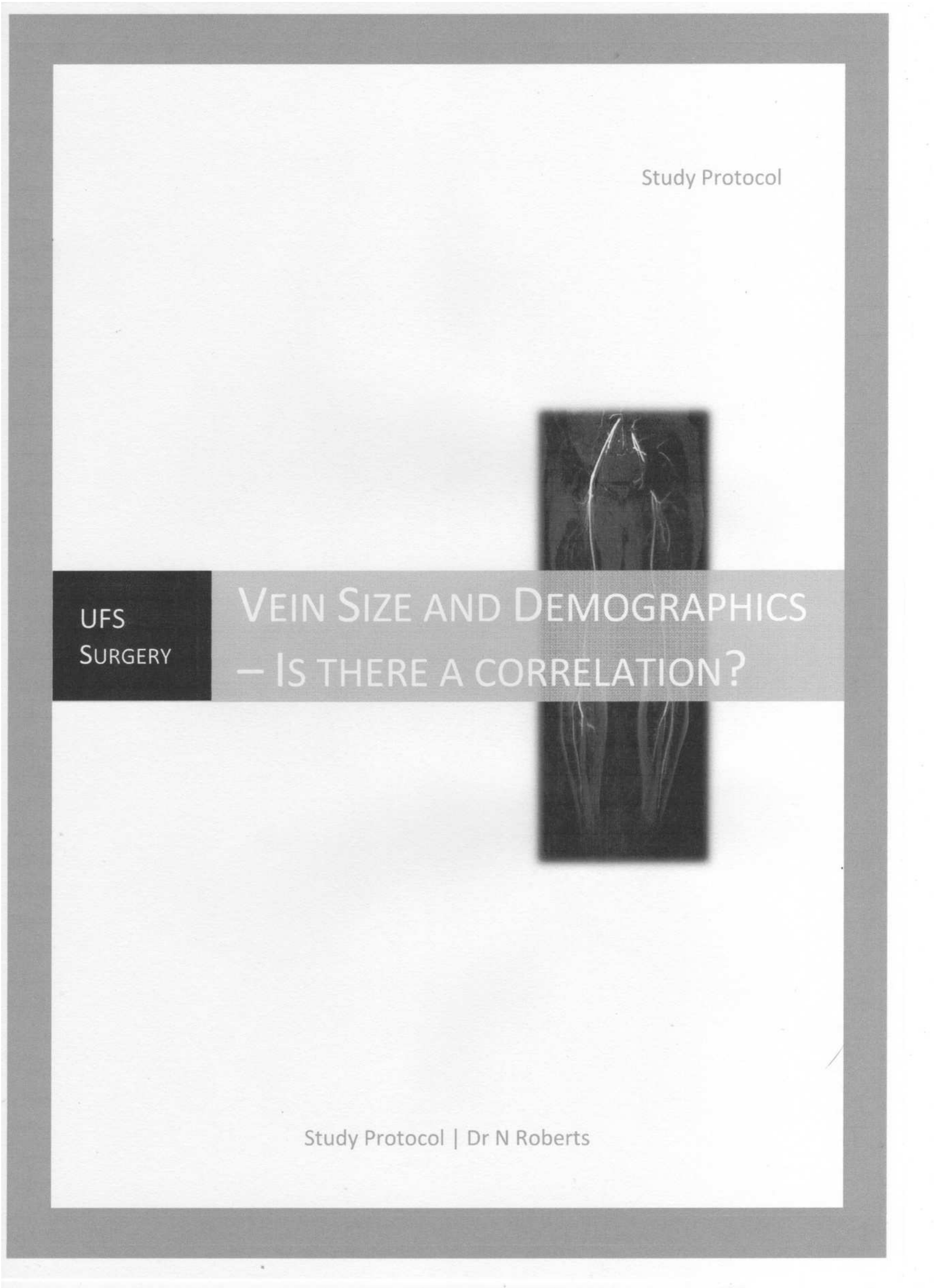
Research Protocol



Study Protocol

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SURGERY

VEIN SIZE AND DEMOGRAPHICS – IS THERE A CORRELATION?

Study Protocol | Dr N Roberts

Index

Researchers

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Introduction

Limb-threatening ischemia occurs in approximately 1% of patients with Peripheral Arterial Disease and profoundly impacts global morbidity, mortality and economy.[1] Lower Limb Amputation is associated with a 50% 5 year mortality rate and therefore, efforts to re-establish blood flow is crucial. Initial revascularisation may be achieved with either endovascular interventions or open surgical revascularisation with endogenous or synthetic graft bypass, depending on many factors, including availability of a favourable conduit.[2,3,4]

The preferred endogenous conduit for open infrainguinal revascularization is the great saphenous vein (GSV), which is proven to provide the best long-term patency [3,4,12]. It is usually available at the desired length, and is harvested easily in a relatively swift manner. As part of the preparation for lower limb bypass surgery, pre-operative vein mapping (phlebography) measures the diameter of the GSV at several levels in order to find a suitable conduit for the bypass procedure. These findings closely correlate with in situ vein diameters. Veins with chronic phlebitis, calcification, or an existing intraluminal thrombus are also identified and excluded in pursuit of an optimal graft conduit. Alternative conduits are used when endogenous veins are discovered to be unfavourable, either pre-, or intra-operatively.

Vein size (as measured for preoperative evaluation), may be influenced by ambient temperature, human error of the operating ultrasonographer, drugs causing vaso-constriction or –dilatation, cardiac output, contraction of skeletal muscles, hydrostatic forces (gravity), and circulating blood volume. Studies have failed to find a correlation with body habitus and average vein size.

Factors associated with an increased risk of primary vein graft failure (within 30 days post-operatively) include patient factors, such as female gender, African-American race, small diameter conduit, and non-adherence with post-operative ultrasound surveillance, as well as procedural factors, e.g. endothelial damage during harvesting of the vein.[5,6,7] Minimum vein diameter for conduits vary from 2.0 and 3.0mm in diameter, and are illustrated in table 1.

Table 1. Minimum GSV diameter recommended by authors

Author	*Date*	*Recommended minimum GSV diameter in mm*
Cruz	2004	2.5 – 3.0
Chew	2005	3.0
DeFreitas	2012	3.0
Johnston	2012	2.0
Jah-Kabba	2014	3.0
Oresanya	2014	3.0

Existing Studies indicate that African Americans, especially women, are more prone to Peripheral Arterial Occlusive Disease, as well as Diabetes Mellitus.[13] Furthermore, they are also more likely to lose their limbs compared to Caucasian patients. Multiple factors may contribute to these findings, including less access to health care, educational level, and socioeconomic status. No studies concerning these differences exist to date in South African literature, and no data up to this date exists on the difference in average vein size between races and genders. This study aims to find a correlation between vein sizes between different races, which, in the light of the proven correlation of conduit size with outcome of revascularisation procedures, might contribute to decreased success rate of infrainguinal limb salvaging procedures in certain population groups.

Aims and Objectives

The Primary aim of the proposed study is to determine the average Greater Saphenous Vein (GSV) size in our study population, and relate these sizes to the amount of veins deemed as suitable conduits for infrainguinal bypass surgery.

The secondary objective is to demonstrate a relationship between average vein size and demographic variables, like race, age, and gender.

Methodology

Study design

This will be a retrospective cross-sectional study.

Study participants

Population:
The population will consist of all patients who presented for Duplex Doppler Ultrasound Phlebography at Universitas Academic Hospital for assessment for potential lower limb bypass surgery from January 2006 to December 2015.

Sampling:
All patient records meeting the inclusion- and exclusion criteria will be used for the study. A count of excluded records and the reason for exclusion will be made.

Inclusion criteria:

- Only Lower limb imaging studies will be included.
- All participants will be 18 years and older.

Exclusion criteria:

- Patients of whom demographic data is incomplete or unavailable
- Vein mapping results which do not state the size of the GSV (vein simply deemed inadequate for bypass surgery)
- Cases where multiple vein mappings were done on the same patient.

Measurements

Demographic data on the hospital's electronic data base (Meditech) will be matched to the handwritten data forms of vein mappings in the vascular suite. Data recorded will be captured on a data sheet (appendix A). Average sizes will be determined from the most proximal measurement.

The meteorological season during which the imaging was recorded, will be used as surrogate indication of average temperature in vascular suite. Patient information will be kept anonymous. The hospital number will be recorded, but not coded for, and used to acquire demographic information on the Meditech system.

It will be presumed that all imaging procedures in the vascular suite are performed in a standardized manner. In our suite, this is as follows: the patient is placed in a room of which the ambient temperature is centrally regulated along with other rooms in the hospital. The patient is placed first in a seated and then in a standing position. Duplex ultrasound is then performed with a Toshiba®Nemio or Philips®CX50 Ultrasound with a linear probe. The frequency of this probe ranges between 3 – 11 MHz. Imaging in our suite is performed by two permanently employed qualified sonographers. Bilateral GSV are followed out and the diameter thereof recorded at 6 predetermined areas, namely: the inguinal area, mid upper leg, above the patella, below the patella, mid lower leg, and ankle. Veins are labelled as unusable when: diameter is less than 2.0mm or greater than 5.0 mm; veins have thickened walls – suggesting chronic phlebitis; or an existing thrombus in the lumen.

Methodological and measurement errors

Human error may influence sizes of veins measured. The measured diameter by ultrasound may also differ from in situ diameter. Bias is minimised in this study, due to the consistency of measurement by the permanently employed sonographers, but will be taken into account when interpreting data.

Ambient temperature has a marked effect on vascular tone, but is not routinely recorded in our vascular suite. The dates will be used to indicate the meteorological season and thereby account for differences in average vein size measurements.

The assumption that race can be purely defined is debatable, but cultural differences in different racial backgrounds are well documented. In this study, race will be classified using the electronic data base information on admission of participant.

Due to the retrospective nature of the study, missing or incomplete records in the electronic data base, as well as the filed handwritten sheets containing the imaging results may be problematic, and incomplete records will be excluded from this study.

Analysis

Analysis of data collected will be performed by the researchers and the department of Biostatistics at the University of the Free State. Data will be captured on an Excel spreadsheet. The data will be expressed as frequencies, percentages, mean, median and ranges. A p-value of <0.05 will be considered significant, testing the null hypothesis of similar average vein sizes among people of different races and gender. Age will be correlated with vein size using pearson correlation coefficients, and differences in the correlations will be determined for race and age via Fisher's r-to-z transformation. Age will then be grouped by decade. Vein size will be compared by means of factorial ANOVA including race, age group, gender and meteorological season and the interaction between these variables.

The odds for the prevalence of suitable vs unsuitable veins will be determined for race, age group, and gender.

Proposed Time Schedule

Date	*Task*
January to February 2016	Writing of Protocol
March 2016	Submission of Protocol to Ethics Committee
September to December 2017	Data Capturing
January 2018	Submission of Data for Analysis
June 2018	Submission of Completed Article

Ethical considerations

The study protocol will be submitted to the Ethics Committee of the Faculty of Health Sciences, University of the Free State. A progress report will be submitted yearly. A report on conclusion of the research will be submitted to the Ethics Committee.

As this is a retrospective study, all data and information collected will be regarded as confidential. Encryption with new numbers will be done to replace the hospital numbers and names of patients. Hospital numbers will be recorded on the data sheet, but will not be coded for. Every precaution will be undertaken to ensure the privacy of the research participants and the confidentiality of their personal information.

The data file will be stored by the researcher in the Department of Surgery in the University of the Free State. Permission for the research will be obtained from Dr. NE Pearce, Acting Head of Department of Surgery, University of the Free State and Dr. R. Nathan, Head of Clinical Services, Universitas Academic Hospital.

Budget

A printed data sheet will be completed for each participant. The projected cost of stationary is estimated at ±R500, which will be covered by the researchers. Data analysis will be done at no additional cost. The researchers will perform the research at no additional salary costs. This study will not be funded by sponsors.

Implementation of findings

This study will be used for the M.Med dissertation to be handed in and marked as part of the curriculum. Owing to the existing risk of small conduit size for graft failure, a significant association of vein size with race and gender might improve future selection parameters for the choice between prosthetic and autogenous graft, potentially avoiding revision of grafts or overall failure with possible limb amputation or prolonged morbidity and cost implications. The use of endovascular procedures are preferred to open grafts in the presence of unfavourable anatomy. Although not included in this study, the risks of graft failure due to inadequate conduit may also apply to upper limb bypass surgery, arterio-venous fistulae for access in hemodialysis, and Coronary Artery Bypass Graft surgery.

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Data Capture Sheet

Data Capture Sheet

Sheet Number	[ ]			1 [ ]
Hospital Number	[ ][ ][ ][ ][ ][ ]			Not coded
Gender	M 1	F 2		2 [ ]
Age	[ ][ ]			3 [ ]
Race	B 1	W 2	C 3 / O 4	4 [ ]
Leg	R 1	L 2		5 [ ]
GSV diameter in mm above knee:				
Groin	[ ]	Not Recorded*		6 [ ]
Mid	[ ]	Not Recorded*		7 [ ]
Above knee	[ ]	Not Recorded*		8 [ ]
GSV diameter in mm below knee:				
Below knee	[ ]	Not Recorded*		9 [ ]
Mid	[ ]	Not Recorded*		10 [ ]
Ankle	[ ]	Not Recorded*		11 [ ]
OR				
USABLE 1	NON-USABLE 2			11 [ ]

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The rationale for analysis based on racio-ethnic-cultural categorisation should be indicated.

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