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ORIGINAL ARTICLE

Surgeon's Focussed Ultrasound Examination of the Long Saphenous Vein Reduces Surgical Time and Wound Complications

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Background Despite increased use of arterial grafts, the long saphenous vein (LSV) is often utilised as conduit for coronary artery bypass graft (CABG). Preoperative ultrasound (U/S) vein assessment is limited to patients with varicosities, clinical signs suggestive of poor vein conduits and a history of cardiac or vascular surgery. The aim of this study was to evaluate the usefulness and logistics of the surgeon incorporating intraoperative U/S assessment of the LSV into their regular practice.

Methods All patients undergoing coronary artery revascularisation and open vein harvest in our institution were recruited from July 2016 to February 2017. Demographics, including known risk factors for wound complications were documented, in addition to surgical details such as harvest time, vein length and surgical repairs of the conduit. Focussed U/S assessment was performed intraoperatively by the surgical registrar before beginning the procedure. The diameter of the leg pre and postoperatively, as well as the incidence, type and severity of wound complications were documented for further statistical analysis.

Results A total of 103 patients were included in this study. Two patients died perioperatively and were excluded from the study. The remaining 101 patients were separated in two cohorts—U/S group (n = 32) and blind technique group (n = 69). Demographics were similar between the groups, whilst other risk factors for harvest complications, such as presence of superficial varicosities on clinical examination and renal failure were significantly more frequent in the U/S group. The median harvest time was significantly lower within the U/S group (25 mins versus 40 mins; $p = 0.001$), as was the rate of overall wound complications (6.2% vs 23.2%; $p = 0.04$).

Conclusions Ultrasound assessment of the LSV by the surgical team intraoperatively is feasible, easy to learn and does not demand extra costs or delays. It significantly reduces surgical harvest time and it is associated with a reduced incidence of wound complications, swelling and postoperative mobility impairment.

Keywords Vein harvesting • Conduit harvesting • Focussed ultrasound • Coronary bypass graft • Vein conduit

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Introduction

The long saphenous vein (LSV) together with the left internal mammary artery remain the conduits of choice used in coronary artery bypass grafting (CABG). This is despite recommendations for total arterial revascularisation [1,2]. The morbidity associated with harvesting of the LSV is a burden to patient recovery and provider costs, with an incidence of up to 40% [3]. Complications include surgical site infections, pain, swelling and impaired mobility.

There has been abundant research into refining the harvest methods. Since the introduction of endoscopic harvesting in 1995, this technique has become increasingly popular because of its benefit in wound healing, [4] however, its use is still limited to a few centres in Australia due to cost, concerns of conduit damage, and the learning curve [5,6].

The use of ultrasound (U/S) in assessing and accessing vascular structures has become mandatory across different specialties due to low cost, availability and improved outcomes [7,8]. However, preoperative ultrasound assessment of the LSV is often reserved for patients with varicosities, clinical signs suggestive of poor conduit, or a history of vascular surgery.

Success of the traditional ''blind technique'' relies on physical examination, experience and expectation of a typical vein anatomical distribution, however, several studies suggest that the incidence of ultrasound-detected anatomical variations affecting the LSV ranges from 20 to 40% [3]. In addition to variable anatomy, approximately two-thirds of the Australian population are classified as overweight or obese which further renders crude physical examination to identify the LSV as obsolete [9].

The aim of this study was to evaluate the usefulness and applicability for the surgeon to incorporate intraoperative focussed ultrasound assessment of the LSV into routine practice, and the impact of this practice on wound healing and recovery when compared to a ''blind technique''.

Material and Methods

Study Design and Population

We started with the hypothesis that harvest site wound complications occur independently to the use of focussed ultrasound examination of the LSV. To explore this hypothesis, we recruited all patients undergoing coronary artery bypass surgery and open vein harvest in our institution from July 2016 to February 2017. At the time of the study, endoscopic vein harvest was introduced in our unit, as the original study was designed to compare wound complications in open vein harvesting, no data was collected for these patients and, therefore, not included in our study. Randomisation was not possible due to equipment limitations in our centre (available ultrasound machines in theatre), but data was prospectively collected and analysed independently.

Patient demographics, particularly those associated with a higher risk of postoperative wound complications, were documented. These included age, gender, body mass index, the presence of superficial varicosities (on preoperative clinical examination), peripheral vascular disease, diabetes, renal failure and steroid usage. In addition to this, all patients underwent routine measurement of their leg diameter preoperatively above the ankle, below the knee and mid-thigh level.

Outcomes

Postoperative details were collated. Wound complication was defined by the presence of wound infection with an ASEPSIS [16] score higher than 30; dehiscence requiring surgical intervention; and unnecessary second limb incision (contralateral limb) where either a vein was not found on initial incision or its quality was deemed to be not usable for grafting and discarded.

Other secondary outcomes included length of hospital stay, patient mobility, patient satisfaction and the difference of pre and day 5 postoperatively leg diameters, as a measure for swelling.

To assess the usefulness and applicability, the following operative details were recorded for each case: extension to thigh, length of vein, harvest time, number of vein repairs, wound closure time, total harvesting time and total surgical time.

Statistical Analysis

Continuous variables are presented as mean $\pm$ standard deviation (SD) or median and inter-quartile range and analysed either with Student's t-test or the Mann-Whitney U test according to each variable data distribution. A two-tailed p-value of <0.05 was considered statistical significant. Binary data is presented as frequencies and analysed using Pearson Chi-squared test. Statistical analysis was performed with the software SPSS 22 (IBM Corp, Armonk, NY, USA).

Ultrasound Assessment Technique of the Lower Limb

Prior to this study being carried out, the five surgical registrars in our unit received a short training tutorial regarding how to perform lower limb vein ultrasound. Three of the registrars were experienced operators (with more than 100 vein harvests) and the other two were novice operators.

Based on different publication descriptions [3,10], we created a technique protocol which we describe here.

Ultrasound assessment was performed by the surgical registrar in theatre, immediately after anaesthesia and prior to beginning the procedure. A linear array transducer was used due to its high resolution when scanning shallow structures. Gain was slightly increased to demarcate layers and subcutaneous structures. The depth was adjusted to 1–3 cm for the leg and 3–5 cm for the thigh.

The patient was initially positioned with abducted hips and flexed knees with support of a pillow under the thighs and the standard LSV anatomical landmarks were marked (2 cm anterior to the medial malleolus in the ankle, 5 cm medial to the medial border of the patella in the knee and the saphenous opening in the groin) (Figure 1). The ultrasound examination was started from any of these landmarks.

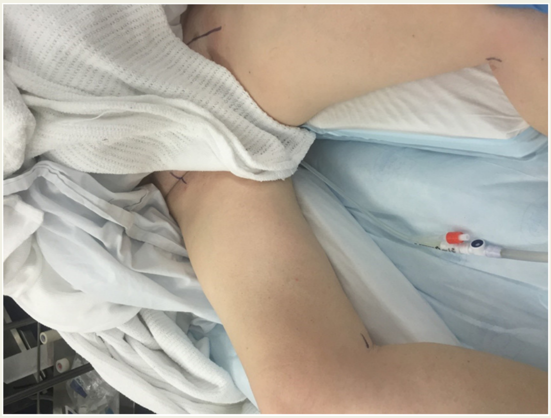

Figure 1 Positioning of patient.

To identify the saphenous vein, the ''Egyptian eye" sign was located and then the vein was followed proximally and distally (Video S1 in the online version at DOI: 10.1016/j.hlc.2018.09.012). The vein was measured and assessed for presence of varicosities or thrombus. The skin was marked with a surgical pen proximal and distal to the probe location (Figure 2) as well as its major tributaries. In difficult cases, the use of a tourniquet to distend the veins aided the process as well as the use of colour Doppler.

Results

From the 103 patients that had CABG with open vein harvest, two patients died within 72 hours of surgery and were, therefore, not included in the cohort. The remaining 101 patients were distributed in two groups: Ultrasound group (n = 32) and Blind technique group (n = 69).

Age, body mass index (BMI) and steroid use were statistically similar in between both groups, there was a trend towards more females, patients with diabetes and peripheral vascular disease in the ultrasound group but not reaching statistical difference. The presence of superficial varicosities on preoperative clinical examination (28.1% vs 2.9%, p = 0.001) and renal failure (21.9% vs 5.8%, p = 0.016) was significantly higher in the ultrasound group (Table 1).

Intraoperative Characteristics

The length of the harvested veins as well as the number of veins requiring repairs, were similar among the groups. The median harvest time was significantly longer in the blind technique group (25 mins [20–30] vs 40 mins [30–50]; p = 0.001) but with similar wound closure time. This difference in time affected the total time required to harvest and close the wound in favour of the ultrasound group (50 mins [40–70] vs 70 mins [50–90]; p = 0.04), however, the total surgical time remained statistically similar in between the groups (Table 2).

Outcomes

The overall wound complication rate was significantly lower in the ultrasound group (6.2% vs 23.2%; p = 0.04). A similar pattern in favour of the ultrasound group was found for the number of patients with mobility impaired (3.1% vs 19.1%; p = 0.03), and distal thigh diameter difference between day 5 and preoperatively as indicator of swelling (0.5 cm [0–3] vs 3.5 cm [0–6.6]; p = 0.002).

Figure 2 Examination and marking of the long saphenous vein.

Table 1 Patient characteristics.

	U/S Group N = 32	Blind Group N = 69	P-value
Age	65 ± 11	65 ± 11	0.86
Gender: Female	37.5%	21.7%	0.10
BMI	31.8 ± 8	29.7 ± 5	0.20
Diabetes	56.2%	36.2%	0.058
Steroid use	3.1%	0%	0.32
Varicosities*	28.1%	2.9%	0.001
PVD	15.6%	5.8%	0.11
Renal Failure	21.9%	5.8%	0.016

Abbreviations: BMI, body mass index; PVD, peripheral vascular disease.
*Superficial varicosities on preoperative clinical examination.

Table 2 Intraoperative data.

	U/S Group N = 32	Blind Group N = 69	P-value
Harvest time (mins)	25 [20–30]	40 [30–50]	0.001*
Wound closure time (mins)	27 ± 13	31 ± 18	0.27
Total harvest time (mins)	50 [40–70]	70 [50–90]	0.04*
Total surgical time (Hours:min)	4:24 [3:56–4:45]	4:08 [3:52–4:48]	0.42*
Vein length (cm)	37.2 ± 12	40.3 ± 12	0.21
Vein repair	13.8%	8.3%	0.45

Abbreviations: U/S, ultrasound.
*non-parametric test.

Patient satisfaction, calf swelling, and admission days were similar among the groups (Table 3).

Discussion

The long saphenous vein, which is still largely utilised for CABG, is rarely assessed prior to surgical harvesting. This lack of preoperative information about the anatomy and quality of the vein can lead to unnecessary incisions, significant soft tissue trauma, formation of tissue flaps that eventually can lead to significant wound morbidity.

Multiple methods have been introduced which seek to avoid this wound morbidity, such as endoscopic harvesting which has proven superiority in wound healing [4] and the use of negative pressure wound therapy [11]. Unfortunately, these methods are expensive and not always available.

Ultrasound assessment of vascular structures and real-time cannulation was introduced in the early 1980s [12] and has become popular since then and even compulsory through different specialties in theatre, intensive care and emergency departments due to the reduction of complications [8].

Currently, assessment of the LSV prior to surgery is usually performed outside theatre by an ultrasonographer and limited to patients with previous limb vascular surgeries or the presence of superficial varicosities on preoperative physical examination. In comparison to other published studies, the vein assessment in our study was performed by the surgical registrar in theatre prior to the start of the case.

The protocol utilised for the ultrasound assessment was adapted by the author from the techniques described by Colin R. at the coursework of the University of Melbourne Masters of Clinical Ultrasound [13] and the protocols used by Soo et al. and Luckraz et al. [3,10] This protocol was easily

Table 3 Outcomes.

		U/S Group N = 32	Blind Group N = 69	P-value
Complication□		6.2%	23.2%	0.04
Patient satisfaction		96.9%	91.2%	0.29
Mobility affected by wound		3.1%	19.1%	0.03
Leg measurement Difference (cm)	Distal calf	0 [0–1]	2 [0–4]	0.09*
	Proximal calf	2 [0.5–3]	2 [1–6]	0.21*
	Distal thigh	0.5 [0–3]	3.5 [0-6.6]	0.002*
Admission days		10 [7–13]	8 [6–10]	0.25

Abbreviations: U/S ultrasound., not shown.
*non-parametric test.
□Complications included: The presence of wound infection with an ASEPSIS [16] score higher than 30; dehiscence requiring either surgical intervention or wound clinic follow-up; and unnecessary second limb incision due to either a vein was not found on initial incision or its quality was deemed to be insufficient for grafting and not used.

learnt by the five surgical registrars in our unit. The time required to perform this assessment in theatre was around 10 minutes which did not affect the total time that patients were in theatre room (4 hrs 24 mins [3:56–4:45] vs 4 hrs 8 mins [3:52–4:48], $p > 0.05$).

Most of the demographic characteristics of our cohort were statistically similar, but we noted that the ultrasound group had a trend towards patients with increased risk for wound complications such as females, peripheral vascular disease (PVD) and diabetics [14] and statistically more patients with superficial varicosities on clinical examination (28.1% vs 2.9%, $p = 0.001$) and end-stage renal failure (21.9% vs 5.8%, $p = 0.016$).

The accurate prediction of the anatomy and size of the harvested vein by ultrasound was noted in all cases which was also demonstrated by Luckraz et al. [3]. This translated in significantly shorter harvesting times in the ultrasound group (25 mins [20–30] vs 40 mins [30–50], $p = 0.001$) despite the mixed level of expertise of the operators, without affecting the harvested vein length or quality.

The complication rate in the ultrasound group was significantly lower (6.2% vs 23.2%, $p = 0.04$) despite this group having patients with baseline characteristics that rendered them surgically more complex than the blind technique group.

Whilst length of hospital stay was not statistically different in our study, a reduction in length of stay has been proven in previous smaller studies [3,15]. In our study, the reduction in wound complications resulted in less patients reporting mobility impairment due to pain or swelling in the harvested side (3.1% vs 19.1%, $p = 0.03$).

Conclusion

The authors acknowledge the limitations of non-randomisation but, based on the findings from this observational study, we conclude that focussed ultrasound examination of the long saphenous vein by the surgeon in theatre is feasible, it reduces surgical harvest time without affecting conduit quality and it is associated with reduced incidence of wound complications, swelling and postoperative mobility impairment. We encourage its use especially in patients at increased risk of wound complications.

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