

Institutional report - Coronary Accessory and great saphenous veins as coronary artery bypass conduits

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Abstract

Anatomic, histologic and ultrasound studies demonstrate two distinct types of longitudinal veins in the lower extremities. The great saphenous vein is deep to the saphenous fascia. Accessory saphenous veins are superficial to this layer, have thin walls with diminished muscle cells and elastic fibers. Vein characteristics may affect long-term graft patency. This study assesses the incidence of accessory saphenous veins in various patient groups and evaluates issues related to their use as coronary conduits. Ultrasound imaging assessed great and accessory saphenous veins in 476 normal limbs, in 42 patients post-saphenous vein harvesting and in 75 patients undergoing coronary revascularization. Accessory saphenous veins are found in 67% of normal subjects. Intraoperative ultrasound identifies accessory saphenous veins in 54% of limbs, most in the proximal calf where 42% of all accessory vein segments are located. Great saphenous vein segments are more common in males while accessory veins are more common in females. In 54 limbs following saphenectomy, patent great saphenous vein segments are demonstrated in 20%, adjacent to incision sites, indicating use of accessory saphenous veins in these patients. Ultrasound studies at two medical centers document the common occurrence of accessory saphenous veins. Additional studies are required to determine the efficacy of utilizing accessory saphenous vein segments for coronary artery bypass conduits.

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1. Introduction

Correlation of anatomic, histologic and ultrasound studies demonstrates two types of longitudinal veins in the subcutaneous tissue of the lower extremities [1,2]. The great saphenous vein (GSV) is deep to the saphenous fascia and abuts the muscular fascia while accessory saphenous veins (ASVs) are superficial to the saphenous fascia. The fascial layers join after arching over the GSV, delimiting the saphenous compartment [1,3]. Longitudinal veins devoid of a fascial envelop and close to the dermis are ASVs [4]. GSVs may be atretic, hypoplastic, of caliber appropriate for use as coronary conduit, dilated or thrombosed. Each vein type has differing anatomic, histologic, and physiologic characteristics [2,3].

Saphenous vein conduit selection is based on length and lumen characteristics. During saphenous vein harvesting, transition of a GSV to an ASV cannot clearly be distinguished by external examination. Due to morphology, size and length, ASVs are utilized for coronary artery conduits, though the frequency of their use is unknown. Histologic studies demonstrate that ASVs have thinner walls with less elastic fiber and muscle cells than adjacent segments of GSVs. On ultrasound examinations, the wall of the GSV is more echogenic than adjacent ASV segments. It has been

postulated that ASVs are more prone to varicose changes [2,4]. With these findings, the concept that all superficial veins in the lower extremity are equally suited for use as an arterial conduit is necessarily challenged.

The purpose of this study is to assess the frequency of occurrence of ASVs in normal subjects and in patients undergoing coronary artery bypass surgery and to assess issues related to their use.

2. Materials and methods

2.1. Normal subjects study

Studies were carried out at University of Rome 'La Sapienza', Rome, Italy. Ultrasound evaluations were performed in normal subjects and in subjects with suspected arterial vascular disease. Superficial venous anatomy was evaluated by ultrasonography utilizing a Siemens Sequoia Model 512 scanner with a Model 15L8 ultrasound probe (Siemens Medical Solutions, Mountain View, CA). Studies were performed on 476 limbs (291 females; median age 61 years; 185 males; median age 63 years) according to methodology and criteria previously described [1,5].

Subjects undergoing venous biopsies gave written informed consent with project approval by the local Ethics Committee. Selective biopsies were obtained from patients undergoing saphenous vein harvesting to assess cellular histology and wall thickness.

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2.2. Post-saphenous vein harvesting study

Data for this study were gathered at University of Rome 'La Sapienza', Rome, Italy in 54 limbs of 42 patients who had previously undergone excisional 'saphenous vein' harvesting during coronary revascularization. Post-operative studies were performed from one month to 8 years following the coronary artery bypass. Anatomy of the superficial venous bed was evaluated adjacent to the incision sites used for harvesting the saphenous veins.

2.3. Intraoperative coronary artery bypass ultrasound study

This patient data study was approved by the Sutter Health Central Area Institutional Review Committee with exempt status waiver.

The study was performed at Sutter Medical Center, Santa Rosa, CA in 75 consecutive patients undergoing coronary revascularization. Patients with superficial venous disease and those with previously excised saphenous veins were excluded.

Intraoperative venous ultrasound studies are performed routinely in all coronary artery bypass patients following endotracheal intubation utilizing a high-resolution ultrasound scanner. A proximal thigh tourniquet in the supine position is utilized to provide venous distension [6].

Saphenous vein segments are evaluated in the proximal and distal calf and thigh, corresponding to the use of vein segments at these sites for coronary artery conduits. GSV and ASV segments are suitable for use as arterial conduits, if they measure 2 to 5 mm in internal lumen diameter and extend one-half the length of the calf or thigh. Dilated vein segments are identified as veins 5 mm in diameter. Thrombosed veins are defined as incompletely compressible vein segments with application of probe pressure. For the purposes of this study, a vein segment was assigned a single category based on the major portion of the vein segment fulfilling the defined criteria.

Statistical analysis of categorical data was performed by the χ^2 method. Percent values are rounded to whole numbers.

3. Results

3.1. Normal subjects study

One or more ASVs between 2 and 5 mm internal lumen diameter were present in 67% of limbs examined. The length of the ASV was variable, some veins extending a few centimeters while others were more than 15 cm, easily confused with GSVs based solely on caliber and length considerations. In 12% of limbs, a portion of the GSV was aplastic and, at that level, only a large ASV was visible. Dilated veins, measuring 5 mm internal lumen caliber, were present in 19% of GSVs and 17% of ASVs.

Selective tissue specimens of GSVs and adjacent ASVs were obtained for histologic study. Sampling sites were correlated with pre-operative ultrasound studies. An example of one of these studies is shown in Fig. 1.

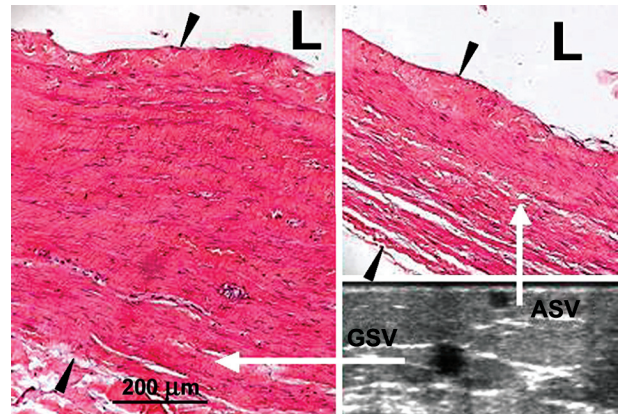


Fig. 1. Histology of great and accessory saphenous veins of a 63-year-old male. Light microscopy of GSV and ASV. Specimens obtained from vein sites corresponding to the pre-operative ultrasound scan, as shown above. Vessel lumen indicated by 'L'. Wall thickness indicated by black arrowheads. GSV wall thickness measures 686 μm and ASV measures 374 μm . Hematoxylin-eosin stain, original magnifications 20 \times .

3.2. Post-saphenous vein harvesting study

A patent GSV segment, proximal to the site of its ligation and excision, was always present. The GSV originated from the confluence of small tributaries or as the continuation of an enlarged ASV. In 11 limbs (20%), a patent segment of the GSV of varying length, was demonstrated in proximity to the skin incision. Most of these GSV segments were over 6 cm and were of sufficient diameter and echogenic characteristics to be considered for use as coronary artery conduits.

3.3. Intraoperative coronary artery bypass ultrasound study

Coronary bypass procedures were performed in 60 males and 15 females. Mean age for all patients is 67 years.

GSV and ASV morphology are recorded in Table 1. Eight segment levels were evaluated in each patient. Abnormalities in GSV lumen caliber to preclude their use as coronary conduits due to diminished vessel size or dilatation occurred in 14% proximal thigh segments, 33% distal thigh segments, 39% proximal calf segments and 17% distal calf segments.

ASV segments 2 mm and <5 mm internal lumen diameter were identified in 144/600 (24%) limb segments. Most ASVs were in the proximal calf where 42% of all ASV segments in this caliber range were identified. At least one ASV was present in 81/150 (54%) limbs. Of 204 vein segments harvested for conduit use, 6% were ASVs. Gender distribution of ASV segments is shown in Table 2. An ultrasound image of a GSV and ASV is shown in Fig. 2. An image of an ASV and a hypoplastic GSV is shown in Fig. 3.

ASVs were identified in the distal thigh, adjacent to the incision site for endoscopic vein harvest. Isolated ASVs in the caliber range 2–5 mm internal lumen diameter, associated with a GSV <2 mm diameter were found in 31 of 150 (21%) limbs with a statistically significant gender difference (male=17%, female=37%, $P=0.016$), Fig. 3. ASVs and GSVs, both in the caliber range 2–5 mm diameter (Fig. 2), were found in 16 of 150 (11%) limbs. Gender differences were not significant.

Table 1
Distribution of GSV and ASV vein segments

LIMBS	<i>n</i>		150		150	
			<i>n</i>	%	<i>n</i>	%
			GSV	GSV	ASV	ASV
THIGH	PROXIMAL	NORMAL	129	86	9	6
THIGH	PROXIMAL	SMALL	4	3	139	93
THIGH	PROXIMAL	DILATED	17	11	2	1
THIGH	PROXIMAL	THROMBUS	0	0	0	0
THIGH	DISTAL	NORMAL	100	67	49	33
THIGH	DISTAL	SMALL	40	27	96	64
THIGH	DISTAL	DILATED	10	7	5	3
THIGH	DISTAL	THROMBUS	0	0	0	0
CALF	PROXIMAL	NORMAL	91	61	60	40
CALF	PROXIMAL	SMALL	59	39	89	59
CALF	PROXIMAL	DILATED	0	0	1	1
CALF	PROXIMAL	THROMBUS	0	0	0	0
CALF	DISTAL	NORMAL	124	83	26	17
CALF	DISTAL	SMALL	26	17	124	83
CALF	DISTAL	DILATED	0	0	0	0
CALF	DISTAL	THROMBUS	0	0	0	0

Values record number (*n*) and percent (%) occurrences of GSVs and ASVs. NORMAL=internal lumen caliber 2 mm and <5 mm. SMALL=absent or small vein segments, <2 mm internal lumen diameter. DILATED=internal lumen caliber 5 mm. THROMBUS=incompletely compressible vein segment. Intraoperative ultrasound studies are performed on 75 patients without known venous disease. A total of 600 vein segments are examined in 150 limbs. Vein segments at each level total 100%. Percent values may not summate to 100% due to rounding.

Dilated vein segments were detected in 27 (5%) GSVs and 8 (1%) ASVs out of a total of 600 limb segments examined.

4. Discussion

Large ASVs, parallel to the GSV, are present in 67% of limbs from normal subjects, similar to the findings in the Intraoperative Coronary Artery Bypass Ultrasound Study group. In the Normal Subjects Study group, ASVs as large as the corresponding segment of the GSV or larger, were visible in 35% of limbs. In 12% of limbs, only ASVs were visible, associated with segmental aplasia of the GSV.

Table 2
Gender distribution of GSV and ASV segments

	GSV		GSV		<i>P</i>	ASV		ASV		<i>P</i>
	Male		Female			Male		Female		
	<i>n</i>	%	<i>n</i>	%		<i>n</i>	%	<i>n</i>	%	
PROXIMAL THIGH	103	86	26	87	0.906	7	6	2	7	0.864
DISTAL THIGH	85	71	15	50	0.030	34	28	15	50	0.024
PROXIMAL CALF	79	66	12	40	0.010	43	36	17	57	0.037
DISTAL CALF	103	86	21	70	0.040	16	13	10	33	0.010

Values indicate number (*n*) and percent (%) occurrences of GSVs and ASVs in vein segments of males and females measuring 2 mm and <5 mm internal lumen caliber and extending one-half of the length of the thigh or calf. Within this vein diameter range, GSVs are more common in males and ASVs are more common in females. Distal thigh and calf GSV and ASV segments illustrate significant gender distribution differences by the χ^2 statistic. Ultrasound studies are performed on 75 patients, 60 males and 15 females. A total of 600 venous segments are examined in 150 limbs. At each of the four segment levels, 120 vein segments are examined in males and 30 segments in females.

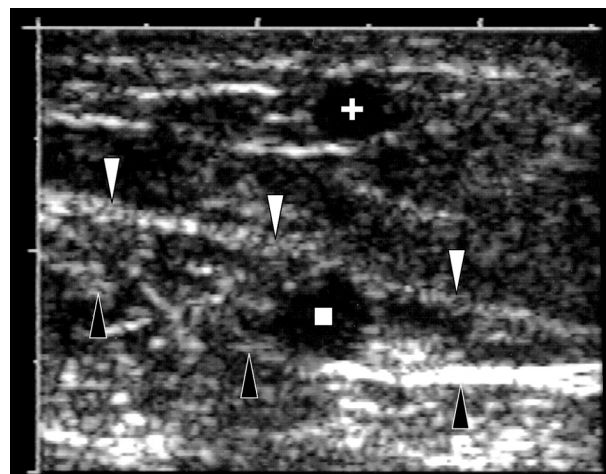


Fig. 2. Accessory and great saphenous vein ultrasound study of eighty-five year old male. Intraoperative ultrasound recording of GSV (■) and ASV (+). Transaxial image of the distal thigh. ASV is located in the subdermis adipose tissue and measures 3.0 mm internal lumen diameter. The GSV is enclosed by muscular (black arrowheads) and saphenous (white arrowheads) fascia. GSV internal lumen diameter is 3.6 mm. The fascial layers form an ensheathing envelop along the course of the GSV, verified by transaxial real-time ultrasound tracking. Vertical axis, full scale, is 20 mm.

These similar results from two institutions support the conclusion that ASVs commonly occur in patient populations.

Wall thickness of the GSV is about twice the thickness of the adjacent ASV (Fig. 1), though vein diameters are similar on the pre-operative ultrasound study. Wall thickness differences between GSVs and ASVs persist even if the ratio between wall thickness and lumen caliber are consider-

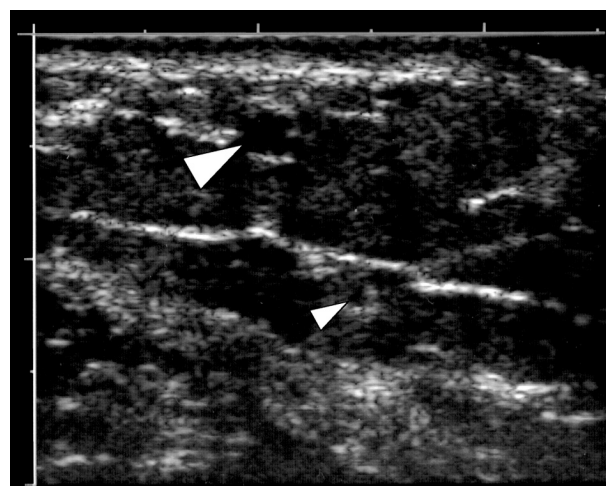


Fig. 3. Accessory and hypoplastic great saphenous vein ultrasound study of a 62-year-old male. Intraoperative ultrasound recording of ASV (large arrowhead) and hypoplastic GSV (small arrowhead). Transaxial image of the distal thigh. ASV is located in the subdermis adipose tissue and measures 2.0 mm internal lumen diameter. The GSV is enclosed by muscular and saphenous fascia. GSV internal lumen diameter is 0.4 mm. The fascial layers form an envelope along the course of the GSV. Transaxial real-time ultrasound tracking confirms the longitudinal extension of the fascial envelop surrounding the hypoplastic GSV. Patency of the GSV lumen is demonstrated by probe compression. Saphenous and muscular fascial layers can be identified even if a GSV is absent or hypoplastic. Vertical axis, full scale, is 20 mm.

ed [2]. The increased wall thickness of the GSV is associated with hyperechoic ultrasound signals adjacent to the vein lumen.

The finding of a long segment GSV on the post-saphenous vein harvesting study indicates that an adjacent segment of ASV had been excised for use as a coronary conduit, at the time of coronary revascularization. Thus, when performing reoperative coronary procedures, ultrasound examination of saphenous vein excision sites should routinely be performed to determine if suitable GSV conduit can be identified.

ASVs in patients undergoing coronary bypass surgery are common. Most surgeons do not differentiate between ASVs and GSVs as long as anatomic factors are favorable. If harvested saphenous vein segments in the subcutaneous location are of satisfactory quality, sufficient caliber, and adequate length, they are likely to be utilized for coronary artery conduits.

The increased incidence of ASVs in females (Table 2) also suggests that ASVs in females are more likely to be utilized as coronary conduits. Analysis of ultrasound studies of distal thigh segments demonstrate a high incidence of ASVs adjacent to the incision site where a vein segment for endoscopic vein harvesting would be found. Use of intraoperative ultrasound studies avoids harvesting ASV segments in this location.

In the Intraoperative Coronary Artery Bypass Ultrasound Study group, hypoplastic or absent GSVs, were documented in 3% of proximal thigh segments, increasing to an incidence of 39% in proximal calf segments. Dilated venous segments were identified in 5% of all GSV segments, representing 13% of limbs.

Our studies identify ASVs as a common finding in several patient populations at two medical institutions employing identical ultrasound scanning equipment and similar ultrasound performance methodologies. Recognizing that ASVs may be less satisfactory as coronary artery conduits, we attempted to limit their use. However, due to limitation in GSV availability, ASVs were used as coronary conduits in 6% of patients in the Intraoperative Coronary Artery Bypass Ultrasound Study group. Though ASVs were used in only a total of 8 patients, the percent use in females was 27% while the percent use in males was 7%, consistent with their gender distribution differences.

Intravascular ultrasound imaging studies of coronary artery conduits following revascularization demonstrate increasing wall thickness which occurs within six months following surgery [7]. Marin et al. [8], and Davies et al. [9] demonstrated a link between initial intimal and medial wall thickness and subsequent graft stenosis.

ASVs with their thin walls may be subjected to increased wall shear stress changes following arterial revascularization and undergo accelerated biochemical and histological changes. Ishikawa et al. [10] indicated that matrix metalloproteinase-1 may play a role in collagen alterations in vascular walls as a response to hemodynamic shear stress and elevated metalloproteinase-1 has been found in varicose veins [11]. Alternatively, the initial presence of increased intimal smooth muscle cells and muscularization of the media and adventitia in GSVs may be associated with a different pattern of shear stress pressure response.

The abundance of cellular structures in GSVs may lead to increased biochemical expression through mechanical signal transduction after coronary artery bypass [10,12]. Following coronary revascularization, saphenous vein biochemical and histological changes over time are likely to be different based on initial anatomic, histologic and biochemical characteristics of GSVs and ASVs [2,13].

Transaxial ultrasound imaging defines the relationship of the saphenous veins to fascial structures. Though ASVs usually are thin-walled with multiple, small, friable branches, the external appearances of GSVs and ASVs are similar and the two vein types cannot be clearly differentiated on visual inspection [2]. While it is commonly thought that donor saphenous veins are homogeneous, differences in saphenous vein histology, physiology and ultrasound characteristics [14] prove this not to be the case.

Histologic and physiologic characteristics of ASVs may be associated with remodeling changes that are different from GSVs. Females have a higher incidence of ASV segments and likely a higher frequency of use as arterial conduits. Whether use of ASVs in females is an additional adverse risk factor in graft patency, morbidity and mortality [15] requires further investigation. Ongoing studies are in progress to determine long-term outcomes of ASVs as coronary artery conduits.

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