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Bedside Vein Mapping for Conduit Size in Coronary Artery Bypass Surgery

Frank Manetta, MD, Pey-Jen Yu, MD, Allan Mattia, MD, John C. Karaptis, PAC, Alan R. Hartman, MD

ABSTRACT

Background and Objectives: The greater saphenous vein has been used in coronary artery bypass grafting (CABG) for more than 50 years. Endoscopic vein harvesting has greatly reduced the morbidity associated with obtaining the vein, but the quality of the vein could not be assessed before its was exposed surgically or after the endoscopic procedure had been performed. This study was conducted to evaluate the accuracy of preoperative mapping of the greater saphenous vein at the bedside in assessing suitable conduit size for use in CABG.

Methods: Seventy-two consecutive patients undergoing saphenous vein harvesting for use as a conduit during CABG underwent preoperative ultrasonographic vein mapping on the operating table after the leg was positioned for vein harvesting. Vein diameters at 3 distinct locations were measured by ultrasonography after vein harvesting and preparation. Similar linear regression was used to determine the correlation between measurements by ultrasonography and the true vein size after harvesting. Standard methods of computing 95% lower and upper confidence limits for single predicted values were also used.

Results: Two hundred twenty measurements were obtained from 72 patients. Mean vein diameters were 3.4 ± 0.9 and 4.6 ± 0.9 mm as measured by ultrasonography and after vein harvest, respectively. True vein size was an average of 1.2 ± 0.4 mm larger than that measured by ultrasonography. Ultrasonographic determination of vein diameters closely correlated with the true vein diameter (correlation coefficient, 0.91; $P < .001$), and the measurement obtained predicted the true measurement within 1.6 mm with 95% confidence.

Conclusion: Bedside ultrasonographic vein mapping provides an accurate noninvasive method for preoperative assessment to determine the suitability of the greater saphenous vein for use as a bypass conduit. It is therefore an important component of preoperative planning before CABG.

Key Words: Coronary artery bypass, Preoperative care, Saphenous vein.

Department of Cardiovascular and Thoracic Surgery, Hofstra Northwell School of Medicine Manhasset, New York, USA (all authors).

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Address for Correspondence: Frank Manetta, MD, Department of Cardiovascular and Thoracic Surgery, 301 East Main Street, Bay Shore, NY 11706. Telephone: 631-968-3525, Fax: 631-968-3022, E-mail: fmanetta@northwell.edu

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INTRODUCTION

The greater saphenous vein was first used as a conduit for coronary artery bypass grafting (CABG) by Sabiston in 1963.[1] Today, it remains commonly used along with the left internal mammary artery. Traditionally, the greater saphenous vein has been harvested by creating an incision from the ankle up to the groin. The harvesting technique was deemed cosmetically unappealing by many and carried with it a large degree of morbidity, including wound infections, swelling, and pain, with resultant reduced mobility after surgery. Endoscopic vein harvesting was first introduced in 1995 and is now widely accepted as the standard of care.[2–5]

In the past, the quality of vein could not be assessed until after open exposure or after harvesting was completed when the endoscopic technique was used. Studies have demonstrated that preoperative vein mapping is helpful in determining the size and course of the greater saphenous vein. In this study, we sought to evaluate the accuracy of bedside ultrasonography for vein measurements in determining conduit size for use in CABG.

METHODS

This study was conducted with the approval of the Northwell Health System Institutional Review Board with specific waiver of the need for individual patient consent. A prospective nonrandomized study was performed on 72 consecutive patients undergoing saphenous vein harvesting for use as a conduit during CABG. The vein mapping was performed at the bedside with a SonoSite (Bothell, Washington, USA) portable ultrasonography machine with a 10-MHz probe. Independent ultrasonographic measurements of the vein were taken in at least 3 distinct locations. Measurements were taken in the operating room and in some cases on the medical floor. The patient was placed supine, and the leg was flexed to 30° at the hip and knee, with support placed under the knee. A tourniquet was applied at the proximal thigh. With the 10-MHz SonoSite probe, the course of the greater saphenous vein was mapped and marked. Particular attention was focused on the size and depth of the vein. Vein bifurcations, varicosities, and lack of dispensability were noted (Video can be accessed at: https://www.youtube.com/watch?v=yAcGB8IH5-A&feature=youtu.be). The size of the vein at the proximal, mid, and distal ends of the proposed harvest segment were then entered into a database. Vein harvesting was performed by either the standard open or the endoscopic technique, at the discretion of the operating surgeon. After the vein was harvested, it was inspected and distended by using a heparin-based solution. Measurements were taken by the surgeon who was blinded to the initial measurements and entered into a database for analysis.

Simple linear regression was used to determine the correlation between measurements by ultrasonography and the true vein size after harvesting. Standard methods of computing 95% lower and upper confidence limits for single predicted values were used.

RESULTS

Seventy-two consecutive patients who were undergoing saphenous vein harvesting for use as a conduit during CABG were included in the study. Measurements were taken with the Sonosite 10-MHz probe at the proximal, mid, and distal ends or the harvest site before surgery and after the vein was harvested. Two hundred twenty measurements were obtained from the 72 patients. Mean vein diameters were 3.4 ± 1 0.9 and 4.6 ± 0.9 mm, as measured by ultrasonography and on the harvested vein, respectively. True vein size was an average of 1.2 ± 4 mm larger than that measured by the scan. The ultrasonographic determination of vein diameter closely correlated with the true vein diameter (correlation coefficient, 0.91; $P < .001$). Ultrasonographic measurement was shown to predict the true measurement within 1.6 mm, with 95% confidence (**Table 1**).

Table 1.
Measurements with 95% Confidence Limits

Ultrasound Measurement (mm)	Predicted True Measurement (mm)	95% Confidence Limit	
		Lower Limit (mm)	Upper Limit (mm)
1.5	2.8	2.0	3.6
2.0	3.3	2.5	4.1
2.5	3.8	2.9	4.5
3.0	4.2	3.4	5.0
3.5	4.7	3.9	5.5
4.0	5.1	4.3	5.9
4.5	5.6	4.8	6.4
5.0	6.1	5.3	6.9
5.5	6.5	5.7	7.3
6.0	7.0	6.2	7.8
6.5	7.5	6.6	8.3
7.0	7.9	7.1	8.8
7.5	8.4	7.6	9.2

n = 72. Consecutive patients who underwent pre-operative measurements and surgeon measurements.

This is a regressional analysis of predicted vein measurements based on ultrasound measured size. True measurements ranged from 1.8–5.5 cm.

DISCUSSION

Harvesting of the greater saphenous vein for use as a conduit in CABG has been performed since 1963.[1] Traditionally, an open incision had to be made from the ankle to the groin. Such incisions carried with a high risk of morbidity including poor cosmesis, wound infections, swelling, and pain, with resultant reduced postoperative mobility.[2–5] With the advent of endoscopic vein harvesting in 1995, incisions are now smaller and the morbidity associated with the procedure has been reduced.

Leg wound complications after CABG are a substantial burden on the healthcare system. It has been reported that up to 40% of patients who have open greater saphenous vein harvesting via the traditional method would have a postoperative complication.[6] The complication rate decreased to 10% with the advent of minimally invasive techniques.[7,8] These complications translate into increased costs due to a longer hospital stay and the additional nursing care required.

Luckraz et al[9] performed a single center randomized control trial in 2008 in which 61 patients were recruited.

Thirty-one patients had preoperative ultrasonographic vein mapping, and 31 did not. All vein harvesting was performed by the traditional open technique. This group found a correlation coefficient of 0.87, slightly less than our coefficient of 0.91. However, the difference should be noted that all of the veins harvested in our study were obtained endoscopically. Our study also included a larger number of measurements compared with previous studies.

In a nonrandomized study, Head and Brown[10] stated that the preoperative vein diameter, as assessed by high resolution real-time ultrasonic imaging, was 1.5 mm smaller in diameter when compared to its distended size. Their measurements correlate well with the measurements found in our study, as true vein diameter was determined to be 1.2 ± 4 mm larger than that measured by ultrasonography. These results were further qualified in a literature review performed to evaluate the average wall thickness of the greater saphenous vein. Human et al[11] evaluated the greater saphenous vein morphology of over 200 patients to undergo CABG. Using light microscopy the wall thickness varied among individuals based on amount of intimal thickening. Wall thicknesses measured 565.7 ± 138.4 μm in individuals with marked intimal hyperplasia vs 398.7 ± 123.2 μm in the average patient. These measurements validate the results of our study, showing that ultrasonography was predictive of the true measurement to within 1.6 mm, with 95% confidence, as the wall of the vessel was included in the measurements taken after harvest in the operating room.

At our institution, the physician assistant staff was trained by senior physician assistants on the use of the ultrasound machine. Accurate measurements of the greater saphenous vein were reproducible by the staff over a short time interval. The time to complete the assessment averaged between 5 and 10 minutes depending on the individual's comfort level with the machine and experience.

Based on the data collected in the study, we have concluded that bedside ultrasonographic vein mapping provides an accurate noninvasive method during the preoperative assessment to determine the suitability of the greater saphenous vein for use as a bypass conduit. It should therefore be deemed an important component of the preoperative planning process before performing CABG. Ultrasonography allows for accurate planning of the vein harvest as well as the optimal harvest strategy. Based on the ultrasonographic findings, the optimal vein can be chosen for harvesting as well as the technique best suited for the procedure. We believe that the use of ultrasonography decreases the morbidity associated with vein harvesting by minimizing the amount of vein that must be harvested.

One of the limitations of this study is the user variability that comes with ultrasonography. The technique was easily taught to the physician assistant staff at our institution, without external training. Based on the results of this study, we recommend that all surgeons use bedside ultrasonography for vein mapping when the greater saphenous vein is to be used as a bypass conduit.

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