

### An 18-Year Experience Utilizing Distal Revascularization With Interval Ligation (DRIL) as the Primary Treatment for Hand Ischemia Following Dialysis Access Creation

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**Objective:** Arterial steal syndrome after angioaccess surgery can lead to potentially devastating complications. Past treatments ensured loss of the newly created access by performing ligation or attempted salvage by increasing resistance within the fistula. None of these proved to be entirely satisfactory. In 1994, we began to use distal revascularization with interval ligation (DRIL) as our primary method of relieving hand ischemia after dialysis access creation. We describe our experience with this procedure.

**Methods:** After Investigational Review Board approval, the records of all patients undergoing the DRIL procedure for relief of hand ischemia after dialysis access surgery were reviewed. Patient demographics, risk factors, type of fistula, and indications for operation were recorded. The clinical results of DRIL surgery, duration of fistula use for dialysis, and bypass graft patency were noted. Kaplan-Meier survival curves were created, and differences between groups were tested by the log-rank method. Fistula survival was defined as the duration of use before abandonment as the primary method of achieving dialysis access, and bypass graft survival was determined by clinical examination or duplex scan.

**Results:** Between May 1994 and August 2011, 81 DRIL procedures were performed on 77 patients (32 men, 45 women) with a mean age of 64 years (range, 37-91 years). Diabetes was present in 77.6%. DRIL procedures were performed for ischemic symptoms after 51 autogenous fistulas (37 brachiocephalic and 14 brachioabasilic), and 30 were created after prosthetic bridge fistulas. Thirty-eight DRILs were performed for patients with ischemic rest pain, 20 after the development of digital ulcers, 16 to help resolve neurologic symptoms, and seven to heal digital gangrene. After performance of the DRIL procedure, complete resolution of symptoms was noted in 90% of patients treated for digital ulceration, 81.6% of patients treated for ischemic rest pain, 56.3% of patients treated for neurologic deficits, and 42.9% of patients treated for digital gangrene. Overall fistula survival after the DRIL procedure was 70.1%, 57.8%, and 44.5% at 12, 24, and 36 months, respectively. Autogenous fistulas had a significantly longer survival after DRIL than prosthetic bridge fistulas ( $P = .009$ ). The 5-year patency of the brachial-brachial bypass graft was 93.7%. No patients died  $\leq 30$  days of operation.

**Conclusions:** The DRIL procedure is a very effective treatment of hand ischemia after dialysis access creation and can be performed with a low mortality. It is extremely successful in treating ischemic rest pain and digital ulceration, but less so when used to treat patients with digital gangrene and neurologic deficits. Autogenous fistula survival after the creation of the DRIL is excellent and considerably longer than that of prosthetic bridge fistulas.

### Placement of a Brachial-Hemiazygous Arteriovenous Graft for Hemodialysis Using the Gore Hybrid Graft

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**Objective:** To develop additional options for hemodialysis access after common sites for arteriovenous (AV) fistulae and grafts have been exhausted, but before resorting to higher-risk sites, such as the vena cava and right atrium, we report the use of a new hybrid stent graft to access and secure an AV graft to a traditionally difficult-to-expose and fragile vein.

**Methods:** We identified a patient with end-stage renal disease with a failing cross-pubic femoral artery-to-external iliac vein graft with a history of multiple failed AV grafts and central venous occlusions. The patient was no longer a candidate for peritoneal dialysis or renal transplant. A 9-mm Gore Hybrid graft was introduced into the hemiazygous vein percutaneously through a site at the base of the neck. After the stent portion of the graft was deployed in the vein, the graft was placed in a subcutaneous tunnel from the neck to the left brachial artery, where a conventional anastomosis was performed. In another patient, the same technique was used to implant an AV graft between the subclavian vein and the brachial artery.

**Results:** The graft was successfully placed without complication, and dialysis pump speeds of 400 mL/min were achieved.

**Conclusions:** The Gore Hybrid graft has been primarily used to simplify and speed placement of AV grafts using conventional vessels. However, in patients where those vessels are no longer available, it can also be used on vasculature that has been considered too difficult or risky to use as a graft site using traditional surgical techniques.

### Routine Genetic Testing Should be Standard of Care for Patients Receiving Oral Anticoagulants

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**Objective:** A significant number of patients who receive anticoagulants experience major or minor bleeding events or continue to experience thrombotic complications. Black box warnings on the labels of the two most commonly prescribed oral anticoagulants (clopidogrel and warfarin) inform physicians that genetic differences can reduce or augment drug effectiveness.

They additionally include information on the available genetic tests: *CYP2C19* status for clopidogrel and *CYP2C9/VKORC1* status for warfarin. This study assessed the incidence of gene variations that may influence patient response to both drugs.

**Methods:** Molecular laboratory analysis was performed from four buccal swabs done on each patient. *CYP2C19* ( $n = 6664$ ) test subjects were classified as normal, normal intermediate, intermediate, poor, rapid, or ultrarapid metabolizers. *CYP2C9* ( $n = 6073$ ) test subjects were classified as normal, intermediate, or poor metabolizers. *VKORC1* ( $n = 6066$ ) test subjects were classified as low, intermediate, or high sensitivity.

**Results:** Overall genetic variations that would affect clopidogrel efficacy were more common ( $n = 4054$  [60.8%]) compared with normal metabolizers ( $n = 2610$  [39%]). Poor and ultrarapid metabolizers accounted for 3% and 4%, respectively. Genetic variations that would affect warfarin metabolism in the *CYP2C9* assay were noted in 1700 patients (28%). *VKORC1* assay was nonintermediate (low and high sensitivity) in 3424 patients (56.5%).

**Conclusions:** A significant percentage of the patients taking oral anticoagulants, especially clopidogrel, have genetic variations that determine drug efficacy. On the basis of our study, we would recommend that patients receiving drugs with a narrow therapeutic margin should have a mandatory molecular profiling to best determine a safe, effective and individualized drug dosage.

**Table.** Phenotype of genetic assay

Assay response	No. (%)
<i>CYP2C19</i>	
Normal	2610 (39.2)
Poor/intermediate	1954 (29.3)
Rapid/ultrarapid	2100 (31.5)
<i>CYP2C9</i>	
Normal	4373 (72)
Intermediate	1552 (25.6)
Poor	148 (2.4)
<i>VKORC1</i>	
Low	2672 (44)
Intermediate	2642 (43.6)
High	752 (12.4)

### Importance of Intravascular Ultrasound Imaging During Percutaneous Treatment of May-Thurner Syndrome

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**Objective:** May-Thurner (MT) compression of the left common iliac (LCIV) vein can present as unilateral leg swelling with or without associated deep vein thrombosis (DVT). This report describes our diagnostic approach (with emphasis on the importance of intravascular ultrasound imaging), management, and outcome in these patients.

**Methods:** This was a retrospective analysis of all patients evaluated for MT from 2006 to 2011.

**Results:** MT was diagnosed in 27 patients (63% female) who presented with unilateral left leg swelling, with ( $n = 15$ , thrombotic) or without ( $n = 12$ , nonthrombotic) associated DVT. All patients underwent duplex imaging and contrast angiography, and intravascular ultrasound (IVUS) imaging was performed in 11 (83% of those with nonthrombotic MT). Mean age was 42.9 years. Prior DVT, pulmonary embolism, and hypercoagulable state were each present in 25% of nonthrombotic patients and in 80%, 33%, and 53% of thrombotic patients, respectively. Pain and swelling were present in all patients, and venous claudication was present in 63%. At presentation, all nonthrombotic patients were CEAP C<sub>3</sub>; thrombotic patients were C<sub>3</sub> (86.7%) or C<sub>6</sub> (13.3%). Four of the nonthrombotic patients were treated conservatively. Eight underwent LCIV stenting, leading to reduction or amelioration of symptoms in 87.5% and a decreased CEAP score in 75%. For thrombotic patients, all but one underwent LCIV stenting (with or without lysis), resulting in alleviation or amelioration of symptoms in 100% and decreased CEAP score in 85.7%. Angiographic findings in nonthrombotic patients included LCIV stenosis, collateralization, and contrast stagnation in 91.7%, 83.3%, and 75% respectively. However, contrast angiography overestimated LCIV minimum diameter by 61% (7.0 vs 4.2 mm) and cross-sectional area by twofold (104 vs 53 cm<sup>2</sup>) relative to IVUS imaging. Correction of LCIV compression in nonthrombotic patients was associated with a threefold increase in mean cross-sectional area (53 to 166 cm<sup>2</sup>). One-year primary patency (mean follow-up, 9.7 months) was 100% for nonthrombotic patients and 78.6% for thrombotic patients, with 100% secondary patency for both. Complications

included two early reocclusions (treated with reintervention). There were no pulmonary embolisms or death.

**Conclusions:** Excellent 1-year patency rates and a significant reduction in symptoms and CEAP class can be attained with percutaneous intervention for MT syndrome. IVUS imaging is essential for accurate diagnosis and stent sizing in patients with nonthrombotic MT syndrome.

**Comparative Effectiveness of Endovascular and Open Surgical Revascularization in Diabetic Patients With “Critical Limb Ischemia” (Rutherford 5 and 6) Due to Severe Tibial Artery Occlusive Disease**

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**Objective:** The original 1982 definition of “critical limb ischemia” (CLI) excluded patients with diabetes. Although endovascular therapy (ENDO) has become the dominant revascularization method, its effectiveness for tibial disease compared with bypass surgery (OPEN) in diabetic individuals with CLI is unclear. Assessment of revascularization outcomes is difficult in diabetic patients due to neuropathy, wounds, and infection. We evaluated and compared outcomes in such patients using validated risk stratification schemes (Prevent III and FinnVasc) and the Society for Vascular Surgery (SVS) objective performance goals (OPGs).

**Methods:** We studied 94 consecutive tibial/pedal interventions in 70 limbs of 59 diabetic patients (64% men) with CLI who initially underwent ENDO (n = 37) or OPEN (n = 33). Mean age was 69 years, and all had tissue loss (Rutherford 5-6). We evaluated Prevent III and FinnVasc scores in both groups. We compared wound healing time (WHT) and major SVS OPGs, including 1-year amputation-free survival rate, major adverse limb events, and major adverse cardiac events.

**Results:** Prevent III and FinnVasc preintervention risk scores were similar in both groups. Limb salvage rates and WHT were also comparable, but there was a trend toward faster WHT for OPEN. There were no significant differences between groups regarding amputation-free survival rate, major adverse limb events, and major adverse cardiac events.

**Conclusions:** This is the first study to assess outcomes of tibial revascularization in diabetic patients with CLI using current risk stratification schemes and SVS OPGs. ENDO and OPEN both met the target 1-year amputation-free survival SVS OPG of 70%, suggesting that with proper selection, each therapy is efficacious. Existing risk factor stratification scores are suboptimal predictors of amputation and major adverse events in such a heterogeneous group of patients. Important variables that influence therapy and outcomes, such as patient factors (functional status, life expectancy), wound factors (presence, depth, and location), infection (presence, severity, and extent), conduit availability, target availability, and outflow are lacking, suggesting the need for a new classification system for CLI in this grouping subgroup.

**Table.** Risk stratification and comparison of outcomes with Society for Vascular Surgery Objective Performance Goals

Variable	ENDO (N = 37)	OPEN (N = 33)	P
Prevent III, mean ± SD	5.39 ± 1.97	5.24 ± 1.87	.7457
FinnVasc, mean ± SD	2.16 ± 0.83	2.52 ± 0.91	.088
1 year AFS, %	83.8	69.7	.25
WHT, days (95% CI)	227.4 (177.3-277.5)	174.6 (132.3-216.9)	.18
MALE, %	43.2	45.5	1
MACE, %	2.7	3.0	1

CI, confidence interval; MACE, Major adverse cardiac events; MALE, major adverse limb events; SD, standard deviation; WHT, wound healing time.

**Axillary Branch Artery Aneurysms: A Rare Cause of Upper Extremity Ischemia in High-Performance Athletes**

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**Objective:** Axillary artery branch aneurysms (AABA) occur due to extreme repetitive upper extremity effort and can result in hand ischemia from embolic occlusion. Because these are found in otherwise healthy high-performance athletes, the diagnosis is often missed or delayed. We describe two cases of AABA resulting in thromboembolism and hand ischemia in two nationally competitive athletes.

**Methods:** Preoperative imaging and perioperative findings were reviewed in two patients.

**Results:** A 57-year old senior United States Tennis Association player in the national finals presented with right upper extremity paraesthesias associated with diminished pulses and weakness after a vigorous match. The

patient underwent upper extremity angiography and subsequent thrombolysis, demonstrating a posterior circumflex humeral AABA (Fig 1, a) that had embolized to his wrist (Fig 1, b). Treatment with suture ligation (Fig 1, c) and anticoagulation allowed him to recover without recurrent ischemia, and he played in the national finals. A 17-year-old starting quarterback for a division I football program noted progressive thumb pain and ischemia over the last four games of his freshman season, necessitating wearing gloves and placing his hand in warm water after games. Angiography and computed tomography angiography confirmed a similar AABA (Fig 2, a), and angiography confirmed embolization to digital arteries of the thumb (Fig 2, b). He was treated with anticoagulation and similar ligation to prevent future embolic events (Fig 2, c). He has returned to starting quarterback for his sophomore season.

**Conclusions:** These cases highlight AABAs resulting from recurrent upper extremity trauma and subsequent thrombosis and embolism to the hand and wrist. Treatment entails thrombolysis or anticoagulation, or both, and then ligation of the branch to prevent future embolic potential. A high index of suspicion for axillary artery pathology should be present when high performance athletes with repetitive overhead motions present with upper extremity arterial insufficiency.

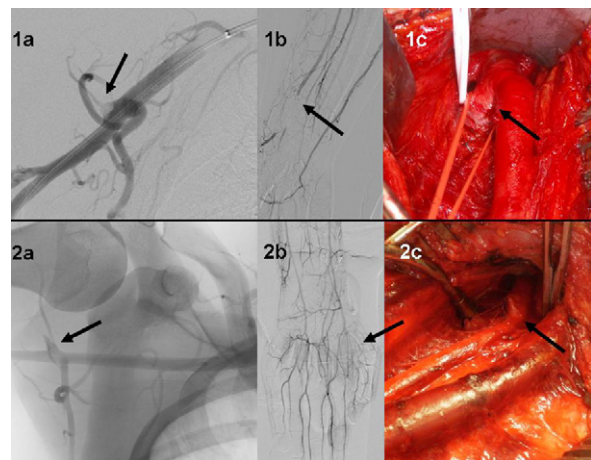


Fig.

**Endoscopic Vein Harvest for Infra-inguinal Arterial Bypass**

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**Objective:** Endoscopic harvest (EH) of saphenous vein for lower extremity bypass decreases length of incisions and was initially thought to decrease wound complication rates without adversely affecting patency. However, recent studies have shown lower patency without a wound complication benefit. We sought to further study the wound complication and patency rates of EH compared with open harvest (OH) techniques in infrainguinal arterial bypass procedures.

**Methods:** Infrainguinal bypasses performed between 2000 and 2011 were analyzed. Only procedures using a single segment of great saphenous vein were included. Patients were grouped according to EH or OH. The two groups were frequency-matched for body mass index and diabetes. Baseline characteristics were compared. Univariate and multivariate analysis was performed, as appropriate, to determine correlation of baseline data and harvest method on patency.

**Results:** The study included 76 bypasses: 35 in the EH group and 41 in the OH group. Baseline characteristics between the OH and EH groups were not significantly different. Mean age was 72 years in the EH group and 67 years in the OH group. The difference in the numbers of men and women between the two groups was not significant. Mean follow-up was 747 days. There was no significant difference between the EH and OH groups in 30-day wound complication rates (29% vs 27%; P = .86), 3 year primary patency rates (47% vs 49%, P = .82), or 3 year primary assisted patency rates (88% vs. 76%, P = .2). There was a trend toward increased secondary patency in the EH group (92% vs 73%, P = .053). High body mass index improved primary patency (hazard ratio [HR], 0.89; 95% confidence interval [CI], 0.82-0.97). Patients requiring hemodialysis had increased risk for loss of primary assisted patency (HR, 12.05; 95% CI 3.19-45.57) and secondary patency (HR, 5.27; 95% CI 1.60-17.34). This remained significant on multivariate analysis when accounting for type of vein harvest.