**Purpose:** Radial access is being increasingly used for both diagnostic and interventional cardiac procedures. Prospective data comparing ultrasound- vs palpation-guided radial catheterization are largely lacking.

**Materials and Methods:** In this prospective single-center study, 183 consecutively enrolled patients scheduled for transradial cardiac catheterization by an experienced interventionalist were assigned 1:1 to either palpation- or ultrasound-guided radial access. Demographic and procedure parameters were prospectively recorded.

**Results:** Baseline demographic and clinical parameters did not differ significantly between the ultrasound (n=92) and palpation (n=91) groups. The initial radial catheterization success rate (87% vs 86.8%; \( P = 0.999 \)) and time to access (47 s [interquartile range (IQR) 20-90 s] vs 31 s [IQR 20-75 s]; \( P = 0.179 \)) did not differ between the ultrasound and palpation groups. Pulse quality (absent, weak, strong) was independently associated with access failure in both groups (\( P < 0.001 \)). Obesity was associated with access failure in the palpation (\( P = 0.005 \)) group but not in the ultrasound group (\( P = 0.544 \)). In 3/12 cases (25%) in the ultrasound and 2/6 cases (33%) in the palpation group, the operator was able to establish radial access using the alternative method (\( P = 0.710 \)). If palpation-guided radial access failed, an additional ultrasound-guided attempt before cross-over to femoral access was associated with a shorter overall time to access (525 s [IQR 462-567 s] vs 744 s [722-788 s]; \( P = 0.016 \)).

**Conclusion:** Ultrasound-guided radial access seems to provide no substantial additional benefit over palpation-guided access alone. Attempting the alternative guiding methods to establish radial access before cross-over to femoral access seems to be a reasonable approach.

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**Prospective Evaluation of the Safety and Efficacy of the Mynx Vascular Closure Device in Thrombocytopenic Patients**


**Purpose:** To prospectively evaluate the safety and efficacy of the Mynx Cadence and MynxGrip devices (AccessClosure, Santa Clara, CA) for closure of arteriotomy in high-risk thrombocytopenic and coagulopathic oncology patients who undergo common femoral arteriography closure after transarterial chemoembolization (TACE) or transarterial radioembolization (TARE) of hepatocellular carcinoma.

**Materials and Methods:** This was an institutional review board (IRB) approved, single institution, prospective study. We evaluated 45 high-risk oncology patients (34 men, 11 women; mean age, 64.7±9.6 years) who underwent TACE or TARE between March 2012 and July 2012 for treatment of hepatocellular carcinoma (HCC) with thrombocytopenia (platelets <100 K/μL; mean, 65.8 K/μL; range, 32.94 K/μL). In all cases, SF common femoral arterial access was utilized. Procedures included TACE and TARE for treatment of HCC. A total of 34 Mynx Cadence and 11 MynxGrip devices were deployed. Measured outcomes included technical success of arterial closure, immediate postprocedure closure-related adverse events, and delayed closure-related adverse events 4 weeks postprocedure. Immediate technical closure-related adverse events were assessed by physical exam and limited Doppler ultrasound within 24 hours postprocedure. Delayed adverse events were assessed by a phone survey 4 weeks postprocedure (range, 3-5 weeks).

**Results:** Forty-five common femoral arteriotomies were successfully closed with the Mynx Cadence in 34 patients and the MynxGrip in 11 patients (Table). Platelet counts were <100 K/μL (mean, 65.8 K/μL; range, 32.94 K/μL). The Mynx Cadence and MynxGrip devices effectively sealed the arteriotomy in 34/34 patients (100%) and 11/11 patients (100%), respectively. Three of 34 patients (8.8%) developed small groin hematomas after closure with the Mynx Cadence device that resolved without further intervention. One patient (2.9%) was transfused with packed red blood cells after presenting to the emergency department 2 weeks after arteriography closure with the Mynx Cadence device. One patient (2.9%) experienced minor bruising the day after arteriography closure with the Mynx Cadence device. Three of 34 (8.8%) patients in the Mynx Cadence group and 2 of 11 (18.2%) in the MynxGrip group experienced localized pain at the access site. Six of 45 patients (13.3%) were unable to be reached at the 4-week follow-up. None of the patients studied suffered major complications requiring additional percutaneous or surgical intervention.

**Conclusion:** The Mynx Cadence and MynxGrip arteriotomy closure devices are safe and effective in high-risk thrombocytopenic and coagulopathic patients undergoing TACE or TARE procedures in this single-institution prospective study.

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**Table. Mynx cadence and MynxGrip adverse events**

<table>
<thead>
<tr>
<th>Mynx Cadence</th>
<th>Mynx Grip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful hemostasis</td>
<td>Large (&gt;3 cm) hematomas</td>
</tr>
<tr>
<td>34</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

**Conclusion:** The Mynx Cadence and MynxGrip arteriotomy closure devices are safe and effective in high-risk thrombocytopenic and coagulopathic patients undergoing TACE or TARE procedures in this single-institution prospective study.

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**Transradial Approach for Complex Renal Interventions: A Single-Center Initial Experience**

V. Bishay, R. Patel, E. Kim, S. Nowakowski, R. Lookstein, A. Fischman

**Purpose:** While transfemoral access (TFA) is the standard approach for renal intervention, transradial access (TRA) provides distinct advantages. Lower morbidity, decreased cost, and fewer bleeding complications with greater patient comfort and faster time to ambulation have all been reported. This study was conducted to evaluate the safety and technical considerations of TRA for complex renal interventions.

**Materials and Methods:** Over a 9-month period, 14 procedures were performed in 14 patients (9 female, 5 male; mean age, 55 years). Procedures included diagnostic renal angiogram (n=3), renal angioplasty or stenting (n=6), and renal embolization (n=5). Embolization materials included coils, n-butyl cyanoacrylate (n-BCA), Onyx (ev3, Plymouth, MN), and gelatin particles. A Barbeau test was performed using a pulse oximeter prior to all procedures. A Glidesheath (Terumo Medical Corporation, Somerset, NJ) was placed in the left radial artery (RA) using ultrasound guidance in all cases. Sheath sizes included 5F (n=6) and 6F (n=8). A solution of 3000 U heparin, 2.5 mg verapamil, and 200 mcg nitroglycerin was administered interarterially.
following sheath placement. Catheter selection included 5F and 6F guiding catheters ranging in length from 100-110 cm. At completion, a TR band (Terumo Medical Corporation, Somerset, NJ) was placed for radial compression. Technical success and 30-day major and minor adverse events were evaluated.

**Results:** Technical success was achieved in 92.9% of cases (13/14). In 1 patient a long segment brachial artery occlusion was discovered from a prior brachial artery puncture requiring TFA. Barbeau waveforms included type A (21%) or type B (79%). One procedure was the result of an initial failed attempt via TFA due to severe downward angulation of the renal artery and was successfully completed via TRA. Mortality at 30 days was 0%. There were no major adverse events. Minor grade I hematomas, which resolved spontaneously, were seen in 14.3% of cases (2/14). All patients were able to ambulate immediately after the procedure.

**Conclusion:** TRA is a safe, feasible, and well-tolerated access option for complex renal interventions. In certain instances, TRA is preferable due to anatomical limitations of TFA.

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**Celiac Artery Dissection During Angiography in a Patient Undergoing Sorafenib Therapy for Hepatocellular Carcinoma.**


**Purpose:** Emerging cancer therapies now include the use of agents that target multiple tyrosine protein kinase pathways including vascular endothelial growth factor receptors (VEGFR). The full effects of VEGFR inhibition are still unknown. Arterial dissection and hemorrhage have been reported in patients undergoing therapy with this class of medications, including 1 case of acute aortic dissection in a patient taking sorafenib (Nexavar). Postoperative risks due to bevacizumab (Avastin) are well documented in the surgical literature.

**Materials and Methods:** Sorafenib is increasingly used for the treatment of hepatocellular carcinoma (HCC), sometimes combined with transarterial chemoembolization (TACE). We present a case of a 56-year-old female with multifocal hepatoma who received sorafenib for greater than 12 weeks prior to undergoing TACE at a high-volume center. Immediately upon gentle manipulation of the celiac artery, severe dissection occurred, leading the experienced operator to believe the artery seemed overly fragile.

**Results:** The arterial dissection was successfully treated with a stent, and TACE was completed.

**Conclusion:** Until further study is completed to determine the degree of risk, the effects of sorafenib on the vascular endothelium may warrant extra caution during intra-arterial catheterization.

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**Combined Endovascular and Open Management of a Mycotic Thoracic Aortic Aneurysm: A Case Report**


**Purpose:** Mycotic thoracic aortic aneurysms (MTAAs) is a rare and life-threatening pathology. Traditionally, these aneurysms were treated in a solely open fashion, which imparted a significant amount of morbidity to the patient and proved to be a technical challenge to the surgeon. We present a case of a newly diagnosed MTAAs that was successfully treated with a combined endovascular and open approach.

**Materials and Methods:** This is a case report.

**Results:** A 62-year-old female presented to the hospital with back pain and weakness. She had a history significant for ventral hernia repair complicated by mesh infection and bacteremia 7 years ago. A magnetic resonance imaging (MRI) was performed, which revealed multiple spinal epidural abscesses. Blood cultures were also obtained and revealed her to be bacteremic with methicillin-resistant *Staphylococcus aureus* (MRSA). She was started on antibiotics and had computed tomography (CT)-guided drainage of the abscesses. Follow-up imaging 2 weeks after the drainage showed a 7.1-cm thoracic aortic aneurysm (TAA) that was not present on prior studies. Due to the rapid appearance of the TAA and the patient’s comorbidities, an endovascular approach was considered; however, due to the location of the TAA relative to the great vessels of the aortic arch, the decision was made to repair it via a hybrid approach. A bypass from the ascending aorta to the innominate artery and left common carotid was performed with a bifurcated Dacron graft and then a thoracic aortic endograft was placed. The endograft was successfully excluded with the endograft. The patient tolerated this procedure and was eventually discharged home in stable condition. A 4-week follow-up CT scan revealed complete exclusion of the MTAAs.

**Conclusion:** Mycotic thoracic aortic aneurysms can be a challenging disease to manage. This report illustrates that they can be treated successfully using endovascular techniques. Anatomic considerations may occasionally make a hybrid procedure necessary.
The purpose of this study was to analyze the outcomes of patients undergoing EVAR with exclusion of 1 or both hypogastric arteries in a single-center experience.

Materials and Methods: This was a retrospective analysis of a prospectively collected database. During EVAR procedures for aneurysms involving a single common iliac artery or iliac bifurcation, the homolateral hypogastric artery was excluded by coil embolization, vascular plug deployment, or simple coverage by an endograft. For aneurysms involving both iliac axes, revascularization of at least 1 hypogastric artery was always attempted. Techniques of hypogastric salvage included branch devices, flow modulator stents, and sandwich, periscope, and bell-bottom techniques. Primary outcome measures analyzed were intestinal and spinal cord ischemia, buttock claudication, sexual dysfunction in male patients, and buttock skin necrosis.

Results: From January 2008 to February 2013, 275 patients underwent elective EVAR, of which 85 (30.9%) had iliac involvement. In 61 patients with unilateral iliac involvement (71.8%, group A), 1 hypogastric artery was excluded. Twenty-four patients (28.2%) had bilateral iliac involvement (group B); 10 of these (41.7%) had 1 hypogastric artery excluded with revascularization of the contralateral artery (group B1); in the remaining 14 patients (58.3%), both hypogastric arteries were excluded (group B2). No cases of intestinal or spinal cord ischemia were recorded in any group. At 30 days, buttock claudication, buttock skin necrosis, and sexual dysfunction rates in group A were 16.6%, 2%, and 8.3%, respectively, and in group B were 32.8%, 5%, and 17.9%, respectively (P < 0.05). At a mean follow-up of 10.8 months (range, 4.4-47 months), the hypogastric exclusion-related complications in group B2 were more disabling than those in groups A and B1 (P < 0.05), regardless of embolization techniques used.

Conclusion: Monolateral hypogastric artery exclusion is associated with acceptable complications rates; the relationship between embolization technique and complication rates was no longer evident in the long-term follow-up. When anatomically feasible, at least 1 hypogastric artery should be salvaged.

Modified Zenith Technique for Common/Internal Iliac Artery Aneurysms: A New Approach to Maintain Pelvic Circulation

J. D. Adams, G. Upchurch

Purpose: To describe a novel endovascular technique to treat common or internal iliac artery aneurysms while maintaining patency of the internal iliac artery.

Materials and Methods: The modified Zenith technique to treat common or internal iliac artery aneurysms involves the following steps: 1) back table modification of a Zenith Flex device (Cook Medical, Bloomington, IN) to remove the suprarenal stent and appropriate number of Z stents; 2) deployment of the bifurcated device from the ipsilateral femoral approach with the contralateral gate just above and directed towards the internal iliac artery origin; 3) from one of a variety of approaches, selection of the internal iliac artery through the contralateral gate; 4) deployment of self-expanding covered stent grafts within the internal iliac artery from distal to proximal, building up to 13 mm to seal the contralateral gate; 5) deployment of the ipsilateral limb in the external iliac artery; and 6) balloon molding of seal zones and overlap zones.

Results: To date, this technique has been used to successfully treat 3 patients with a combination of common and internal iliac aneurysms or isolated internal iliac artery aneurysms. In 2 patients, a contralateral femoral approach was utilized to select the internal iliac artery and deliver the self-expanding stent grafts. In the remaining patient, the Heli-FX Guide (Aptus Endosystems, Sunnyvale, CA) was used to select the contralateral gate and internal iliac artery and deliver the self-expanding stent grafts from the ipsilateral femoral approach. Technical success was achieved in 100% of patients and was defined as successful exclusion of the aneurysm without endoleak and with maintained patency of the external and internal iliac arteries. Follow-up computed tomography (CT) angiograms at 4-6 weeks postprocedure revealed no endoleak and 100% patency of the targeted internal iliac artery.
Successful catherization of internal iliac artery through the contralateral gate

Successful endovascular exclusion of internal iliac artery aneurysm

Conclusion: This technique was developed to provide an off-the-shelf option to overcome current device constraints and anatomical limitations for the endovascular treatment of common iliac and/or internal iliac artery aneurysms while maintaining patency of pelvic arterial circulation. The modified Zenith technique is a safe, relatively simple procedure with excellent short-term results; however, more experience and long-term follow-up is needed.

Purpose: The purpose of this study was to evaluate 38 cases of thoracoabdominal aortic aneurysm (TAAA) treated with a multilayer flow modulator (MFM) outside the indications for use. These cases were identified during collection of data for the independent MFM global registry. All of the cases were compassionate use cases in continental Europe in patients in whom comorbid disease severity precluded more invasive treatment alternatives.

Materials and Methods: There were 30 males with a mean age of 70.8 years and 8 females with a mean age of 67.8 years. The mean TAAA diameter was 7.1 cm. Ten patients presented with ruptured TAAA. Twenty-three patients had prior interventions: 20 had thoracic endovascular aortic repair (TEVAR) with commercially available thoracic endografts and 3 had open repair. One patient had a combined procedure in which both commercially available endografts and an MFM were deployed at the same primary setting. Thirteen patients had chronic Stanford type B aortic dissection with aneurysmal dilatation of more than 6 cm. Six patients had mycotic aneurysms. Four patients had saccular aneurysms, while the numbers with Crawford type I, II, III, and IV TAAAs were 1, 7, 5, and 2, respectively.

Results: No occurrences of death, paraplegia, cerebrovascular accident, or renal or visceral compromise were documented during the perioperative hospital stay. During a mean follow-up of 10.03±6.96 months, 34 patients died (89.5%); 27 deaths (71.1%) were aneurysm related. All-cause survival, freedom from aneurysm-related death, and rupture-free survival were 17.5%, 25%, 31.5%, respectively, at 18 months.

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the EVAR group had shorter operative time, less blood loss, and fewer blood transfusions than the OAR group (P < 0.05). There were no statistical differences between groups in perioperative complications, technical complications, and intensive care unit (ICU) stays. Perioperative mortality was comparable between the 2 groups (9% [2 patients] in each group). During the 2-year follow-up, 1 patient in OAR group and 4 patients in EVAR group needed reintervention due to graft infection. The overall mortality rate at 2 years was 13% (3 patients) in the OAR group and 35% (8 patients) in the EVAR group (P = 0.165).

Conclusion: For the treatment of IAAA, endovascular treatment might provide good results in the perioperative period, but there were more reinterventions and a higher long-term mortality rate in the EVAR group compared with the open surgical repair group in this study.

Prevention of Type II Endoleak Is Better Than Treating It: Our Experience With Aneurysm Sac Embolization in Endovascular Aneurysm Repair

M. Natrella, G. Lunardi, M. Cristoferi, G. Fanelli, T. Meloni

Purpose: To evaluate the role of intraoperative aneurysm sac embolization during endovascular aneurysm repair (EVAR) using a standard dose of coils and fibrin glue and to assess the effectiveness of this strategy in terms of prevention of sac growth to type II endoleak.

Materials and Methods: From October 2011 to September 2013, 52 patients underwent to EVAR. Twenty-six consecutively enrolled patients (23 men; median age, 79 years; range, 62-90 years) undergoing elective EVAR since the protocol was introduced in June 2012 were included in group A; 26 consecutively enrolled patients (23 men; median age, 77 years; range, 55-90 years) who underwent EVAR immediately prior to the protocol were used as controls (group B). Our protocol consisted of injection of fibrin glue in association with coils into the aneurysm sac during EVAR to facilitate sac thrombosis and reduce the incidence of type II endoleak. The exact dose of material required to prevent this complication was calculated based on the volume of the aneurysm. Primary outcome measures were type II endoleak rates and secondary intervention rates.

Results: No major complications were observed intra- and periprocedure. The operative time of group A was longer than that of group B (about 15 minutes). The type II endoleak rate at 6 months was 23% for group B compared with 11% for group A. The 6 type II endoleaks in group B included 5 lumbar artery endoleaks and 1 inferior mesenteric artery (IMA) endoleak. The 3 type II endoleaks in group A included 2 lumbar artery endoleaks and 1 IMA endoleak. In group B, 1 patient presented with a type Ic endoleak. Of the patients with type II endoleak, 26% in group B required intervention (2 transcaval endoleak embolizations) compared with no patients in group A. We treated the patient with type Ic endoleak with a covered stent in branched EVAR. All treatments for type II endoleaks were performed without major complications and with complete exclusion of the endoleak.

Conclusion: Although further confirmatory studies are needed, sac embolization during EVAR may be a valid approach to preventing type II endoleak and its complications.

Development of Residual Endoleak Immediately After Endovascular Aneurysm Repair: Matter of Persistency and Effect

N. Y. Yim, H. O. Kim, Y. T. Kim, J. K. Kim

Purpose: This study examined the persistency of residual endoleaks that can develop immediately after endovascular aneurysm repair (EVAR) of infrarenal abdominal aortic aneurysms (AAAs) and whether such residual endoleaks could affect outcomes after EVAR.

Materials and Methods: This was a retrospective study of 112 patients who had EVAR for an infrarenal AAA between March 2006 and July 2011 at a single center. Enrolled patients (102 men, 10 women) had a mean age of 71.3 years. Outcomes following EVAR were evaluated in patients who had a follow-up period of >1 year. Results: Sixty-one patients experienced residual endoleaks immediately after EVAR. By the time of the first follow-up (within 30 days), residual endoleaks had disappeared in 37 patients (60.7%) but persisted in 24 patients (39.3%). Sixty-five patients had a follow-up period of more than 1 year; 8 of these patients (12.3%) showed persistent residual endoleak for more than a year. There was no significant difference in outcomes after EVAR in patients with residual endoleak vs patients without residual endoleak (P = 0.503). However, aneurysmal sac expansion after EVAR was significantly more frequent in patients with persistent residual endoleak (P < 0.005; odds ratio = 87; 95% confidence interval [CI], 6.72 to 1121.3).

Conclusion: In our series, 60.7% of residual endoleaks were self-limiting. Such transient residual endoleaks usually did not affect the outcome after EVAR. However, persistent residual endoleak for more than 1 year was associated with poor outcome after EVAR.

Techniques to Preserve Internal Iliac Artery Patency With Off-the-Shelf Devices in Aortoiliac Aneurysmal Disease

D. Do, J. Adams, N. Garg, J. Robison, C. Schonholz

Purpose: To describe and review 4 different techniques to maintain internal iliac artery patency in patients with aortoiliac aneurysmal disease, including the sandwich technique, hypogastric branch technique, external iliac artery-to-internal iliac artery endovascular technique, and Adams modified Zenith technique. All these techniques are done with off-the-shelf devices.

Materials and Methods: All patients demonstrated multiple risk factors with presence of aortoiliac aneurysmal disease and were evaluated preoperatively with computed tomography angiographic imaging with 3-dimensional (3D) multplanar reconstructions. Standard arteriography was performed usually at the time of the procedure. The sandwich technique involves placement of a bifurcated stent graft main body, placement of an additional stent within the internal iliac artery aneurysm, and placement of the iliac limb extension with appropriate overlap such that an appropriate “sandwich” is created. The hypogastric branch technique involves modification of a stent graft with graftotomy made to allow for end-to-side polyester side arm that will connect with a stent graft within the internal iliac artery. The external iliac artery-to-internal iliac artery endograft technique requires use of an aortouniiliac endograft with extension into the ipsilateral external iliac artery, coil embolization of the ipsilateral internal iliac artery if needed, placement of a femorofemoral bypass graft, and use of a contralateral external iliac artery-to-internal iliac artery endograft. The Adams modified Zenith technique involves back-table modification of an abdominal stent graft system by removing the top Z-stent and suprarenal fixation with placement of the body within the common iliac artery and ipsilateral limb within the external iliac artery. Patency and exclusion of internal iliac artery aneurysmal disease is achieved by placing covered, overlapping stents through the contralateral gate into the internal iliac artery.

Results: In patients with aortoiliac aneurysmal disease, the aneurysms were successfully repaired while maintaining patency of the internal iliac artery using each of the various listed techniques. Short-term follow-up with computed tomography angiographic imaging demonstrated desired aneurysm exclusion and patency of the grafts as well as the internal iliac artery.

Conclusion: The sandwich technique, hypogastric branch technique, external iliac artery-to-internal iliac artery endograft technique, and Adams modified Zenith technique provide safe and effective options in maintaining internal iliac artery patency in patients with aortoiliac aneurysmal disease.

Angiographic Core Laboratory Assessments Versus Physician Assessments: Observations From the DEFINITIVE LE Study

K. J. Rocha-Singh

Purpose: To assess the differences between physician-reported and angiographic core laboratory–reported procedural angiographic data collected in the DEFINITIVE LE study. The DEFINITIVE LE study assessed the safety and effectiveness of directional atherectomy (DA) using the SilverHawk and/or TurboHawk peripheral plaque excision devices (Coviden, Mansfield, MA) to treat peripheral arterial disease. The study enrolled 800 patients at 47 multinational centers.

Materials and Methods: Percent diameter stenosis as assessed by the angiographic core laboratory was compared with that reported by the operating physician both preprocedure (baseline) and post-DA. Associations between the 2 assessments were analyzed separately for femoropopliteal and infrapopliteal lesions (P < 0.001 in all cases). Overall, the correlation between core laboratory–reported and physician-reported data was stronger at baseline than post-DA (r = 0.80 and r = 0.47, respectively) (Table), with modest differences between femoropopliteal and infrapopliteal lesions (P = 0.0001 in all cases). Linear modeling showed no differences between femoropopliteal and infrapopliteal lesions at baseline (r = 0.82 vs r = 0.73, respectively) and post-DA (r = 0.49 vs r = 0.41, respectively). Linear modeling showed no differences between femoropopliteal and infrapopliteal core laboratory–reported baseline values (P = 0.54), and post-DA, even after accounting for differences in physician-reported data, the core lab adjudicated a higher level of stenosis in infrapopliteal lesions (P = 0.001).

Table. Procedural percent diameter stenosis assessments

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Core Laboratory</th>
<th>Physician</th>
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<tbody>
<tr>
<td>Baseline</td>
<td>73.6% ± 18.7%</td>
<td>74.7% ± 18.7%</td>
</tr>
<tr>
<td>Post-DA</td>
<td>59.1% ± 18.7%</td>
<td>57.9% ± 18.7%</td>
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Abbreviation: DA, directional atherectomy; SD, standard deviation.
Conclusion: Angiographic core laboratory assessment of percent diameter stenosis in the DEFINITIVE LE study differed significantly from physician-reported assessment both at baseline and post-DA, with stronger correlations prior to treatment. Notably, infraarterial lesions showed less reliable correlations between physician- and core laboratory–reported values and greater mean differences.

Glubran 2 Transcatheter Embolization of Active Gastrointestinal Hemorrhage

R. Marcello, G. Marcello

Purpose: The aim of our study was to demonstrate the safety and effectiveness of percutaneous transcatheter glue embolization of active gastrointestinal (GI) hemorrhage.

Materials and Methods: From February to December 2012, 6 patients referred to the emergency unit of our institution complained of melena and associated symptoms of active lower GI bleeding. All patients received contrast-enhanced multidetector computed tomography (MDCT) of the upper and lower abdomen in order to detect the active bleeding site. In 5 patients, a localized vascular lesion of the bowel wall was detected. One patient previously treated elsewhere with superior mesenteric artery (SMA) stenting was diagnosed with multiple arteriovenous malformations of the bowels. Common femoral artery access was obtained and all patients received selective visceral angiography. A microcatheter (Progreat 2.7F; Terumo, Tokyo, Japan) was then advanced to the target lesion through the diagnostic catheter. Glue embolization with different dilutions of Glubran 2 (GEM Srl, Viareggio, Italy) was carried out. Patients were closely observed for 48 hours after the procedure.

Results: Cessation of active hemorrhage was achieved in all patients. No further intervention was necessary, and no immediate or late complications were observed. No complaints of abdominal pain or disfunction were recorded. All patients were discharged from hospital within 2 to 8 days following the procedure.

Conclusion: Our experience with a limited number of patients suffering from GI hemorrhage treated by percutaneous transcatheter glue embolization showed the safety and the effectiveness of such a procedure. However, further evaluation of glue embolization of active GI bleeding on a larger number of patients is needed.

Minimal Aortic Injury: A Pictorial Review of Imaging Findings and Treatment Recommendations

J. Woodhouse, S. Dhaliali, G. Annamalai, E. David, C. Dev, R. Pugash

Purpose: Acute injury of the aorta is widely held to be an emergent condition that can herald potentially fatal progression; operative management is considered the standard of care. With the advent of a new generation of high-resolution computed tomography (CT) scanners and the establishment of early CT (including angiographic phase imaging) as a gold standard imaging test for patients with polytrauma, increasingly subtle aortic injuries are being observed. Minimal aortic injury (MAI) is a term ascribed to these injuries and refines management algorithms for the management of blunt aortic injury. Recognition of MAI as a distinct and separate entity from more serious aortic injuries and recognizing that these injuries have the potential for nonoperative management can allow the imaging specialist to prevent serious morbidity and mortality that would occur should misdiagnosis of a more serious aortic injury and subsequent operative management occur.

Materials and Methods: We provide cases (with pictorial examples), review the spectrum of clinical findings, and review the current literature related to MAI and the data related to follow-up imaging for this uncommon but increasingly recognized condition.

Results: We discuss the spectrum of imaging findings of MAI and contrast them with higher grades of blunt aortic injury, and we review the current literature related to management and imaging follow-up.

Conclusion: MAI is an uncommon entity following blunt aortic injury that is increasingly identified with the evolution of higher-resolution scanners. It can be managed in a nonoperative and expectant manner, so it is important for the vascular imaging specialist to recognize and distinguish it from higher grades of aortic injury.

Pooled Analysis of the CONFIRM Registries: Outcomes in Patients With Renal Disease Treated for Peripheral Arterial Disease With Orbital Atherectomy

M. S. Lee, G. Adams

Purpose: Peripheral arterial disease patients with renal disease typically have calcified lesions and may have worse clinical outcomes after peripheral intervention compared with patients without renal disease. These hard-to-treat patients with renal disease historically have been excluded from clinical trials.

Materials and Methods: Analysis of the CONFIRM I-III registries that included a real-world patient population revealed 1105 patients with renal disease (1777 lesions) and 1969 patients without renal disease (2907 lesions) who underwent treatment with orbital atherectomy. This study compared the overall procedural complication rate, a composite of dissection (all types), perforation, slow flow, vessel closure, spasm, embolus, and evidence of an embolus formation, for patients with and without renal disease in the CONFIRM series.

Results: As expected, patients with renal disease had a higher prevalence of diabetes, hypertension, hyperlipidemia, and coronary artery disease. In addition, a higher percentage of patients with renal disease were classified as Rutherford class 5-6, and patients with renal disease had a higher number of infraarterial lesions treated. The overall procedural complication rate for patients with and without renal disease was similar (21.3% vs 22.4%, respectively; P=0.46). The following complication rates for patients with and without renal disease were similar: dissection (11.1% vs 11.5%, respectively; P=0.83), perforation (0.6% vs 0.8%, respectively; P=0.55), slow flow (5.0% vs 4.2%, respectively; P=0.19), spasm (6.7% vs 6.2%, respectively; P=0.40), embolism (1.7% vs 2.6%, respectively; P=0.12), and evidence of thrombus (1.4% vs 1.0%, respectively; P=0.56). The renal disease group had a trend towards decreased vessel closure compared with patients without renal disease (1.1% vs 1.6%, respectively; P=0.08).

Conclusion: In one of the largest registries that included patients with renal disease, plaque modification with orbital atherectomy provided similar clinical outcomes in the renal disease group compared with the group without renal disease despite having more unfavorable baseline clinical and lesion characteristics.

Sonothrombolysis of Submassive and Massive Pulmonary Embolus With the EkoSonic Endovascular System and Tissue Plasminogen Activator

C. Davis, C. Declue, T. Lewis, J. Fisher, H. Rojas, B. Zwiebel, J. Mateus

Purpose: Despite advances in venous and arterial thrombolysis, there is no consensus on endovascular strategies for the treatment of submassive and massive pulmonary embolus (PE). In a recent randomized controlled trial in Europe, the ULTIMA trial, sonothrombolysis of the pulmonary artery with tissue plasminogen activator (tPA) demonstrated significant improvement in right ventricular/left ventricular (RV/LV) ratio at 24 hours and 90 days compared with traditional heparin therapy in patients with submassive PE with no major bleeding events. Although these findings are promising, there are no current guidelines on total time of infusion, dose of tPA, or end point of therapy. At our institution, we perform sonothrombolysis using the EkoSonic Endovascular System (EKOS Corporation, Bothell, WA) with recombinant tPA (rtPA) (Genentech, San Francisco, CA) with varying infusion times, rates, and total doses due to a range of patient symptomatology (submassive/massive PE). The intention of this retrospective review was to evaluate if physiologic measurements, such as troponin I, heart rate (HR), or RV/LV ratio, could be used to evaluate severity of hemodynamic impairment at baseline characterized by pulmonary artery pressure (PAP) and, importantly, whether total time of tPA infusion or total tPA infusion dose predicts improvements in PAP.

Materials and Methods: With approval from the institutional review board (IRB), we conducted a retrospective chart review of consecutively enrolled PE patients treated with sonothrombolysis at our institution from 2008-2012. Patients who were in cardiopulmonary arrest (CPA) and resuscitated within 15 minutes prior to the procedure were excluded. Pretreatment risk factors (body mass index [BMI], hypercoagulable disorders, RV/LV ratio by computed tomography angiography [CTA], troponin I level, hypotension, symptom score, pulmonary artery size by computed tomography [CT], preprocedure CPA, embolization), procedural details (HR, pulmonary artery pressures, tPA dose), and postprocedure findings (PAP, HR, mortality, pulmonary artery size by CT, RV/LV ratio by CT) were collected.

Results: Thirty-one patients met the inclusion criteria, among which 6 had massive PE and 25 had submassive PE (Table). Seventeen patients (55%) were at high risk for deep vein thrombosis (DVT) prior to the procedure (current diagnosis of cancer, hypercoagulable disorder, previous PE, surgery within 14 days, inpatient over 14 days). Mean BMI was 24±7.8. Four patients (13%) had been intubated prior to the procedure for hypoxia or hypotension. Association of baseline RV/LV ratio to baseline diastolic PAP (DPAP) and mean PAP (MAP) was significant based on Spearman coefficient (r=0.013 and 0.016, respectively). Following sonothrombolysis with a total dose of 25.5±8.9 mg tPA infused over 20.9±6.5 hours, patients exhibited statistically significant decreases in PAP from pre- to postprocedure (53.2±10.8 to 40±11.7 mm Hg [systolic]; 21±10 to 13±6 mm Hg [diastolic]; 33.8±10.8 to 23±6.2 mm Hg [mean]; P=0.0099) (Figure). There was no association with infusion time with regards to change in DPAP, systolic PAP (SPAP), and MAP with Spearman coefficient testing (P=0.3162). However, there was a positive correlation between total tPA dose and the reduction in DPAP and SPAP with Spearman coefficient testing (P=0.0027 and 0.0240). Mean baseline serum troponin I was elevated in 21/29 patients (72%). Troponin levels were not measured in 2/31 patients. Mean troponin I prior to procedure was 0.55±0.41 ng/mL (normal=0.05). Troponin I level was poorly correlated with the level of RV/LV ratio and did not correlate with baseline preprocedure MPAP pressures (P=0.05). Heart rate was 93±19.3 bpm at baseline and 86.8±15.5
Conclusion: There was no correlation between HR and pulmonary artery pressure (<28 mm). Postprocedure CT was performed in 6 patients (19%) for other symptoms. At our institution, to avoid excessive radiation, we do not perform postprocedure CT of the chest after thrombolysis. Of those 6 who received postprocedure chest CT, mean baseline RV/LV ratio was 1.93±0.22, and mean postprocedure RV/LV ratio was 1.05±0.15, a change of 46%. Two patients died during the procedure or within the infusion time. Only 4 of 31 patients were intubated prior to the procedure; 2 (50%) of these patients died during or immediately after the procedure. One of the patients who died had a PAP of 100/80, an MPAP of 65 mm Hg, and a preprocedure pulmonary artery size of 46 mm (normal: <28 mm). She had cardiopulmonary arrest approximately 1 hour after placement of the catheter. The second patient had cardiopulmonary arrest several hours prior to the procedure and was intubated and hypotensive prior to placement of the catheters. He died immediately after pulmonary catheter placement. There were no complications related to bleeding/hematoma in the other 29 patients.

Table. Summary of results

<table>
<thead>
<tr>
<th>Summary of Results</th>
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</thead>
<tbody>
<tr>
<td>Total Patients</td>
</tr>
<tr>
<td>Massive/Submassive</td>
</tr>
<tr>
<td>Mean RV/LV ratio</td>
</tr>
<tr>
<td>Mean SPAP pretreatment</td>
</tr>
<tr>
<td>Mean SPAP post treatment</td>
</tr>
<tr>
<td>Mean tPA dose (bolus infusion)</td>
</tr>
<tr>
<td>Mean total infusion time</td>
</tr>
<tr>
<td>Elevated troponin I</td>
</tr>
<tr>
<td>Change in RV/LV ratio (6/31 had follow-up CT post procedure)</td>
</tr>
</tbody>
</table>

Abbreviations: CT, computed tomography; LV, left ventricular; PE, pulmonary embolus; RV, right ventricular; SPAP, systolic pulmonary artery pressure; tPA, tissue plasminogen activator.

Figure. Preprocedure and postprocedure pulmonary artery pressures

Conclusion: 1. Elevated RV/LV ratio measured on pulmonary embolus protocol CTA had a positive correlation with direct mean pulmonary artery pressures (P=0.0159, Spearman coefficient). 2. There were significant changes in MPAP, SPAP, and DPAP (-12.5±11.4, -6.4±7.6, and -9.6±8.2 mm Hg, respectively) after sonothrombolysis using the EkoSonic Endovascular System with low doses of tPA (25.5 mg) and less than 21 hours of infusion (P=0.0009, <24 h). 3. Changes in the PAP pre- and postprocedure were correlated with the total tPA infusion dose (P=0.0027, Spearman coefficient). There was no correlation with total time of tPA infusion and change in pulmonary artery pressures. 4. Preprocedure troponin I serum level was not correlated with level of RV/LV ratio (P=0.2990). 5. Given the sample size, it is difficult to determine procedure risks. Bleeding complications were not encountered (0%), but there was a 6.4% mortality rate due to cardiopulmonary arrest. Two of 4 patients who were intubated prior to the procedure died. One patient had cardiopulmonary arrest in the hours prior to the procedure but was stable enough to have the catheters placed; that patient died immediately after placement. 6. Although the sample size is small, patients who received postprocedure CT (19%) had a 46% drop in the RV/LV ratio.

12-Month Patency Rates in Eccentric Atherosclerotic Lesions: A Subset of the DEFINITIVE LE Study

S. F. Janzer

Purpose: To retrospectively assess the effectiveness of directional atherectomy (DA) to treat eccentric atherosclerotic lesions in subjects enrolled in the DEFINITIVE LE study.

Materials and Methods: DEFINITIVE LE was a multinational study that assessed the effectiveness of DA using the SilverHawk and TurboHawk peripheral plaque excision systems (Covidien, Mansfield, MA) for treatment of peripheral artery disease in femoropopliteal and tibial/peroneal arteries. All lesions were treated with DA. Angiographic and sonographic core laboratories were used to analyze all imaging data. The angiographic core laboratory classified lesions as eccentric when there was a 3 times more plaque volume on one side of the arterial wall as compared with the opposite wall.

Results: The DEFINITIVE LE study enrolled 800 subjects with 1022 lesions. Of those, 83 lesions in 78 subjects were eccentric (per angiographic core laboratory assessment). Sixty-four subjects (82%) had claudication and 14 (18%) had critical limb ischemia (CLI). The mean lesion length was 4.4 cm (4.6 cm in claudication, 3.9 cm in CLI). The baseline diameter stenosis was 69.2% (68.6% in claudication and 71.4% in CLI), which was reduced to 22.3% (21.8% in claudication and 24.3% in CLI) following treatment with DA. Adjunctive devices were used in 47.0% (39/83) of lesions, predominantly percutaneous transluminal angioplasty (PTA) alone (42.2%, 35/83). Three stents were placed (4.5%), all in claudicant patients. The residual diameter stenosis following adjunctive therapy was 15.5%. The 12-month freedom from target lesion revascularization (per Kaplan-Meier estimate) was 89.6% (93.3% in claudication and 76.5% in CLI). The 12-month primary patency rate (per Kaplan-Meier estimate) was 80.6% (85.7% in claudication and 60.5% in CLI).

Conclusion: DA devices are uniquely designed to target treatment. This is conceptually ideal for the treatment of eccentric disease since it can minimize the disruption of contiguous nondiseased areas of the vessel. DA is an effective treatment option for eccentric atherosclerotic lesions with a low bail-out stent rate and good patency and freedom from revascularization rates in both patients with claudication and patients with CLI.

A Detailed Review of Thoracic Outlet and Peripheral Arterial Injury and Interventional Treatments

C. Coroian, B. Shearer, D. Feldstein, B. Bianco, A. Trebelev

Purpose: An educational review of arterial injury in thoracic outlet and extremity trauma with a focus on the interplay between surgical and endovascular repair.

Materials and Methods: At our level I trauma center in Philadelphia, we evaluate and treat numerous patients with thoracic outlet and extremity trauma. Six cases have been selected to illustrate the role of the interventional radiologist: subclavian artery injury related to clavicular fracture, brachial artery injury related to gunshot wound, radial artery pseudoaneurysm related to surgery, superficial femoral artery (SFA) compression related to femoral fracture, popliteal artery transection related to knee fracture/dislocation, and popliteal artery pseudoaneurysm with arteriovenous (AV) fistula related to gunshot wound.

Results: According to the Centers for Disease Control and Prevention’s National Center for Health Statistics, falls, firearms, and motor vehicle traffic-related injuries represent 51% of injury mechanisms resulting in death. Of all arterial injuries, the extremities are the most common location involved. Peripheral vascular injuries are caused by penetrating trauma 75%-80% of the time and blunt trauma 5%-25% of the time. Fifty percent of these result from guns, 30% from stabs, and 5% from shotguns. As morbidity and mortality with these injuries is high, soft signs and hard signs have been developed to guide management. Although arteriography has a sensitivity of 95%-100% and a specificity of 90%-98%, it should be reserved for patients with soft signs of vascular injury or intraoperatively in cases where anatomical information is needed in patients with hard signs without delay of definitive therapy. The spectrum of arterial injury includes (a) intimal disruption (flaps, subintimal hematoma); (b) intimal and medial disruption with or without pseudoaneurysm formation or arteriovenous...
ISET Abstracts

**Summary of published data on infrapopliteal arterial disease over the last decade**

<table>
<thead>
<tr>
<th>Year</th>
<th>Procedure</th>
<th>Patients</th>
<th>ABI Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Infrapopliteal disease</td>
<td>452</td>
<td>Pre: 0.69 +/- 0.080</td>
</tr>
<tr>
<td>2010</td>
<td>Infrapopliteal disease treated with primary</td>
<td>500</td>
<td>Pre: 0.69 +/- 0.080</td>
</tr>
</tbody>
</table>

**Abbreviation:** ABI, ankle-brachial index.

**Conclusion:** The primary goal of the presentation is to provide information about the specific process of infrapopliteal arterial disease, which is scantily studied and described in the existing literature. The reader will be better equipped to interpret findings, discuss etiology, classify patients, and create a suitable treatment plan with a high confidence in technical success.

### Atherectomy of the Common Femoral Artery: A Safe and Reasonable Alternative

S. Gonda, J. Winblad, S. Iqbal

**Purpose:** Atherosclerotic disease of the common femoral artery (CFA) is commonly seen and can be the primary etiology of a patient’s claudication. Traditionally, the gold standard of treatment of peripheral arterial disease has been surgery. However, there are far less data regarding atherectomy of the CFA. We present a series of patients who presented with claudication secondary to disease of the CFA who were treated with atherectomy. The objective of this poster is to raise the awareness of atherectomy as a safe and reasonable technique in the CFA.

**Materials and Methods:** A retrospective review of all interventional procedures performed at 2 separate facilities from July 2011-2013, revealing 6 cases in which atherectomy was used to treat symptomatic CFA lesions. The patient’s preprocedural and postprocedural claudication symptoms and ankle-brachial index (ABI) values were reviewed. The mean follow up was 8.2 months.

**Results:** All patients had moderate-severe claudication symptoms (Rutherford category 3) before atherectomy was performed. In 5 of the 6 patients, directional atherectomy (TurboHawk, Covidien, Mansfield, MA) was used followed by balloon angioplasty. In a single case, orbital atherectomy (Diamondback, CSI, St Paul, MN) was performed followed by angioplasty. In all 6 cases, there were no major complications. In 1 patient, there was mild aneurysmal dilatation of the CFA, which was followed with ultrasound. There were no flow-limiting dissections or branch occlusions. Five patients demonstrated symptomatic improvement. Five patients had postprocedural ABIs and demonstrated improvement as well (Table).
Results: An 85-year-old African American female presented with a left great toe ulcer and calf pain (history of coronary artery disease, hypertension, diabetes, and peripheral vascular disease). She underwent an abdominal aortogram, which demonstrated a complex left SFA occlusion (Figure A) and poor tibial runoff. An attempt was made to open it endovascularly, but it was unsuccessful from an antegrade approach; however, a popliteal, retrograde approach was successful. Atherectomy and stenting were performed on the left SFA. Initially, her claudication symptoms improved, but over the next few weeks they returned. Ankle brachial indexes were performed, which were abnormal, and the patient subsequently returned for an angiogram. A significant arteriovenous (AV) fistula between the popliteal artery and the deep venous system was noted (Figure B), as well as the previously noted poor tibial runoff (Figure C). Since the patient was a poor surgical candidate, we decided to utilize a percutaneous approach. Recognizing the poor runoff, we felt that opening up her tibial vessels would allow adequate runoff so as to decompress the AV fistula. In an office-based setting, we utilized crossing techniques/technology as well as orbital atherectomy and angioplasty to open up 2 of her 3 tibial arteries (Figure D). With this new runoff, the AV fistula was decompressed and showed negligible flow on subsequent angiograms (Figure E). Ultimately, the patient’s claudication symptoms resolved, and the ulcer on her great toe healed.

Conclusion: SFA patency postintervention is dependent on distal runoff. An AV fistula proximal to a distal arterial blockage is unlikely to close as the flow of blood is going to take the path of least resistance. This patient’s entire vascular occlusion was treated in an outpatient center with endovascular techniques. The patient was not a candidate for a general anesthetic or traditional open surgical technique. In the face of a complication, the patient was ultimately treated safely and effectively in an outpatient setting utilizing endovascular techniques.

Clinical Efficacy of Infrapopliteal Endovascular Therapy for Patients With Critical Limb Ischemia

T. Sahu, V. Anand, V. Motukuru, S. Raj, K. R. Suresh

Purpose: Infrapopliteal angioplasty is routinely used to treat critical limb ischemia (CLI) despite limited data on its outcomes. It may be performed after femoral angioplasty or in conjunction with iliac or femoral lesions. Although restenosis, reintervention, or amputation is high after infrapopliteal angioplasty for CLI, excellent limb salvage rates may be obtained with careful follow-up and reinterventions when necessary. Additional long-term follow-up and cost data are needed to thoroughly define the appropriate role for infrapopliteal angioplasty.

Effectiveness and Outcomes of Carotid Artery Stenting in High-Risk Patients

S. Cella, B. Kudryk, B. Rau, T. Black

Purpose: To evaluate the effectiveness and long-term outcomes of carotid artery stenting in high-risk patients treated at our facility using the end points set forth by the CREST trial.

Materials and Methods: This was a retrospective evaluation of high-risk patients at our facility who underwent a total of 104 carotid stenting procedures. High-risk patients were defined as those having prior carotid endarterectomy, prior neck radiation, or prior stroke or those who were poor surgical candidates due to other medical conditions. Patients were both symptomatic and asymptomatic at initial presentation (Table 1). Primary end points included myocardial infarction (MI), stroke, and death at 30 days. Long-term follow-up was determined by duplex carotid ultrasonography and/or carotid computed tomography angiography (CTA) demonstrating presence of a hemodynamically significant stenosis. Data were obtained from the electronic medical records. Two experienced interventional radiologists performed the procedures. Acculink or Xact stents (Abbott Vascular, Santa Clara, CA) were placed with distal protection in all of the cases.

Table 1. Patient characteristics

<table>
<thead>
<tr>
<th>Patient Characteristics of Study Group</th>
<th>66.1% ± 7.3</th>
<th>67.3%</th>
<th>32.7%</th>
<th>9%</th>
<th>11%</th>
<th>25%</th>
<th>25%</th>
<th>16.8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs ± SD)</td>
<td>Male (%)</td>
<td>Asymptomatic (%)</td>
<td>Symptomatic (%)</td>
<td>Reason for Stent</td>
<td>Prior MI (%)</td>
<td>Prior XRT (%)</td>
<td>Prior CEA (%)</td>
<td>Other (%)</td>
</tr>
<tr>
<td>Follow-up (months ± SD)</td>
<td>25.1% ± 16.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Abbreviations: CEA, carotid endarterectomy; SD, standard deviation; XRT, radiation therapy.

Results: A total of 104 carotid stenting procedures were performed in patients ranging from 51-87 years of age, with a mean follow up of 25.1 months. Our data demonstrated that within the periprocedural period (30 days), 0% of patients experienced MI, 1.9% developed a stroke, and 1% died (Table 2). Our data were compared with data from the CREST trial, which showed periprocedural rates of 1.1% for MI, 4.1% for stroke, and 0.7% for death. The ipsilateral stroke rate was 0% at an average follow-up of 25 months in our study compared with 2% at 4 years in the CREST trial.
reintervention rate for patients who underwent carotid stenting was 4.8%. Of our 2 patients with poor outcomes, 1 had a history of complete occlusion of 1 carotid artery and >90% stenosis on the contralateral side. Reperfusion injury led to a hemorrhagic stroke and eventually death. The other patient developed a minor stroke on imaging but after a prolonged hospital stay was discharged with a full recovery. Two patients experienced transient visual disturbances in the early postprocedural period, though these symptoms resolved without any permanent deficits.

### Table 2. Primary end points in patients post–carotid artery stenting in the periprocedural period (30 days) (N=104 procedures)

<table>
<thead>
<tr>
<th>Event</th>
<th>Number of Event</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI, asymptomatic</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MI, symptomatic</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stroke</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>Symptomatic</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Death</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Reintervention</td>
<td>3</td>
<td>4.8</td>
</tr>
<tr>
<td>Symptomatic</td>
<td>2</td>
<td>2.9</td>
</tr>
</tbody>
</table>

**Abbreviation:** MI, myocardial infarction.

**Conclusion:** Our data indicated that high-risk patients at our facility who underwent a total of 104 carotid stenting procedures as an alternative to carotid endarterectomy achieved similar or better outcomes than those reported during the CREST trial.

### Endovascular Repair of Traumatic Popliteal Artery Disruptions: A New Approach to a Classic Injury


**Purpose:** Popliteal artery injury from blunt trauma occurs at an incidence of 4%-20%. Standard treatment for such injuries has historically involved open exploration and bypass, which can often be a challenge in patients with other concomitant traumatic injuries. Thus, the treatment of these injuries with endovascular techniques is an appealing alternative to standard open surgery. We present a series of 2 patients with traumatic injury to the popliteal artery who were treated by endovascular techniques.

**Materials and Methods:** From 2011 to 2013, all traumatic injuries to the popliteal artery who were treated by endovascular techniques. Traumatic injury to the popliteal artery who were treated by endovascular techniques. Five patients were treated for peripheral arterial chronic total occlusions when using the Ocelot catheter (Avinger, Redwood City, CA).

**Results:** The mean age of the patients was 24.5 years. The mean injury severity score for the 2 traumatic popliteal injuries was 14.5. Computed tomography angiography was performed on both patients prior to operative intervention. The traumatic popliteal injuries in both patients were repaired via an antegrade endovascular approach. Intimal artery dissection was suspected in both cases. All lesions were crossed with a hydrophilic wire, and balloon angioplasty was performed. Successful angiographic results were achieved in both cases. Postoperatively, patients were maintained on antiplatelet medication.

**Figure.** Traumatic popliteal artery injury before and after endovascular repair

**Conclusion:** We report a series of 2 cases of popliteal artery injuries treated endovascularly. Popliteal artery injuries are not an uncommon occurrence after blunt extremity trauma. Traditionally, these injuries have been treated with open exploration and bypass. However, with improvements in technology and techniques, endovascular therapy poses a viable option for patients with traumatic or iatrogenic causes of popliteal artery injury. Endovascular treatment may also result in decreased morbidity, faster recovery, and more expeditious operative intervention compared with open treatment. We believe that the management of traumatic popliteal lesions should be approached endovascularly first prior to considering open intervention.

### Hybrid Surgical and Endovascular Treatment of Complex Proximal Common Carotid and Innominate Artery Lesions: A Single-Center Experience


**Purpose:** We report our experience in the hybrid surgical and endovascular treatment of complex proximal common carotid and innominate artery lesions at a single center.

**Materials and Methods:** Eleven of 14 symptomatic patients who underwent hybrid procedures with surgical exposure (with or without endarterectomy) of the carotid artery and retrograde endovascular intervention of a common carotid and/or innominate artery lesion were included in the study.

**Results:** The mean percentage of stenosis was 81%. Seven patients underwent a carotid endarterectomy (CEA), and 4 patients underwent only a surgical cutdown for retrograde endovascular access of the innominate artery or left common carotid artery.

**Conclusion:** The hybrid retrograde endovascular approach through carotid exposure with or without CEA appears to be an effective and safe treatment in selected patients who have high-risk complex anatomy or tandem lesions.

### Lumivascular Approach to Crossing Chronic Total Occlusions Without Fluoroscopy

**T. Davis**

**Purpose:** To demonstrate a case series where the use of optical coherence tomography (OCT) greatly reduced or eliminated fluoroscopy during the crossing of peripheral arterial chronic total occlusions when using the Ocelot catheter (Avinger, Redwood City, CA).

**Materials and Methods:** Fifteen patients were treated for peripheral arterial chronic total occlusions (CTO) between January 2013 and June 2013 (Table). Sixteen lesions were crossed using real-time OCT as the primary imaging modality in these cases. The mean patient age was 73 years (range, 50-91 years). Ten males and 5 females were treated. Radiographic values measured included diagnostic angiography, CTO crossing fluoroscopy, and therapeutic fluoroscopy times.

**Table.** Characteristics of case series demographics, lesions, and fluoroscopy times

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Target Vessel</th>
<th>SR (%)</th>
<th>Diagnostic Fluoroscopy</th>
<th>Crossing via OCT</th>
<th>Interventional Fluoroscopy</th>
<th>Total Fluoroscopy</th>
<th>Lesion Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>79</td>
<td>M</td>
<td>RSFA</td>
<td>10.7%</td>
<td>17.9</td>
<td>20.2</td>
<td>31.6</td>
<td>31.9</td>
<td>36.6</td>
</tr>
<tr>
<td>85</td>
<td>F</td>
<td>RPOP</td>
<td>10.4%</td>
<td>21.3</td>
<td>24.5</td>
<td>36.8</td>
<td>36.8</td>
<td>16.3</td>
</tr>
<tr>
<td>79</td>
<td>M</td>
<td>RSFA, RPOA</td>
<td>10.4%</td>
<td>22.5</td>
<td>25.6</td>
<td>38.1</td>
<td>38.1</td>
<td>16.3</td>
</tr>
<tr>
<td>80</td>
<td>F</td>
<td>RSFA, RPOA</td>
<td>10.3%</td>
<td>23.4</td>
<td>26.3</td>
<td>39.3</td>
<td>39.3</td>
<td>16.3</td>
</tr>
<tr>
<td>75</td>
<td>M</td>
<td>RSFA</td>
<td>10.8%</td>
<td>20.1</td>
<td>24.5</td>
<td>34.9</td>
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<td>15.1</td>
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<tr>
<td>80</td>
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<td>10.4%</td>
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<tr>
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<td>M</td>
<td>RSFA</td>
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<td>M</td>
<td>RSFA, RPOA</td>
<td>10.4%</td>
<td>22.5</td>
<td>25.6</td>
<td>38.1</td>
<td>38.1</td>
<td>16.3</td>
</tr>
</tbody>
</table>

**Abbreviations:** F, female; LCIA, left common iliac artery; LSFA, left superficial femoral artery; LT-P, left tibial-peroneal trunk; M, male; RPOP, right popliteal artery; RSFA, right superficial femoral artery; SR, stenosis reduction.

**Results:** One hundred percent of CTOs in this series were crossed successfully via the true lumen without the use of assist or reentry devices. Mean CTO crossing fluoroscopy time was 0.24±0.36 minutes (14.4±2.16 seconds) using the Ocelot (Figure). In comparison, mean diagnostic and therapeutic fluoroscopic times were 5.99±3.07 minutes and 14.88±6.36 minutes, respectively. Mean lesion length treated was...
18.6 cm (18.63±8.58 cm). Sixteen of 16 lesions were reduced from 100% stenosis to less than 10% stenosis. In 15/15 cases, the mean contrast volume administered across procedures was 176.6±50.08 mL (median, 180 mL; range, 100-230 mL). There were no adverse events reported at 60 days.

Figure. Measured fluoroscopy times

Conclusion: Luminovascular techniques allow for safe, quick, and efficient crossing of peripheral arterial CTOs while eliminating or significantly reducing fluoroscopic exposure and contrast administration.

Pedal Arch Reconstruction: Case Presentation
A. C. Lee

Purpose: Orbital atherectomy (OA) successfully treats peripheral arterial disease, particularly in areas of intense calcification. We describe our experience using OA on the pedal arch.

Materials and Methods: Support catheters were integral in this case: 0.014" CXC and 0.018" CXI support catheters (Cook Medical, Bloomington, IN) were both used for selective angiography as well as for supporting wire action. Wires employed during the case included 0.018" Treasure 12 (Asahi Intecc, Nagoya, Japan), 0.014" Regalia (Asahi Intecc, Nagoya, Japan), 0.014" Whisper (Abbott Vascular, Santa Clara, CA), 0.014" Fielder XT (Asahi Intecc, Nagoya, Japan), and 0.014" ViperWire (CSI, St Paul, MN). Orbital atherectomy was performed with a 1.25-mm Stealth microcrown (CSI, St Paul, MN). Balloons were Cook 14LPs (Cook Medical, Bloomington, IN). Angiography was performed on a 60-year-old man with diabetes, peripheral neuropathy, hypertension, and dyslipidemia, which revealed a severely diseased posterior tibial artery (PTA) with occluded peroneal artery and anterior tibial artery (ATA).

Selective injection of the ATA showed subtotal occlusion culminating in occlusion at the ankle. The PTA was treated with the Stealth 360 Peripheral Atherectomy System (OAS) (CSI, St Paul, MN) using a 1.25-mm microcrown and balloon angioplasty, and the ATA was treated with balloon angioplasty only. Runoff was still poor, so selective angiography with orthogonal views was performed into the plantar arch (PA) (Figure A) via the dorsalis pedis and common plantar artery using both 0.018" CXI and 0.014" CXC support catheters. The PA was eventually wired true lumen to true lumen using a 0.014" Regalia wire. A balloon could not be passed to treat the PA, so it was treated with OAS using a 1.25-mm microcrown (Figure B). The OA treatment allowed for successful balloon angioplasty in the PA, resulting in excellent flow (Figure C).

Figure. Initial pedal runoff (A), treatment with orbital atherectomy through the pedal arch (B), and postatherectomy and angioplasty runoff images (C)

Conclusion: Completion angiography revealed excellent flow and complete reconstruction of the pedal arch. Reconstruction of the pedal arch requires a good understanding of the anatomy and the frequent anatomical variants seen below the knee and especially in the foot. Strong consideration should be given to employing an antegrade approach and then judicious use of superselective angiography via support catheters. Wire selection and escalation methods including knuckle wire, subintimal arterial flossing with antegrade-retrograde intervention (SAFARI), and reverse controlled antegrade and retrograde subintimal tracking (CART) techniques can be employed to try to connect the anterior and posterior circulations. Judicious use of OA for vessel preparation should be considered in these cases as calcium is almost always present and reducing the incidence of high-pressure balloon inflation and subsequent dissection is extremely important.

Pooled Analysis of the CONFIRM Registries: Outcomes in Diabetic Patients Treated for Peripheral Arterial Disease With Orbital Atherectomy
M. S. Lee, G. Adams

Purpose: Patients with diabetes have a high risk of developing peripheral arterial disease (PAD). There has been an epidemic increase in the rate of diabetes, which is a strong risk factor for development of arterial calcification. The presence of heavy calcium burden is associated with periprocedural complications such as dissections, potentially making the treatment of PAD technically more challenging. This study compared the procedural complication rates in diabetics and nondiabetics treated with orbital atherectomy in the CONFIRM series.

Materials and Methods: Analysis of the CONFIRM registry series revealed 1842 diabetics (2819 lesions) and 1247 nondiabetics (1885 lesions). The rates of procedural complications, including perforation, slow flow, vessel closure, spasm, embolectomy, and thrombus formation, were analyzed for diabetics and nondiabetics.

Results: Diabetics were younger but had a higher prevalence of coronary artery disease (P<0.001), renal disease (P<0.001), and hyperlipidemia (P<0.001) and lower ankle-brachial index scores (P=0.007). Diabetics had more severe PAD (Rutherford class 4-6) (P<0.001), longer lesions (P<0.001), more infrapet nibial lesions (58% vs 46%; P=0.001), and more lesions with severe and moderate calcium (86% vs 78%; P<0.001). Diabetics and nondiabetics had a similar composite rate of procedural complications (21.8% vs 21.8%; P<0.001), dissection (11.4% vs 10.8%; P=0.68), embolectomy (2.2% vs 2.4%; P=0.67), and thrombus formation (1.3% vs 1.1%; P=0.75). However, diabetics had lower rates of perforation (0.5% vs 1.1%; P=0.03) and spasm (5.5% vs 7.6%; P=0.005) but a higher rate of slow flow (5.0% vs 3.5%; P=0.02) and a trend towards increased vessel closure (1.7% vs 0.9%; P=0.06).

Conclusion: Plaque modification with orbital atherectomy resulted in similar low procedural complication rates in both the diabetic and nondiabetic groups, despite diabetics having more unfavorable baseline clinical and lesion characteristics. This study suggests that the OA can be safely used in both the diabetic and the nondiabetic population and that the OAS is an effective treatment modality that does not preclude future treatment options.

Prosthetic Arteriovenous Fistula for Hemodialysis: Maintenance Is Durability

Purpose: Prosthetic arteriovenous fistula (AVF) is an alternative access for hemodialysis in patients with end-stage renal disease and inadequate superficial vein outflow; however, its long-term patency is limited by a high rate of thrombosis. The aim of this study was to evaluate the long-term primary and assisted patency of AVF in patients enrolled in a close surveillance program compared with a historical group of patients in which AVF malfunction was monitored with simple clinical evaluation.

Materials and Methods: We have enrolled all patients with AVF into a duplex ultrasound surveillance program with a 6-month interval evaluation in order to assess malfunction or stenosis of the AVF. Findings of malfunction included a reduction of the vascular lumen of 50% with subsequent blood flow reduction (<600 mL/min). In such cases, patients were submitted to angiography and endovascular treatment. Long-term patency of AVF in the surveillance program was compared with that of a historical AVF control group in which the malfunction was detected only clinically (presence of thrill and bruit, dialysis performance).

Results: Thirty-three patients were included in the surveillance program, with a mean follow-up of 60±45 months. During that period, 15 AVF malfunction (45%) were detected and successfully treated, 10 (66.6%) by angioplasty and 5 (33.4%) by angioplasty and stenting. The historical control group included 27 patients with clinical characteristics similar to those of the surveillance group. By Kaplan-Meier analysis, the primary patency was similar in the 2 groups: 32%±3% in the surveillance group vs 23%±8% in the historical control group (P=0.23); assisted patency was significantly higher in the surveillance group: 42%±13% vs 9%±7% (P=0.03).

Conclusion: AVF has a low primary patency rate; however, a close surveillance protocol allows a significant increase in assisted patency, which can help prolong the durability of the access.

Renal Transplant Artery Stenosis Stenting: A Single-Center Experience
R. Hanna, V. Sheynzon

Purpose: The aim of our study was to evaluate the effect of bare-metal stents over 4 years at a tertiary care referral center in patients who undergo transplant artery stenosis stenting.
Materials and Methods: This retrospective study reviewed the medical records of patients with a history of renal transplant who underwent an interventional radiology procedure from September 2009 to September 2013. Records of renal transplant patients were reviewed to identify those patients who underwent renal transplant arterial stenting. Indications for stenting were analyzed and follow-up creatinine, blood pressure, and ultrasound Doppler findings were recorded. Statistical significance was determined using the Fisher exact test at the 0.05 level.

Results: Renal transplant arterial stenting was performed in 22 of 133 renal transplant patients who underwent an interventional angiographic procedure. Patients included 12 with rising creatinine alone (as defined by the clinical team), 3 with elevated blood pressure alone, 2 with elevated velocities/resistive indices on ultrasound Doppler alone, and 5 with 2 or more of the above causes. Following stenting, 7 patients (31.8%) had to undergo reintervention, including 2 restenting and 5 post-procedure angioplasty; 15 patients required no reintervention.

Conclusion: Our 4-year data in patients with renal transplant arterial stenting reveal that 31.8% of patients will require reintervention. Consideration should be given to standardized 3-month follow-up, which is similar to protocols at some centers for follow-up of dialysis fistula patients. This may assist in prolonging the longevity of the renal transplant once an arterial stenting procedure has been performed.

Through-and-Through Access to Facilitate Carotid Artery Stenting in Patients With a Hostile Aortic Arch

M. I. Syed, T. Akhter, S. Sinnathamby, A. Shaikh, R. Tyrrell, S. Neravetla, K. Morar

Purpose: Carotid artery stenting (CAS) is a well-known procedure for symptomatic patients who are high risk for carotid endarterectomy (CEA). Technical difficulties arise often in the extreme elderly population due to arch vessel tortuosity. Stenting in this situation often results in complications such as catheter tangles and dislodgments of the entire delivery system from the target vessel during the procedure, with resultant arterial dissection and/or stroke. The superficial temporal arterial (STA) and/or the right carotid artery (RCA) is a well-known guide to the carotid bifurcation. The purpose of our abstract is to describe a case series of an entirely percutaneous, ultrasound-guided approach to the STA or RRA to facilitate transfemoral CAS in hostile aortic arches.

Materials and Methods: Patients were chosen based on being symptomatic (transient ischemic attacks [TIAs]) and being at high risk for CEA. Patients also had hostile aortic arches (type II or III). Ultrasound-guided access to the STA or RRA was obtained through a 21-gauge needle and coronary-type guidewire with angled tip. The wire was snared in either the aortic arch or external carotid artery (ECA). Once through-and-through access was established, standard carotid stenting technique with embolic protection device (EPD) was utilized using a long 90-cm 8F sheath.

Results: The results are displayed in the table.

| Table. Summary of experience for through-and-through access in carotid stenting |
|------------------|------------------|
| Patient Age      | Follow-up Time   |
| 40 years         | 20 years         |
| 45 years         | 30 years         |
| 50 years         | 40 years         |
| 60 years         | 50 years         |
| 70 years         | 60 years         |
| 80 years         | 70 years         |
| 90 years         | 80 years         |
| 100 years        | 90 years         |
| 110 years        | 100 years        |

Utility of the TruePath Device in the Endovascular Treatment of Chronic Total Arterial Occlusions

M. Elder, T. Mohamad, A. Kaki, P. Gunasekaran

Purpose: The prevalence of chronic total occlusions (CTO) is approximately 20%-40% in patients undergoing endovascular interventions for symptomatic peripheral arterial disease (PAD). Crossing heavily calcified CTO lesions fails in 20% of cases due to the inability to reenter the distal true lumen from a subintimal location. Adverse effects of conventional balloon or guidewire techniques are substantial dissection or vessel perforation. TruePath (Boston Scientific, Natick, MA) is a true lumen crossing device that achieves recanalization in patients with CTO lesions with a 0.018” guide-wire-like profile, which is 50% smaller than contemporary devices, and a diamond-coated distal tip that spins at a maximum of 18,000 rotations per minute (RPMs) with an added advantage of quantifying the resistance at the tip. The objective of this study is to estimate the success rate of true lumen reentry achieved by crossing of the CTO lesion with the TruePath device and the incidence of procedural complications like vessel perforations requiring treatment, embolizations, dissection, and limb loss both post-procedurally and at the end of 30 days.

Materials and Methods: This will be a prospective single-arm multicenter study. The study population will include 30 hypertensive patients ≥40 years of age, irrespective of their smoking status, with CTO lesions ≥20 mm or more located above the knee, below the knee, or in iliac arteries. Patients will undergo TruePath device-directed CTO occlusion recanalization following failure with conventional guidewires. Patients with a CTO lesion ≥20 mm or more will be crossed with a TruePath device if deemed necessary by the operator.

Results: The primary end point will be technical success in crossing the CTO lesion using the TruePath device. Secondary end points will include time required to cross the CTO lesion and improvement in symptoms 30 days after the procedure. Adverse effects such as bleeding requiring transfusions, embolizations, limb ischemia, recurrence of occlusion, need for open surgical treatments, and occurrence of dissection will be recorded. Ankle-brachial index (ABI) and an angiographic parameters such as extent of occlusion will be recorded both pre- and post-procedurally.

Conclusion: Chi-square test for categorical variables and the student t test for continuous variables will be performed to compare pre- and post-procedural data. This will enable us to ascertain the safety and efficacy of the device.

Vascular Brachytherapy for Renal Artery In-Stent Restenosis

S. H. Silverman, J. B. Exline, R. H. Samson

Purpose: Renal artery in-stent restenosis (ISR) is a common problem occurring at a significant rate. A variety of treatments have been utilized with mixed results including redo percutaneous transluminal angioplasty (PTA), redo PTA with bare-metal stents (BMS), redo PTA with covered stents, and redo PTA with drug-eluting stents. ISR in the first few years is likely secondary to neointimal hyperplasia, and vascular brachytherapy (VBT) has been proven to be effective in preventing repeat BMS restenosis from intimal hyperplasia. This prompted us to utilize and study VBT in renal artery ISR.
Materials and Methods: A database of all patients who had renal artery stenting for renal artery stenosis was retrospectively reviewed. A total of 25 patients were identified from 2004 to 2012 who developed renal artery ISR ≤30 months after the initial procedure. Twenty-one patients (with 22 renal arteries) were available for follow-up and were followed with renal artery duplex scanning as a baseline study and then every 6 months. Patients were treated with redo PTA and VBT based on existing protocols. Statistical analysis was done forming Kaplan-Meier survival curves.

Results: The 21 patients had an average onset of ISR of 11 months (range, 2-30 months). After PTA and VBT, there was an initial technical success of 100%. The mean follow-up was 40 months (range, 14-80 months). All stents were patent except in 1 patient who developed restenosis at 48 months after VBT. Five patients had PTA prior to VBT, and 4 were available for follow-up. These 4 patients had a combined total number of 5 PTAs prior to VBT done for ISR resulting in an average patency of 11.8 months. After VBT, the average patency was 41.5 months, and no patient developed restenosis.

Conclusion: In our experience, VBT with PTA is an extremely safe and effective treatment for patients developing renal artery ISR. Follow-up results also reveal this treatment is durable. This is the largest review of VBT for renal ISR with the longest follow-up.

Alterations in Hypothalamic-Pituitary-Adrenal Axis Following Central Venous Balloon Dilation

M. A. Arata, Z. Sternberg, S. Cen

Purpose: Chronic cerebrospinal venous insufficiency (CCSVI) has been described as a condition resulting from impaired central nervous system (CNS) venous drainage in multiple sclerosis (MS) patients. Venous balloon angioplasty (BA) has been performed as a treatment for CCSVI, although a direct link between venous obstruction and CCSVI has not been conclusively demonstrated. In addition, the dysfunction of the hypothalamic-pituitary-adrenal (HPA) axis has been reported in MS patients, correlating with disease activity. Although MS patients undergoing treatment of CCSVI report improvements in quality of life, the effect of this intervention on the HPA axis is unknown. The purpose of this study was to determine whether BA induces alterations in the HPA axis, indicated by changes in levels of adrenocorticotropic hormone (ACTH) and cortisol.

Materials and Methods: Eighty-eight patients underwent treatment with central venous BA for CCSVI correction. Serum samples were taken at baseline and 30 minutes after the completion of the procedure. ACTH and cortisol were measured using electrochemiluminescence immunoassay. Since the data distributions for changes in serum ACTH and cortisol were not normal, Wilcoxon signed-rank tests were used to assess whether these changes were statistically significantly different from 0 at the level of 0.05. All statistical analysis was conducted using SAS 9.2 software (SAS Institute, Cary, NC).

Results: Central venous BA treatment resulted in statistically significant reductions in both ACTH and cortisol (P<0.01). The distribution in change of ACTH and cortisol shifted towards negative and significantly away from 0, with a median (first quartile, third quartile) of -6.15 (-10.25, -2.23) and -4.15 (-6.9, -2.6), respectively. These changes are counter to the stress-mediated increase in ACTH and cortisol levels expected following an invasive procedure.

Conclusion: Reductions in serum ACTH and cortisol post-BA intervention indicate alterations in the activities of the HPA axis. These hormonal changes can be used as surrogate markers of BA clinical efficacy. This pilot study has potential implications for the treatment of HPA axis dysfunction in pathological states other than MS. Further studies should investigate the long-term endocrine impact of CCSVI treatment.

Cephalic Arch Stenosis: Randomized Controlled Trial of Stenting Versus Angioplasty, an Interim Report


Purpose: To assess the efficacy of drug-eluting stent or stent graft placement after balloon angioplasty compared with balloon angioplasty alone for the treatment of cephalic arch stenosis in patients undergoing percutaneous transluminal angioplasty (PTA) of hemodialysis-access arteriovenous fistula (AVF) or arteriovenous graft (AVG) stenoses. We present the 6-month interim analysis for this ongoing randomized controlled trial.

Materials and Methods: From September 2012 to January 2013, 11 patients (6 males) with cephalic arch stenoses greater than 50% were randomized to balloon angioplasty (PTA group) (n=2); PTA with drug-eluting stent placement (DES group) (n=6); or PTA with stent graft placement (SG group) (n=3). The mean age was 62.94 years (range, 48-81 years). Follow-up angiography was performed at 6 months to assess restenosis rates. Outcome was primary patency rates at 6 months.

Results: Baseline characteristics were similar between groups. Before the 6-month follow-up angiogram, 2 patients in the PTA group, 4 patients in the DES group, and 1 patient in the SG group underwent intervention. A meaningful analysis for restenosis rates could not be performed for a small group of follow-up patients. At 3 months, primary patency rates were 100% in the SG and PTA groups and 67% in the DES group. At 6 months, primary patency rates were 66% in the SG group, 33% in the DES group, and 0% in the PTA group (P=0.328).

Conclusion: Stenting, particularly with graft placement, for cephalic arch stenosis seems to improve primary patency compared with angioplasty alone at 6 months, although this is not statistically significant probably due to small numbers at present. This report serves to highlight our initial experience in this randomized controlled trial.

Complications of Central Venous Access Port Devices: A Pictorial Review

D. C. Feldstein, S. Hanif, C. Coroian, B. Shearer, I. Hersi, E. Matto, B. Blanco, A. Trebelev, W. Fan

Purpose: The purpose of this review is to describe and review various chest port malfunctions seen on conventional angiography with plain film radiograph correlation. Chest port placement in the interventional radiology suite has been shown to have equal or better safety and success rates compared with surgical placement in the operating room. This reflects the major difference in our placement procedure. Surgeons perform venipuncture using anatomical landmarks and do not utilize portable fluoroscopy. In contrast, interventional radiologists utilize sonography to guide internal jugular vein puncture and fluoroscopy to visualize the course and position of catheter deployment. Image guidance nearly eliminates all the risk including pneumothorax, hematoa attributed to arterial puncture, and catheter malposition.

Materials and Methods: A retrospective review was performed of more than 100 chest port evaluations over the last 5 years at Hahnemann University Hospital. Chest ports were referred to the interventional radiology department for evaluation secondary to port malfunction.

Results: We performed a review of more than 10 different cases demonstrating chest port malfunction seen on conventional angiography with chest radiograph correlation. Chest port malfunctions were divided into 2 major categories: device hardware malfunction and improperly placed chest ports. We also included 1 case involving chest port repositioning utilizing a snare approach from the femoral vein.

Conclusion: Proper chest port placement utilizing image guidance is essential to avoid complications and ultimately malfunctions associated with improper port placement.

Digital Subtraction Angiography for Dysfunctional Central Venous Port: Spectrum of Abnormal Findings and Management

R. Nayyar, T. Zaidi, D. Thakur, K. Das, A. Hansra, M. Karmel, K. Kobayashi

Purpose: Central venous ports (CVPs) have been essential for the management of oncologic patients undergoing infusion chemotherapy. Recently interventional radiologists have been playing a key role in the placement and maintenance of CVPs. Digital subtraction angiography (DSA) through the port is a useful tool for the diagnosis of dysfunctional CVPs, and familiarity with various abnormal findings and treatment options for the complications revealed by DSA is of great importance to avoid potentially significant morbidity and mortality. In this exhibit, we will demonstrate a variety of abnormal DSA findings that we experienced at our institution and discuss the treatment options for the complications.

Materials and Methods: We reviewed a total of 190 dysfunctional CVP-related DSA that were performed from January 2010 through September 2013. CVP dysfunction is defined as the inability to aspirate blood and/or freely inject fluid. Complications diagnosed by DSA were categorized as mechanical, venous stenotic/thrombotic, or a combination of the two.

Results: Mechanical complications included intracatheter thrombosis, fibrin sheath formation, catheter tip migration, pinch-off syndrome resulting in extravasation of contrast, catheter fracture with embolization of the fragment within the pulmonary artery, bled port, catheter kinking, and Twiddler’s syndrome. Venous stenotic/thrombotic complications included superior vena cava (SVC) narrowing/thrombosis and internal jugular/subclavian/brachiocephalic vein narrowing/thrombosis in conjunction with catheter retraction, kinking, or SVC narrowing. Endovascular treatments were offered for catheter tip migration, catheter fragment embolization, and fibrin sheath formation, and these treatments were mostly successful.

Conclusion: DSA is a useful tool in the diagnosis of dysfunctional CVPs. Interventional radiologists need to be familiar with various CVP-related complications that can be diagnosed by DSA and their management, including endovascular interventions.
**Endovascular Treatment of Right Atrial Thrombus with Embedding Pulmonary Embolism**

T. Krater, O. Qaqi, M. Marouki, F. Hanna Al-Kass, M. Elder

**Purpose:** We report a potentially lifesaving procedure in patients with high risk of massive pulmonary embolus due to large right atrial thrombus. Our patient was a 44-year-old African American female with a history of metastatic primary carcinoma metastasis stage IIIIB. The patient successfully underwent total abdominal hysterectomy, bilateral salpingo-oophorectomy, partial bowel resection and anastomosis, cholecystectomy, and appendectomy, including left external iliac-to-femoral bypass following iatrogenic injury. A computed tomography (CT) scan of the thorax/abdomen for abdominal abscess was performed, which incidentally discovered thrombus within the superior vena cava and right atrium measuring 3.7 cm in length, 1.8 cm in width, and 2.0 cm in anteroposterior (AP) dimension; as well as thrombus within one of the right lower lobe pulmonary branches, the left common femoral vein, and the superficial femoral vein. The thrombus in the right atrium was mobile and had thromboembolized causing pulmonary embolism (PE). The large right atrial mass was at risk of further thromboembolism causing massive PE.

**Materials and Methods:** Cardiac catheterization was performed with dual access via the right femoral and left internal jugular veins. In addition, transesophageal echocardiography (TEE)-guided imaging was performed. Angiographic images revealed a large right atrial mass extending into the superior vena cava. TEE confirmed the angiographic findings. AngioVac Cannula and Circuit (Angio-Dynamics, Latham, NY) was placed through the femoral vein into the right atrium with multiple runs of thrombectomy. The thrombus was reperfused through the AngioVac and filtered.

**Results:** The use of AngioVac Cannula and Circuit successfully captured a thrombus measuring 3.7 cm length, 1.8 cm in width, and 2.0 cm in AP dimension per CT scan. Postthrombectomy angiographic findings revealed resolution of the mass. TEE confirmed that the thrombus was successfully extracted. The AngioVac filter revealed capture of the thrombus. The filtered specimen was sent to the pathology department, which confirmed that the specimen constituted a thrombus.

**Conclusion:** Right atrial thrombectomy utilizing a vacuum suction device has been successful in 3 previous instances. The use of AngioVac for right atrial thrombectomy should be considered for successful prevention of massive PE due to a large right atrial thrombus.

**Inadvertent Great Vessel Arterial Catheterization During Ultrasound-Guided Central Venous Access: A Potentially Fatal Event**

L. Pilhail, P. Zimmerman, A. d’Audiffret

**Purpose:** To review the incidence, efficacy of treatment, and outcome of inadvertent subclavian or carotid artery catheterization (with arterial catheter placement) during central venous access procedures that required open vascular and/or endovascular repair.

**Materials and Methods:** Five-year retrospective review of all central venous access procedures performed at a teaching hospital.

**Results:** From 2005-2010, a total of 10,731 central venous access procedures were performed. There were 132 (1%) pneumothoraces and/or hemopneumothoraces related to line placement. In 8 patients, there was inadvertent/unrecognized subclavian or carotid artery catheterization (7 subclavian/1 carotid) requiring open and/or endovascular repair. All 8 procedures were done under ultrasound guidance by either anesthesia or critical care physicians attempting jugular line placement in the operating room (OR) or intensive care unit (ICU). Eighty-eight percent (7/8) were successfully repaired. Five vessels (71%) were repaired using endovascular methods, and 2 vessels (29%) were repaired using open surgery. The remaining injured vessel did not require repair due to successful treatment of hemothorax with a chest tube resulting in hemostasis at the site of vessel injury. However, 38% (3/8) of the patients still subsequently died, including the patient whose vessel did not require repair; the other 2 deaths occurred in the patients who had undergone open repair of artery injury (1 subclavian/1 carotid). All deaths were related to the initial injury.

**Conclusion:** Though rare, inadvertent arterial catheterization during central line placement appears to have high morbidity and mortality rates, proving to be a fatal event in 38% of the patients in this study. Endovascular repair of these injuries appears to have a better outcome than open surgical repair. Although ultrasound guidance is the preferred method of jugular venous imaging during central vein catheterization, in this review it did not prevent inadvertent arterial catheterization and may indeed have imparted a false sense of security.

**Primary Angioplasty for Stenotic Iliac Veins Secondary to May-Thurner Syndrome May Be Effective**

T. Lo, K. Farsad, J. Kaufman

**Purpose:** May-Thurner syndrome is a rare clinical entity involving compression of the left common iliac vein by the right common iliac artery and lumbar vertebral body. Standard endovascular treatment involves angioplasty followed by stent placement. We wished to present a case of angioplasty alone in treating venous outflow obstruction, as well as review the literature.

**Materials and Methods:** This is a retrospective case report of a 43-year-old woman with chronic left pelvic deep venous thrombosis initially diagnosed during pregnancy and treated initially with enoxaparin. Since delivery, the patient had symptoms of venous claudication and edema. The patient then underwent venography and was treated with angioplasty to 14 mm.

**Results:** Initial technical success was achieved. At the 3-month follow-up, although the patient’s symptoms had improved, as her activity levels increased, she began noticing symptoms consistent with short-distance venous claudication. She had repeat venography and angioplasty, again to 14 mm. Postangioplasty venography demonstrated a widely patent iliac venous system with brisk central flow and no filling of collaterals. Because of the normal appearance of the iliac venous system after angioplasty, the decision was made not to stent. The patient’s symptoms were markedly improved at her 2-week follow-up.

**Conclusion:** Angioplasty alone for stenotic iliac vein secondary to May-Thurner syndrome may be effective.

**Retrograde Jugular Vein Access From the Inside Out: A Safer New Paradigm for Obtaining First-Attempt Central Venous Access**

L. Pilhail

**Purpose:** Despite increasing use of real-time B-mode ultrasound guidance during outside-in internal jugular vein cannulation, serious and sometimes fatal complications continue to occur, particularly in high-risk patients (eg, patients with morbid obesity, multiple previous central venous [CV] access procedures, CV occlusion, coagulopathy; ventilated critically ill patients; etc). Complication rates are higher when less-experienced practitioners perform the procedure and when more than 2 access attempts are required. Indeed, for the more than 5 million CV access procedures performed annually in the U.S., an overall cumulative 4% rate of serious complications (pneumothorax, arterial laceration, stroke, etc) has been reported. We have developed a new retrograde inside-out method of CV access (SAFE CVAD) that allows for safer, fluoroscopically controlled, precise first-attempt jugular or subclavian vein access.

**Materials and Methods:** The sheep model was chosen to validate this new access device design because of its similarity to human central and surface venous anatomy. The SAFE CVAD is a 100-cm long over-the-wire 7F catheter with a deflectable tip through which a fine puncture wire is deployed from the inside of the vessel to the skin surface at the desired exit site. Initially, percutaneous femoral venous access is obtained. Through the sheath, a 1 wire is passed under fluoroscopy to the superior vena cava (SVC) and an angled catheter is used to guide the wire into the desired central vein. The catheter is replaced with the SAFE CVAD device, which is passed into the vein under fluoroscopy. The tip of the device is deflected under fluoroscopy and brought into contact with the anterior vein surface. The puncture wire is then deployed and recovered at the skin surface. A microintroducer is then used to exchange the puncture wire for a standard wire followed by CV catheter placement in the usual fashion.

**Results:** The SAFE CVAD device has been successfully tested in sheep for both jugular and subclavian vein access from the inside out. Advancement of the device to the desired exit was achieved in 6 of 6 insertions, with the puncture wire exiting the skin sufficiently to permit CV access in all advancements. Position of the puncture wire and rotation of the device tip to target the intended exit site was clear under imaging as there was one-to-one torque control from handle to tip. In addition, successful multiple CV exit punctures from a single femoral venous entry was possible. Bleeding at the entry and exit sites was minimal and managed with compression.

**Conclusion:** The SAFE CVAD device inside-out vascular access device allows for safer central venous access on the first attempt, thereby avoiding the serious complications that may result from repetitive outside-in access attempts, particularly in high-risk patients. In addition, use of the SAFE CVAD device by trainees and less-experienced practitioners may reduce CV access complications encountered during the learning curve, especially when compared with using the landmark technique or ultrasound guidance.

**Extracranial Access of the Cavernous Sinus in the Treatment of Carotid Cavernous Fistulas**

C. M. Granville, J. Salsamendi, K. Pereira, G. Narayanan, A. Aziz-Sultan

**Purpose:** Direct cavernous carotid fistulas (CCFs) originate from the intracavernous portion of the internal carotid artery (ICA) and are typically treated by intraarterial embolization techniques. However, indirect CCFs that originate from small dural carotid branches can be multifocal and may involve the ICA and/or external carotid
Materials and Methods: We present our experience with 5 patients who underwent treatment of a CCA via alternative venous access techniques as detailed below.

Results: Patient #1: The CS was accessed via the facial vein at the inferior aspect of the maxilla. Although cannulation was successful, steep distal superior orbital venous angulation led to termination of the procedure. Patient #2: The CS was accessed via the anterior jugular, which in this patient gave rise to the facial vein. Patient #3: The CS was accessed via supraorbital vein cutdown. Patient #4: The CS was accessed via transcutaneous cannulation of the supraorbital vein. Patient #5: The CS was accessed via direct fluoroscopy-guided cannulation via the inferior orbital fissure.

Conclusion: Percutaneous cannulation techniques to access the CS can offer a minimally invasive alternative to the treatment of CCFs. Close consideration of the anatomic variants and adjacent nerve anatomy and the incorporation of various advanced venous access techniques may offer a minimally invasive treatment option for complex CCFs.

Comparison of Bare-Metal Versus Covered Stents for the Treatment of Carotid Artery Pseudoaneurysms: A Review


Purpose: Extracranial carotid artery pseudoaneurysm (CA-PSA) is an entity seen after trauma and surgical procedures. Traditionally, these injuries are treated surgically, but open surgical repairs are associated with a high rate of complications. An endovascular approach to these lesions has been advocated to reduce the complication rates. The use of covered stents (CS) versus bare-metal stents (BMS) remains controversial. We review the current literature concerning the use of carotid artery stents to manage CA-PSA following surgery or for trauma.

Materials and Methods: An extensive review of the literature using Ovid, PubMed, and Google Scholar was performed. All published cases in the English language since 1997 were identified using the following keywords: “pseudoaneurysm,” “carotid,” “endovascular repair,” “covered stent,” and “stent.” Studies that used a hybrid procedure involving a combination of open and endovascular approaches were excluded.

Results: We identified 174 cases of carotid stents used to treat CA-PSA; of these, 123 were secondary to trauma and 51 were postoperative. Ninety-three patients were treated with BMS, and 81 were treated with CS. Covered stents were used more frequently in older patients (CS 51.8±5.9 years vs BMS 30.7±6.6 years; P<0.01). Stroke and myocardial infarction rates were not significantly different (CS 8.6% vs BMS 5.4%; P=0.58). Patency rates were similar for both groups (CS 93.8% vs BMS 91.4%; P=0.75). Mortality rates were comparable (CS 4.9% vs BMS 4.3%; P=0.56).

Conclusion: Placement of an endovascular stent for the treatment of CA-PSA has been shown to be effective. Our review shows that CS and BMS have similar complication rates and outcomes.

External Carotid Artery Stenting in a Symptomatic Patient With Ipsilateral Internal Carotid Artery Occlusion

B. M. Shearer, C. Corolian, J. White, D. Feldstein, S. Hanif, R. Koenigsberg

Purpose: The goal is to present a case report and literature review on the rare utilization of an external carotid artery stent in a symptomatic patient with ipsilateral internal carotid artery occlusion.

Materials and Methods: A 36-year-old female with a medical history of hypertension, hyperlipidemia, diabetes mellitus, and hypothyroidism presented to our clinic with complaints of a 6-month history of weakness, fatigue, neck pain, intermittent right-sided headaches, and right-sided amaurosis fugax. She was followed from May 27, 2011, until her most recent visit on May 22, 2013.

Results: Over the course of 2 years, our patient’s comorbidities were treated with conservative medical management. On September 16, 2011, an angigram showed occlusion of the right internal carotid artery (ICA) at the cervical bifurcation, high-grade stenosis of the terminus of the right common carotid artery, stenosis of the right external carotid artery (ECA) with delayed poor reconstitution to the ophthalmic artery via the internal maxillary artery, and 80% stenosis of the right vertebral ostium. Due to worsening symptoms, successful balloon angioplasty with stent deployment across the right high-grade ECA stenosis was performed on May 7, 2013, without complications. During her follow-up evaluation on May 22, 2013, resolution of her amaurosis fugax and reduction of her headache symptomatology was achieved.

Conclusion: ECA angioplasty and stenting in the setting of ipsilateral ICA occlusion proved to be an effective strategy to resolve our patient’s amaurosis fugax and ameliorate her headaches.
Femoral Artery Pseudoaneurysms and Orthopedic Stabilizer

R. Marcello, G. Marcello

Purpose: To evaluate the effectiveness and safety of endovascular treatment of femoral artery pseudoaneurysms due to an orthopedic stabilizer applied for a femur fracture.

Materials and Methods: From January 2012 to January 2013, 5 patients with a lower limb trauma were treated in the orthopedic operating room (OR) with positioning of an external stabilizer. After the orthopedic treatment was carried out, all patients experienced the onset of lower limb pain and swelling. Color Doppler examination and contrast-enhanced multidetector computed tomography (ce-MDCT) scanning revealed a pseudoaneurysm of a branch of the deep femoral artery together with a large hematoma of the soft tissues. Contralateral common femoral artery access was obtained, and endovascular repair of ruptured arteries was carried out with stent-graft deployment of different sizes and lengths (WL Gore, Flagstaff, AZ). One patient experienced a large necrosis of the fascia and received surgery in a rescue attempt of limb salvage.

Results: All procedures were successful, and the exclusion of femoral artery pseudoaneurysms occurred in all patients. No major or minor complications related to the procedure were observed.

Conclusion: The endovascular treatment of pseudoaneurysms due to an orthopedic stabilizer is an effective and safe procedure.

Natural History of a Cutaneous Complication After Transarterial Chemoembolization (TACE) of the Liver: A Pictorial Review

S. Iqbal, D. Hechavarria, C. Molgaard, H. Ahari, B. Davison, K. Stuart, S. Flacke

Purpose: To describe and illustrate the risk factors of cutaneous complications of transarterial chemoembolization (TACE) using computed tomography (CT), magnetic resonance imaging (MRI), and angiography, to richly illustrate the natural history of cutaneous complications of TACE using clinical images, and to describe plans to avoid or minimize the risk of cutaneous complications of TACE.

Materials and Methods: TACE procedures have become a common modality for treatment of intermediate-stage hepatocellular carcinoma (HCC) due to their favorable outcome, mild side effect profile, and avoidance of systemic chemotherapy. Multiple chemoembolic procedures are often required to successfully treat HCC, and collateral blood supply from extrahepatic vessels can develop as time elapses between procedures and blood flow from the hepatic artery diminishes. This risk is increased with specific tumor profiles. Exophytic lesions, subcapsular lesions, and lesions in the bare area of the liver have a propensity for parasitizing collateral flow from neighboring vasculature. As these collateral vascular supplies develop, often from tributaries of the phrenic or intercostal arteries, the need for their selective embolization rises. Our patient had a diagnosis of HCC. He underwent TACE a total of 8 times. At the eighth treatment, the lesion was exophytic and had collateral supply from the right intercostal artery. To achieve good outcome, a decision was made to embolize it. However, right after the procedure, the patient complained of pain in the area supplied by the intercostal artery. This was managed by observation, symptomatic treatment, and a Dermatology consult. The patient was closely observed over time for further changes of skin, and clinical pictures were taken at every visit. The skin lesion eventually healed.

Conclusion: After reviewing this exhibit, the reviewer would be able to identify the imaging findings that may lead to cutaneous manifestation of chemoembolization, identify the cutaneous changes immediately after the procedure and its course over time, and identify the risk factors, which may lead to such a complication and prepare to avoid it.

Splenic Preservation Following Proximal Splenic Artery Embolization: A Single-Center Experience

J. Woodhouse, S. Dhaliwah, G. Annamalai, E. David, C. Dey, R. Pugash

Purpose: Splenic injury is a common sequela of blunt trauma and can be managed nonoperatively with splenic arterial embolization with high success rates. Splenic embolization can cause infarction of the residual viable splenic tissue causing excess morbidity (through pain and abscess formation) and resultant lifelong implications for the patient’s immune function. At our institution, proximal splenic embolization is attempted. We review the success of the strategy to preserve distal splenic perfusion via preservation of splenic perfusion via collateral vascular channels.

Materials and Methods: Institutional review board approval was obtained for retrospective analysis of the charts of patients who had splenic embolization following blunt trauma. For high-grade splenic injuries, it is standard practice at our institution, as an adjunct to attempted nonsurgical management, to attempt proximal splenic artery embolization with the use of an Amplatzer 4 vascular plug (St Jude Medical, St Paul, MN). We reviewed the technical issues that occurred during the procedure, the clinical follow-up data to appraise the short-term efficacy (including time to vascular occlusion, endovascular reintervention rates, and progression to surgical management), and the longer-term clinical and imaging outcomes of this technique.

Results: Through interrogation of the hospital radiology information system (RIS) system, 44 patients were identified as having had proximal splenic embolization since January 2009 at our institution. Of these, proximal embolization with an Amplatzer 4 vascular plug had been attempted in 29 patients, and in 27 of these patients, this device was successfully delivered. Patients monitored clinically after their treatment had low reintervention and progression to surgery (for treatment of the splenic trauma) rates.

Conclusion: Proximal splenic artery embolization is a highly effective strategy for the preservation of splenic perfusion following high-grade splenic arterial injury and can be achieved with good success rates using an Amplatzer 4 vascular plug. When used as an adjunct to attempted nonsurgical management, it was highly successful clinically.

Uterine Artery Embolization: Technical and Clinical Aspects

R. Marcello, G. Marcello

Purpose: To describe common pelvic anatomy and its vascular variants, to review the key points and technical aspects of this endovascular procedure, and to discuss the impact of different imaging modalities in the effectiveness and safety of such a treatment.

Materials and Methods: A retrospective review of clinical and imaging findings of patients who received uterine fibroid embolization (UFE) from 2003 to 2011 was carried out. Uterine artery embolization was performed under local anesthesia with single femoral artery access and selective angiography of both uterine arteries with 4F Cobra and Simmons hydrophilic catheter (Glidecath, Terumo, Tokyo, Japan) and hydrophilic 0.035 angled-type guide wire (Terumo, Tokyo, Japan). Embosphere Microspheres 500-900 microns (Merit Medical, South Jordan, UT) were used as embolization particles in all patients. Magnetic resonance imaging was performed for pre-embolization work-up and at 3, 6, and 12 months following the procedure. Pain control was obtained with a combination of drugs given by elastomer pump device.

Results: Uterine fibroid embolization is a highly successful, cost-effective, and uterine-sparing interventional procedure. Hospital stay is quite short, and the complication rate is low. In most patients, long-term control of fibroid-related symptoms is achieved after UFE.

Conclusion: With clear uterine artery anatomy and possible variants, suitable mediation, and appropriate endovascular procedure, UFE is a safe and effective treatment for long-term control of fibroids.

Hypertension Before and After Renal Denervation: Reviewing the Management Options

D. Goldin, S. Berry, B. Mansoor, S. Vartanian

Purpose: To provide a pertinent literature review of the management options for the treatment of resistant hypertension (rHTN) after renal artery denervation (RDN) with respect to various patient factors and comorbidities.
Materials and Methods: Background is provided regarding the emerging results of the effectiveness and outcomes of RDN. A literature review will summarize the essential ingredients in managing rHTN. Since comorbidities are often found in RDN patient candidates, the differing management needs of these patients will be reviewed. The potential for other percutaneous options will also be discussed.

Results: Significant reduction in blood pressure (BP) after renal denervation is reported compared with antihypertensive drugs at 6-month follow-up.1 Higher baseline BP, left ventricular hypertrophy (LVH), older age, obesity, African American race, chronic kidney disease (CKD), and diabetes mellitus are all strong predictors for rHTN and may direct medical management.2 Additionally, the threshold for rHTN is reduced in diabetics and those with CKD.2,3 Findings in rHTN include obstructive sleep apnea in 71%-85% of patients, as well as obesity in 40%.1,3 Beta-blockers may cause exercise intolerance and should thus be avoided in patients undergoing diet and lifestyle modification for lowering BP.4 Patients undergoing RDN are also often taking other medications, such as non-steroidal anti-inflammatory and oral contraceptive drugs, which can elevate blood pressure.2 Diabetics undergoing RDN would benefit from adjuvant angiotensin-converting enzyme (ACE)-inhibitor therapy given the additional benefit of delaying progressive nephropathy.3 However, beta-blockers and diuretics should be used with caution. Patients undergoing RDN may also have or develop significant renal artery stenosis requiring adjuvant therapies or different initial management.7 These and other case scenarios are presented. Currently, there is no surgical option for rHTN after failed RDN, further supporting the need for tight control of medical therapies.

Conclusion: Renal artery denervation is an excellent emerging option for patients with rHTN. To comfortably manage these patients, it is important to understand the clinical and medical treatment options to follow.

References:

Utility of Novel Noncontrast Magnetic Resonance Angiography in Renovascular Mapping for Renal Sympathetic Denervation

K. Chew, U. Pua

Purpose: Respiratory and electrocardiogram (ECG)-gated noncontrast magnetic resonance angiography (NC-MRA) utilizing fast steady-state gradient echo is a novel magnetic resonance technique in vascular imaging. We hereby describe our initial experience integrating NC-MRA as a preprocedural assessment tool in patients referred for renal sympathetic denervation (RDN).

Materials and Methods: All patients in our institution referred for RDN for the treatment of resistant hypertension were prospectively enrolled. NC-MRA was used as the primary renovascular imaging modality for assessment of anatomical suitability. Inclusion criteria for RDN included: 1) significant renal artery stenosis (RAS) (>60% in diameter), 2) atrophied or solitary kidney, 3) renal artery length ≤20 mm, and 4) renal artery diameter ≤5 mm. Other relevant parameters that aid RDN planning, such as 1) early branching patterns, 2) presence of accessory renal arteries (diameter and numbers), and 3) plaque location and size, were also analyzed. NC-MRA findings were correlated with catheter angiography where available.

Results: From November 2011 to January 2013, a total of 14 patients were referred for RDN. NC-MRA was successfully performed in all 14 patients. Four patients were deemed unsuitable for RDN due to significant renal artery stenosis (n=3) and inadequate renal artery diameter (n=2). Catheter angiographic correlations were available in 7 patients (6 RDN only, 1 RND with renal artery stenting) at time of writing and showed good correlation for the recorded parameters (Table). Relevant information such as plaque location (n=4), early branching pattern (n=0), and accessory renal arteries (n=2) allowed for preprocedural planning. RDN was successfully performed in all patients deemed suitable on NC-MRA with no complications.

Table. Image quality of renal arteries with both NC-MRA and DSA

<table>
<thead>
<tr>
<th>Radial Findings of RA (n=17)</th>
<th>NC-MRA</th>
<th>DSA</th>
<th>Concomitant rate (%) of radiological finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA length (&gt;20mm)</td>
<td>17</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>RA diameter (&gt;4mm)</td>
<td>17</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>Plaque location</td>
<td>8</td>
<td>8</td>
<td>100</td>
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<tr>
<td>Vascular alterations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessory arteries</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>Double arteries</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Early branching patterns</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Conclusion: Our early experience supports NC-MRA as a valuable and promising assessment tool for anatomical suitability in RDN. Additionally, NC-MRA provides accurate anatomical information that aids pre-procedural planning. Larger scale studies are warranted to fully elucidate its potential as the main renovascular imaging modality in catheter-based RDN.

Angioembozilation Versus Operative Ligation of Intercostal Artery Injuries for Hemorrhage Control in Trauma Patients

K. H. Nagaratheth, J. DuBose, T. Scalea

Purpose: Intercostal artery injuries (IAI) are infrequent but can be problematic. Approaches include operative ligation (OL) and angioembolization (AE). We believe...
AE can be used effectively in hemorrhage control in the trauma patient with multiple injuries.

Materials and Methods: We reviewed the trauma registry at a level I trauma center between January 2002 and May 2012 for IAI. Individual chart review was done to identify management, specifically the use of AE. Multivariate analysis was performed on patient demographics, trauma scores, length of mechanical ventilation (MV), intensive care unit (ICU) length of stay (LOS), hospital LOS, blood products transfused, and mortality. Multivariate linear regression was also performed using SPSS 20 (IBM Corporation, Armonk, NY).

Results: Eighty-eight patients with IAI were identified. There were 23 in the AE group and 65 in the OL group. Patients with AE were older (39.7±8.0 years vs 32.2±3.9 years; P=0.01) and had a higher injury severity score (ISS) (28.9 vs 20.7; P=0.01). The AE group sustained IAI from blunt trauma more frequently than the OL group (57.9% vs 14.9%; P=0.01) and had a higher injury severity score (ISS) (28.9 vs 20.7; P=0.01). The AE group received more units of fresh frozen plasma (FFP) (16.3 units vs 9.3 units; P=0.02) and spent more time on mechanical ventilation (MV) (15.5 days; P=0.03). Angioembolization was utilized as damage control in 14% of patients who had OL. These were patients who had surgically inaccessible injuries. AE was successful in controlling hemorrhage in 80% of patients with IAI. The overall mortality was higher in the AE group (34.8% vs 14.1%; P=0.03).

Conclusion: Hemorrhage control can be successfully obtained in patients arriving with IAI after blunt trauma. Despite this, these patients often have a higher mortality rate because of their other, concurrent injuries.

Evaluation and Initial Experience of a Novel Balloon Catheter With an Injection Valve

B. H. Lin, R. Chen, S. Liu

Purpose: To evaluate the safety, efficacy, practicality, and value of a novel balloon catheter with an incorporated injection valve for endovascular interventions, with initial experience focused in the dialysis access population.

Materials and Methods: We performed prospective clinical evaluation and data collection from 100 procedures using the GPS balloon catheter (Hotspur Technologies, Mountain View, CA) in both hospital and outpatient center settings. These procedures were performed during the initial market release of the first-generation balloon. The semicompliant balloons were used for treatment of stenoses in arteriovenous fistulas/grafts. The built-in valve allowed for intravascular delivery of pharmacutic agents such as heparin, tissue plasminogen activator, and contrast media without removing the wire from the balloon catheter. All procedures were performed on dialysis patients with arteriovenous fistulas or grafts who presented with occluded or malfunctioning access.

Results: The balloon component proved to be similarly effective as or better than the comparable semicompliant balloons from other manufacturers for angioplasty. Eighty percent of the lesions treated were resolved or significantly improved hemodynamically. The remaining lesions required additional intervention. The rupture rate was 0% at the rated burst pressures. One balloon rupture was encountered at 29 atm. No device fracture/shearing was encountered. The injection valve component was used in each procedure while maintaining wire access in the vessel or across the lesion during delivery. Valve failure was noted in 3% of the cases. The valve technology allowed for fewer lesion crossings and more targeted angiographic evaluation before and after angioplasty, particularly in sheathless settings and occlusions. Subjectively, operators noted decreased fluoroscopy time and procedure time due to fewer lesion crossings and catheter/wire exchanges, particularly in occlusions and anatomicall difficult lesions. The operators also noted that proximity contrast injection showed improved lesion characterization and treatment. The objective and subjective disadvantages documented by various operators included valve backbleeding when switching between modes, handle ergonomics, balloon rewarp, and increased sheath profile requirements.

Conclusion: In this first evaluation study of the GPS balloon catheter in the U.S., the device proved to be safe and effective as a workhorse balloon in endovascular interventions, specifically in the dialysis access setting, for all lesion types, and the balloon function was comparable to that of other balloon devices. Its valve feature provided some advantages in these interventions, particularly for targeted drug/contrast delivery without loss of wire access and has significant potential for other endovascular applications with this platform.

Evaluation of Patient Use of Online Resources for Interventional Radiology Procedures

V. Ramral, S. Athreya

Purpose: To assess patients’ knowledge and use of online resources for patients regarding interventional radiology procedures.

Materials and Methods: From March 1 to April 30, 2013, any adult outpatients who had a procedure performed by an interventional radiologist in a teaching hospital was asked to complete a voluntary questionnaire. Patients evaluated on a 5-point Likert scale their knowledge and use of online resources regarding their procedure.

Results: Throughout the study, 59 patients (age range, 27–93 years; mean age, 60.4 years) completed the study questionnaire. Fifty-two of 59 patients (88.1%) did not access any Internet resources regarding their procedure. The most common cited reason by 19.2% (10 of 52) of patients was that their physician provided an adequate explanation of the procedure. Thirty-eight of 52 patients (73.1%) indicated they would use Internet resources if suggested by their physician. Seven of 59 patients (11.9%) accessed Internet resources to learn more about their procedure. All 7 patients agreed that the Internet resources were beneficial to them prior to their procedure, and all 7 agreed or strongly agreed that they would like more Internet resources to be provided to them by their physician.

Conclusion: There is a lack of use of Internet resources by patients regarding interventional radiology procedures. However, there is a clear demand by patients for more Internet resources to be made available to them by their physicians. Internet resources about interventional radiology procedures should be provided to patients to improve quality of care by better educating them and ensuring the use of accurate sources.

New Hybrid Carotid Stent to Prevent Periprocedural Neurologic Events: First-in-Man Report

T. MacFall, T. Edelstein, T. Brothers, W. Montgomery, M. Guimaraes, C. Schonholz

Purpose: To report the first-in-man implantation of a new hybrid stent to prevent neurologic events during carotid artery stenting (CAS). This hybrid stent is being evaluated in the SCAFFOLD clinical study, which is a multicenter, single-arm, prospective study comparing the GORE Carotid Stent (WL Gore, Flagstaff, AZ) to a performance goal developed from carotid endarterectomy outcomes.

Materials and Methods: The new nitinol stent frame is of an open-cell design to allow for a high degree of flexibility and conformability to the native anatomy. Behind the stent, a lattice material is composed of a high-strength expanded polytetrafluoroethylene (ePTFE) material with a series of 500 micron pores minimizing plaque protrusion through the stent struts. Additionally, the device is coated with a bioactive surface hiraparin to create an antithrombogenic surface. This first procedure was done in a 77-year-old asymptomatic male with a de novo high-grade stenosis and contralateral internal carotid artery total occlusion. Local anesthesia and full anticoagulation with activated clotting time (ACT) >250 seconds was used during the procedure. CAS was done under cerebral protection using the GORE Carotid Filter (WL Gore, Flagstaff, AZ). A 6/8 by 40-mm GORE Carotid Filter was deployed from the right internal carotid artery (RICA) to the right common carotid artery (RCCA). Postdilation was done with a 5-mm balloon. The common femoral artery was closed with a sutured mediated closure device.

Results: The result was satisfactory without residual stenosis. The stent delivery system tracked very well over the filter wire, and deployment was very precise. The patient had bradycardia during postdilation and remained hypotensive during the first 2 hours after the procedure. The patient returned to preprocedural blood pressure and heart rate and was discharged home the next day without neurologic deficit.

Conclusion: The first clinical experience with this new carotid stent showed satisfactory results, including ease of use, precise deployment, conformability to the wall, and protection against embolization.

Percutaneous Cryoablation Versus Partial Nephrectomy (Open and Robot Assisted): Single-Center Cost Analysis

M. Chehab, A. Vartanian, J. Ciacci, A. Krishnan, H. Korman

Purpose: The aim of this study was to compare real-world costs of percutaneous cryoablation (PC), open partial nephrectomy (OPN), and robot-assisted partial nephrectomy (RPN), treatment options demonstrating nearly comparable efficacy in the management of small renal masses.

Materials and Methods: We retrospectively evaluated financial and clinical data for adult PC, OPN, and RPN procedures performed for small renal masses (<4 cm) at our institution from January 2011 to March 2013. Revenue code–based financial data for each encounter included costs and charges reported in real-world values. Total cost was calculated as the sum of direct and indirect dollars itemized into procedural and perioperative hospital elements including operating room, operator fees, surgical supplies, anesthesia, postanesthesia care unit (PACU), room and board, intensive care unit (ICU), lab, pharmacy, dialysis, and other. Charge refers to the amounts billed...
to third-party payers based on these costs. Clinical data regarding age, gender, body mass index (BMI), date of hospital/ICU admission/discharge, blood loss, and dialysis requirements were obtained from medical records. All formal tests compared PC with OPN and then PC with RPN. Categorical variables were analyzed using Pearson or Fisher exact tests, while continuous variables utilized t tests or Wilcoxon 2-sample tests.

Results: One hundred ninety-five cases including 37 PC, 39 OPN, and 119 RPN were compared. PC had significantly lower (P<0.0001) direct, indirect, and total median costs ($21,64, $1536, and $3736) compared with OPN ($5813, $4470, and $10228) and RPN ($6690, $3744, and $10367), respectively. Median charges for PC ($21,486) were also significantly lower than those for OPN ($26,182; P=0.0109) and RPN ($24,468; P=0.0232). These results were predominantly the result of lower surgical supply and hospitalization costs associated with the minimally invasive, outpatient nature of PC. PC demonstrated significantly lower (P<0.05) hospitalization time, blood loss volume, and ICU admission compared with OPN and RPN. No other cost or clinical data elements demonstrated significant differences.

Conclusion: Percutaneous cryoablation can be performed at significantly lower costs and charges compared with open and robot-assisted partial nephrectomy in the treatment of small renal masses.

Preoperative Image-Guided Needle Localization for Musculoskeletal Lesions

M. O. Akinyemi, A. Shah

Purpose: To review clinical indications for computed tomography (CT)–guided hookwire localization for musculoskeletal lesions and to present a pictorial step-by-step approach to performing this procedure.

Materials and Methods: We will present a pictorial step-by-step approach to performing CT-guided hookwire localization for musculoskeletal lesions and will discuss a specific case involving CT-guided needle localization.

Results: Many musculoskeletal lesions can be easily localized with a hookwire needle. This procedure decreases patient morbidity and can potentially decrease hospital length of stay and overall hospital cost.

Conclusion: CT-guided needle localization is a relatively easy procedure to perform. Interventional radiologists should be aware that they may be asked to perform this procedure, especially in smaller community hospitals with no interventional musculoskeletal radiologist.

Radiation Safety in Interventional Radiology for Providers and Patients: Current Strategies and Concepts

C. J. Moran

Purpose: To provide an overview of the basic concepts in fluoroscopy that affect radiation dose, of strategies for dose reduction, and of radiation exposure risks.

Materials and Methods: The basics of fluoroscopy systems with emphasis on parameters that affect radiation dose, both to the patient and the provider, will be presented with supporting diagrams. Examples of strategies to reduce radiation exposure will be provided, with examples tailored to different procedures and patient types. Pitfalls, including those related to technique and patient positioning, will be shown. Operator shielding methods will be presented, with a general overview of the component materials, of the efficacy, and of the recommendations for proper use. National guideline initiatives such as “Step Lightly” will be described.

Results: Concepts in radiation safety continue to evolve. Our understanding of both the stochastic and deterministic effects of ionizing radiation has undergone many changes in recent years. There are several strategies to reduce radiation dose grounded in the basic concepts of fluoroscopy and radiation safety. Several national guideline initiatives have been developed to educate providers and patients.

Conclusion: An understanding of radiation safety and of strategies for dose reduction is an essential component of the modern practice of interventional radiology.

Recanalization of Symptomatic Spleno-Mesenteric-Portal Venous Occlusion


Purpose: The purpose of this study is to evaluate the technical success, safety, and efficacy of spleno-portal vein recanalization using transjugular, transhepatic, and transspenic approaches in patients with symptomatic spleno-mesenteric-portal venous occlusion.

Materials and Methods: Our retrospective study includes 6 patients (all men; mean age, 56.33 ± 5.61 years) with symptomatic spleno-mesenteric-portal venous occlusion who underwent spleno-portal vein recanalization. Data from patient charts and a picture archiving and communication system were integrated into an Excel database and evaluated. The follow-up period was 12 months. Four patients had occlusion of the portal vein alone, 1 had occlusion of the splenic vein alone, and 1 had occlusion of the portal and mesenteric veins. None of the patients had a history of liver transplantation. Indications for the procedure were bleeding varices (n=5) and ascites (n=1) in patients in whom medical and endoscopic management had failed. One procedure used a transhepatic approach to the portal vein, 1 used a transsplenic approach, and 4 used a transjugular approach. Three of the transjugular procedures also involved implanting a transjugular intraportal portosystemic shunt (TIPS) after successful recanalization of the thrombosed vein. Expanded polytetrafluoroethylene-covered stents dilated to 8 mm–12 mm were used in 5 patients for reconstruction of the occluded vein. Balloon dilation of the portal vein was performed in 1 patient, and embolization of esophageal varices was performed in 2 patients. The long-term patency of recanalized veins was assessed by Doppler ultrasonography.

Results: The technical success rate of portal and splenic recanalization was 100%. TIPS was successfully implanted in 3 patients. One patient presented with episodes of encephalopathy and was subjected to TIPS reduction. No major hemorrhagic event was observed in patients who underwent the transhepatic or transsplenic approach. One patient died of severe procedure-related complications (16.67%), probably associated with the extension of occlusion within the main portal vein and the portal vein branches. Two patients died during the follow-up of causes not related to the portal vein occlusion (hemorrhagic stroke and hepatocellular carcinoma progression). There were no cases of variceal rebleeding or untreatable ascites during the follow-up. Spleno-portal patency was observed in 3 patients by the end of the follow-up period.

Conclusion: Spleno-portal vein recanalization is a feasible, safe, and effective treatment for patients with symptomatic spleno-mesenteric-portal venous occlusion in whom medical and endoscopic management has failed. The higher extension of occlusion within the main portal vein and the portal vein branches can predispose to a higher mortality.

The Importance of Embolic Material and Artery Selection During Transarterial Chemoembolization of Hepatocellular Carcinoma

J. White, B. Blanco, B. Shearer

Purpose: To illustrate the importance of proper selection of embolic material and size of embolic particles and to illustrate the importance of superselectivity in transarterial embolization of hepatocellular carcinoma (HCC).

Materials and Methods: A 57-year-old male with newly diagnosed HCC was identified. This case report examines the diagnostic and therapeutic imaging over the course of 6 months.

Results: A computed tomography (CT) scan of the abdomen on October 4, 2012, demonstrated 2 right hepatic lobe lesions (2.5 cm and 1.7 cm) that exhibited the characteristic enhancement pattern of HCC—early arterial enhancement with venous phase washout (Liver Imaging Reporting and Data System [LI-RADS] category 5). The patient was referred to interventional radiology for right hepatic lobar transarterial chemoembolization, which was performed using doxorubicin loaded on 100-300 μm LC Beads (Biocompatibles UK, Farnham, Surrey, UK). A follow-up CT scan on December 4, 2012, demonstrated persistent arterial enhancement of the 2.5-cm segment 5 lesion, indicating tumor survival. Repeat transarterial chemoembolization was performed on February 13, 2013, using doxorubicin loaded on 75-150 micrometer LC Beads and superselective of the segment 5 hepatic artery. A follow-up CT scan on April 1, 2013, demonstrated absent arterial enhancement of the lesion, indicating successful treatment of the tumor.

Conclusion: Smaller embolic particles can penetrate further downstream to a hepatic lesion, thereby delivering more chemotherapy to an HCC lesion. In addition, superselectivity of tumor blood supply will increase drug and embolic material delivery to the tumor while decreasing systemic side effects.

Case Report: Paradoxical Renal Thromboembolism Associated With Patent Foramen Ovale and May-Thurner Syndrome Variant


Purpose: The most common cardiac defect associated with paradoxical embolism (PDE) is patent foramen ovale (PFO), which has a prevalence of 27% to 35% in the general population. Coexistence of PFO and renal artery thromboembolism is rare. In classic May-Thurner syndrome (MTS), the right common iliac artery overlies the left common iliac vein; however, several variant forms have been described in the literature. We report such a case in which multiple thrombotic renal infarcts have occurred.
concurrently with PFO and MTS variant, which to the best of our knowledge has not been reported previously.

**Materials and Methods:** On May 27, 2013, a 59-year-old female with no significant past medical history was brought into Medical Center of Plano for evaluation of a 2-day history of abdominal pain with mild nausea and vomiting. A computed tomography (CT) scan of the abdomen and pelvis with contrast was performed on the same day, which revealed patchy right renal cyst consistent with pyelonephritis. A repeat CT scan of the abdomen and pelvis was conducted, which revealed low-density changes; several areas of perfusion abnormalities predominantly in the lower pole of right kidney; and 3 distinct hypoperfused areas in the left kidney, suggestive of multiple renal infarcts. The patient was scheduled for transesophageal echocardiography (TEE) with bubble study, which revealed a moderate atrial septal aneurysm with right-to-left shunt without Valsalva suggestive of PFO. According to the magnetic resonance imaging (MRI) of the pelvis, no thrombosis was seen within the pelvic venous system; however, there was extrinsic compression of the left common iliac vein suggestive of MTS. The patient was taken to the cardiac catheterization laboratory for PFO closure.

**Results:** MTS, or iliac vein compression syndrome, involves compression of the left common iliac vein by the overlying right common iliac artery against the fifth lumbar vertebra. In the early 19th century, the incidence of MTS was calculated from autopsy data to be around 22%, although this incidence rate has not been confirmed. Nevertheless, MTS may be an underreported etiology. In one study, patients suffering from embolic stroke who had MTS and concurrent PFO were younger (4th decade, *P* = 0.04), female (*P* < 0.01), and active smokers. Patients who present with end-organ ischemia should be screened for this defect, and the possible etiology for the thrombus should be closely evaluated. Treatment options include transcatheter (TC) closure of this defect and anticoagulation to prevent venous embolism.

**Conclusion:** Cryptogenic stroke due to PFO is a well known entity in the younger population, and PFO is also associated with other systemic thromboembolism. Intra-cardiac shunt evaluation should be part of a systemic thromboembolism investigation, especially in the younger population. May-Thurner syndrome is associated with a higher DVT incidence and should be part of the investigation especially in younger females and/or patients with a history of DVT.
Purpose: A. Kim, C. Chan, E. Depopas, E. Cohen

Computed Tomography–Mediated Vessel Diameter Calculation Utilizing a Linear Regression Model

A. Kim, C. Chan, E. Depopas, E. Cohen

Purpose: In vascular recanalization or stenting, vessel diameter measurement is important for optimal treatment. Given that patients requiring intervention usually present with poststenotic dilatation or complete occlusion, it is difficult to assess the true vessel size from an angiogram. The aim of our study was to determine the accuracy of vessel diameter estimation through correlation with other vessels using preprocedural computed tomography (CT) scans.

Materials and Methods: Contrast-enhanced CT scans of the abdomen and pelvis were evaluated in 754 patients. A total of 438 females and 316 males were evaluated. The ages of our subjects ranged from 18-88 years. Celiac, superior mesenteric, renal, and common iliac artery diameters were obtained at their origin. In addition, patient girth, vertebral body, and aortic diameters were measured at the level of the celiac artery origin. Correlation between these parameters was assessed.

Results: Patient girth, as measured by the anteroposterior (AP) diameter and width, served as an internal control, and there was a high degree of correlation (r=0.79) between the AP diameter and the width. The aorta demonstrated a moderate correlation with the celiac artery diameter (r=0.42) as well as the iliac arteries (r=0.57 [right], 0.64 [left]). The celiac artery demonstrated the strongest correlation to the superior mesenteric artery (r=0.45) as well as the left internal iliac artery (r=0.45). The superior mesenteric artery diameter correlated most closely with the celiac, bilateral renal, and iliac arteries (r=0.41-0.47). A low correlation was seen between the aorta and the celiac and superior mesenteric arteries (r=0.34-0.35). The renal arteries demonstrated a moderate correlation with each other (r=0.62), while the iliac arteries demonstrated a high degree of correlation (r=0.79). Interestingly, the left iliac artery demonstrated at least a moderate degree of correlation with all of the compared vessels (r=0.40-0.79). Age-based subgroup analysis demonstrated a moderate to high correlation between the aorta and all measured arteries for patients under the age of 40 (r=0.49-0.72). A low to moderate correlation was seen in patients between 41 and 60 years of age (r=0.33-0.61), and further loss of correlation was seen in the 61 and older subgroup (r=0.17-0.57). There was no significant difference in sex-based subgroup analysis. Linear regression formulas were calculated for arteries with the strongest correlation. The formula comparing the celiac artery with the superior mesenteric artery was DC = 0.4906 DS + 3.8592. The relationship between the aortic and superior mesenteric artery diameter for patients under 40 was DS = 0.1890 DA + 3.8592. The relationship between the aortic and superior mesenteric artery diameter for patients over 40 was DS = 0.3390 DA + 3.8489. These formulas, DC, DS, and DA represent celiac, superior mesenteric artery, and aortic diameters in millimeters, respectively.

Conclusion: Visceral vessel diameters correlate with each other in a linear fashion. Therefore, utilizing linear regression, it is possible to estimate an occluded vessels diameter for correct sizing of a balloon or stent during or prior to an endovascular intervention. Our findings indicate that preprocedural imaging can be useful for treatment planning in mesenteric revascularization. This is of particular utility in vessels that have a relatively short course prior to branching such as the celiac axis.

Matters of the Heart: Cardiac Strain and Thrombi in Pulmonary Embolism

A. Chukus, H. Michell, N. Tirada, C. Nguyen, W. Burke III

Purpose: To show distinguishing computed tomography (CT) signs of cardiac strain in patients with pulmonary thromboembolism (PTE), and to highlight CT imaging findings of increased mortality risk in various PTE patients.

Materials and Methods: Pulmonary thromboembolism is the third most common cause of cardiovascular death, after myocardial ischemia and stroke. Obstruction of the pulmonary circulation in PTE may cause significant strain on the heart that can be detrimental for the patient, if not promptly recognized. CT is an important tool for the evaluation of the complications of PTE. Signs of right heart strain that can be seen with PTE include dilated right heart chambers, increased right ventricle/left ventricle (RV/LV) diameter ratio (with an RV/LV ratio >0.9 associated with higher mortality rates), leftward bowing of the ventricular septum, and reflux of contrast into the inferior vena cava (IVC) from tricuspid regurgitation. In addition, the presence of cardiac thrombi among patients with acute PTE has been associated with worse hemodynamic instability and worse prognosis. Through the use of images obtained at our institution and a review of literature, we aim to illustrate important cardiac findings in patients with PTE that should be recognized and described by every general radiologist.

Results: In patients with PTE and the associated risk factors for increased mortality, prompt identification of said risk factors and ensuing proper, more aggressive treatment and monitoring resulted in complete resolution of the PTE and the associated increased mortality risk factors (increased RV/LV ratio, leftward bowing of the septum, reflux of contrast, and heart chamber dilatation).

Conclusion: Pulmonary embolism can be a fatal cardiovascular disorder. Abnormal position of the ventricular septum, RV/LV ratio, IVC contrast reflux, and presence of cardiac thrombi are predictive of adverse outcomes, thus early recognition on CT imaging is important to facilitate diagnosis and treatment, as identification may play a significant role in treatment planning.

Venous Detour: Collateral Pathways in Superior Vena Cava Obstruction

I. Iyamu, L. Barnes, J. Hummel, C. Trimmer

Purpose: Superior vena cava obstruction is usually an acquired complication caused by conditions such as mediastinal fibrosis or thoracic malignancy. When chronic oc-
Embolization of a Forefoot Congenital Arteriovenous Malformation With Onyx (Ethylene Vinyl Alcohol Copolymer): A Case Report

R. Marcello, G. Marcello

Purpose: To demonstrate the effectiveness and safety of Onyx (ethylene vinyl alcohol copolymer; ev3, Plymouth, MN) as an embolization tool in the treatment of a congenital arteriovenous malformation (AVM) of the foot.

Materials and Methods: A 24-year-old female was referred to our institution with a 2-month history of a swollen and painful right foot. At examination, the foot was presented with skin discoloration of the fifth toe, and there was slight engorgement of the superficial venous network of the right leg. Contrast-enhanced multidetector computed tomography (ce-MDCT) angiography of the lower limbs showed a vascular malformation of the right foot. Therefore, a selective angiography and embolization procedure was planned. Under conscious sedation and right lower leg nerve block anesthesia, a selective angiography by antegrade common femoral artery access revealed an AVM located in the foot, with hyper trophy of anterior tibial and dorsalis pedis arteries giving rise to many arterial feeders. Superselective embolization of the multiple arterial feeders to the AVM with a 2.9 F microcatheter (Proweat; Terumo, Tokyo, Japan) and Onyx liquid embolic system was carried out. Postprocedural angiography showed complete occlusion of the smaller arterial feeders with full patency of the main vessel of the leg. The patient was discharged from hospital in 2 days.

Results: Initial relief of pain, swollen leg, and engorgement of the superficial venous network were detected soon after the procedure; all symptoms improved in the next 3 weeks later. At 1 year, she remained asymptomatic with no recurrence.

Conclusion: Embolization of a congenital AVM of the foot with Onyx is a safe and effective procedure.

Case Report of Iliofemoral Thrombosis Secondary to Iliac Compression Syndrome in Double Inferior Vena Cava


Purpose: We describe the successful treatment of a very rare case of deep venous thrombosis (DVT) in a patient with iliac compression syndrome and duplicate inferior vena cava (IVC), illustrating the special challenges posed by this combination of pathology.

Materials and Methods: A 30-year-old woman on oral contraceptives with no prior medical history presented with a 1-week history of unprovoked left leg swelling, pain, and erythema. Ultrasound showed an extensive left lower extremity DVT and a computed tomography (CT) scan showed a double IVC system with iliac compression, with duplication of the IVC reported at a prevalence rate ranging from 0.2%-3.0% and higher. While duplication of the IVC typically remains asymptomatic, there are certain clinical scenarios where duplication of the IVC may present specific challenges, such as in the setting of caval filtration or retroperitoneal surgery. We discuss an atypical presentation of a duplicated IVC and review the literature regarding various options of IVC filter placement when a caval variant is encountered.

Results: Review of CT scans and cavography in our patient demonstrated a duplicated IVC, with a chronic appearing occlusion of the distal left renal vein. Drainage of both the left IVC and proximal patent left renal vein was into an ascending lumbar vein, which eventually continued as the hemiazygous vein. Duplication of the IVC is the most common caval malformation (1%-3%); however, many other anomalies exist including transposition, interruption of the IVC with azygos continuation, agenesis and anomalous drainage, and circumaortic and retroaortic left renal vein. Anatomic variations are more frequently identified following selective venography, as opposed to standard nonselective cavography. There is established literature with regards to placement of an IVC filter in the case of a duplicated IVC when the left-sided IVC terminates in the left renal vein. Options include deployment of single IVC filters in bilateral infrarenal vena cava limbs, single suprarenal filter placement, or filter placement in the right IVC with coil embolization of anomalous left-sided cava or points of communication between the segments. Studies show comparable complication rates between dual infrarenal filters, the current standard of care, and a single suprarenal filter. Literature is scarce on embolization of the communicating vena cava moiety; however, clinical success has been reported.

Conclusion: We must approach these vascular incongruities as a spectrum of anomalies, and only when one understands the embryologic development of the cardinal system would the different variations make sense. Without being cognizant of the various anatomical variants of the IVC, placement of a filter may prove futile in some patients. Proper cavography is instrumental for proper placement of an IVC filter and also delineates any additional anatomic variants. A myriad of options for filter placement exist, and appropriate examination of preprocedure scans and fluoroscopic images during the procedure helps determine the suitable position and number of filters to be deployed.

Efficacy of Rivaroxaban in Cancer-Related Venous Thromboembolic Disease

M. Sharifi, W. Freeman, C. Bay, F. Schwartz, M. Sharifi

Purpose: Venous thromboembolic disease (VTE) related to cancer portends a poor prognosis. Many patients exhibit resistance to warfarin, leading to a relatively high VTE recurrence rate. For this reason, low-molecular-weight heparins have become
the anticoagulants of choice; however, their parenteral and usually twice-daily administra-
tion makes them inconvenient for many patients. New oral anticoagulants, though promising, have not been used in this setting. This abstract reports the outcomes of patients with cancer-related deep venous thrombosis (DVT) who received rivaroxaban following percutaneous endovenous intervention (PEVI).

**Materials and Methods:** PEVI was performed in 42 patients with cancer who had developed extensive symptomatic DVT. In 7 patients, DVT was in the upper extremity, subclavian or internal jugular vein. It was found in the left and right lower extremity or iliac veins in 20 and 6 patients, respectively, and bilaterally in the lower extremities in 9 patients. At the time of DVT, 15 patients (36%) were on warfarin, of whom 11 had a therapeutic international normalized ratio (INR) (73%). PEVI was performed within 25±3 hours of admission. All patients received heparin, which was stopped after completion of PEVI. Rivaroxaban was initiated at 20 mg daily 2 hours after PEVI and continued indefinitely. The mean follow-up was 12±3 months. The patients were evaluated for mortality, recurrent VTE, and bleeding during this period.

**Results:** There were 4 deaths due to cancer at follow-up. There was no bleeding or recurrent VTE in any patient. All patients tolerated the anticoagulation regimen. The mean duration of hospitalization was 35±5 hours.

**Conclusion:** In patients with cancer-associated DVT, treatment with rivaroxaban following PEVI is highly safe and effective. It leads to shorter hospitalization and no recurrence of symptoms even during long-distance running, but with some symptom recurrence after prolonged standing.

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**Materials and Methods:** A 56-year-old hospitalized patient with a previously inserted (at outside hospital) permanent Vena Tech IVC filter (B Braun, Bethlehem, PA) presented to our service with massive right pleurisy and filter-related iliac thrombosis who was treated successfully with unassisted percutaneously inserted AngioVac suction thrombectomy.

**Results:** There were 4 deaths due to cancer at follow-up. There was no bleeding or recurrent VTE in any patient. All patients tolerated the anticoagulation regimen. The mean duration of hospitalization was 35±5 hours.

**Conclusion:** In patients with cancer-associated DVT, treatment with rivaroxaban following PEVI is highly safe and effective. It leads to shorter hospitalization and no early or late bleeding or recurrent VTE. Additionally, the inconveniences associated with long-term parenteral anticoagulation are eliminated.

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**Percutaneously Inserted AngioVac Suction Thrombectomy for the Treatment of Filter-Related Iliocaval Thrombosis**

**F. Francis, G. Salerno, S. Butty, T. Casciani**

**Purpose:** There are limited options for the treatment of permanent filter-related inferior vena cava (IVC) thrombosis when catheter-directed thrombolysis is not a viable or effective option. AngioVac (AngioDynamics, Latham, NY) is a suction thrombectomy device FDA approved for “removal of undesirable intravascular material.” Limited peer-reviewed data are available on its percutaneous application in the management of iliac caval thrombus. We describe the case of a patient with phlegmasia cerulea dolens and filter-related iliac caval thrombosis who was treated successfully with unassisted percutaneously inserted AngioVac suction thrombectomy.

**Materials and Methods:** A 56-year-old hospitalized patient with a previously inserted (at outside hospital) permanent Vena Tech IVC filter (B Braun, Bethlehem, PA) presented to our service with massive right pleurisy and filter-related iliac thrombosis who was treated successfully with unassisted percutaneously inserted AngioVac suction thrombectomy.

**Results:** There were 4 deaths due to cancer at follow-up. There was no bleeding or recurrent VTE in any patient. All patients tolerated the anticoagulation regimen. The mean duration of hospitalization was 35±5 hours.

**Conclusion:** In patients with cancer-associated DVT, treatment with rivaroxaban following PEVI is highly safe and effective. It leads to shorter hospitalization and no early or late bleeding or recurrent VTE. Additionally, the inconveniences associated with long-term parenteral anticoagulation are eliminated.

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**Ultrasound-Accelerated Thrombolysis for Acute Pulmonary Embolism in Recent Postoperative Patients**

**R. J. Kennedy, H. Kenney, B. Dunfee**

**Purpose:** Treatment guidelines for acute pulmonary embolism (PE) recommend against thrombolytic therapy for patients with a history of recent surgery or trauma. Ultrasound-accelerated thrombolysis has been used for acute PE to achieve...
thrombus resolution and reversal of physiologic dysfunction by regional low-dose thrombolytic administration. The current study evaluated whether this technique demonstrates a safety profile that supports its application for recent postoperative patients with acute massive or submassive PE, who are at increased risk for bleeding complications.

**Materials and Methods:** A total of 103 acute PE patients were treated with ultrasound-accelerated thrombolysis between October 2009 and September 2013 at a single center. Retrospectively, we identified a subset of 10 patients who underwent an operative procedure within 3 weeks prior to ultrasound-accelerated thrombolysis for acute PE. All patients received systemic anticoagulation and treatment using the EkoSonic Endovascular System (EKOS Corporation, Bothell, WA), which was placed into the pulmonary artery thrombus for ultrasound-accelerated thrombolytic infusion of recombinant tissue plasminogen activator (rtPA) at 0.5 or 1.0 mg/hour/catheter. Patient outcomes were evaluated, including pulmonary artery pressures, Miller scores, adverse events, and survival.

**Results:** Ten patients (5 men, 5 women; aged 59±18; 8 bilateral PE, 2 massive PE) were identified with documented recent operative procedures. Treatment results demonstrated complete or near-complete thrombus clearance in all 10 patients following infusion of 30.3±11.9 mg rtPA over 17.0±5.7 hours. Pulmonary artery pressures decreased significantly from pretreatment to posttreatment (systolic: 50±22 to 36±10 mm Hg, \( P = 0.03 \); mean, 25±11 to 18±7 mm Hg, \( P = 0.02 \)), as did the Miller score (25±5 to 13±5; \( P < 0.001 \)). Clinical improvement of symptoms was observed in all patients posttreatment, with no major hemorrhagic complications. All patients survived to hospital discharge.

**Conclusion:** Treatment of acute PE with ultrasound-accelerated thrombolysis demonstrates a favorable safety profile in recent postoperative patients in this study. Thrombolytic therapy should be considered with caution in recent postoperative patients to avoid hemorrhagic complications but may be justified in cases of life-threatening physiologic dysfunction from acute massive or submassive PE.

**Uterine Fibroid Embolization: Case Series Review of Atypical Vascular Supply**

D. C. Feldstein, E. Matto, I. Hersi, A. Trebelev, B. Bianco, W. Fan

**Purpose:** To describe and review extraterine and atypical fibroid vascularization patterns during uterine artery embolization (UAE). Uterine fibroids are the most common female reproductive tract tumor, occurring in greater than 40% of premenopausal women, and symptomatic fibroids are the most common indication for hysterectomy, which is performed in 25%-30% of patients. UAE allows for uterine preservation and avoidance of surgical intervention. The goal of fibroid embolization is occlusion of arterial blood supply resulting in ischemic infarction and gradual decrease in fibroid size. Failure to adequately embolize a fibroid’s entire vascular supply typically results in incomplete and ineffective treatment. Ultrasound is the most common imaging modality used for diagnosis, with magnetic resonance imaging (MRI) being the mainstay for fibroid characterization. Postembolization MRI imaging is also critical to accurately recharacterize fibroids and evaluate the uterus. The uterine arteries make up a fibroid’s vascular supply in the majority of patients. Ovarian arterial supply to fibroids occurs in approximately 5%-10% of cases, predominantly in women with past pelvic surgery, tubal/ovarian disease, and fibroids located in the uterine fundus. Additionally, there is a potential for a fibroid to parasitize blood supply from any surrounding vasculature.

**Materials and Methods:** A retrospective review of all UAE cases at Hahnemann University Hospital over the last 5 years was performed.

**Results:** A total of 4 UAE cases were selected, including normal bilateral uterine supply, ovarian supply, congenital absence of the right uterine artery, and superior mesenteric supply. Both pre- and postembolization images, including MRI and conventional angiography, were used.

**Conclusion:** Awareness and understanding of a fibroid’s vascular supply, including extraterine variations, is essential for appropriate and adequate embolization therapy.