



**New York University School of Medicine**

**VASCULAR AND INTERVENTIONAL RADIOLOGY FELLOWSHIP**

**EDUCATIONAL OBJECTIVES**

The NYU VIR fellowship program requires its fellows to obtain competencies in the 6 areas below to the level expected of a new practitioner:

- a. **Patient Care** that is compassionate, appropriate, and effective for the treatment of health problems and the promotion of health.
- b. **Medical Knowledge** about established and evolving biomedical, clinical, and cognate (e.g., epidemiological and social-behavioral) sciences and the application of this knowledge to patient care.
- c. **Practice-Based Learning and Improvement** that involves investigation and evaluation of their own patient care, appraisal and assimilation of scientific evidence, and improvements in patient care.
- d. **Interpersonal and Communication Skills** that result in effective information exchange and team with patients, their families, and other health professionals.
- e. **Professionalism**, as manifested through a commitment to carrying out professional responsibilities, adherence to ethical principles, and sensitivity to a diverse patient population.
- f. **Systems-Based Practice**, as manifested by actions that demonstrate an awareness of and responsiveness to the larger context and system of health care and the ability to effectively call on system resources to provide care that is of optimal value.

## **SPECIFIC EDUCATIONAL OBJECTIVES**

### **I. GENERAL TOPICS IN INTERVENTIONAL RADIOLOGY**

**GOALS:** At the conclusion of fellowship training, the trainee will be able to:

1. Determine the appropriateness of patient selection for a requested procedure through review of available history, imaging, laboratory values and proposed/expected outcomes of the procedure, as well as obtain deficient information in these areas.
2. Demonstrate understanding of history/physical findings or treatment scenarios that would require pre-procedure assistance from other specialty disciplines such as cardiology, anesthesia, surgery and internal medicine.
3. Obtain informed consent after a review with the patient of the procedure(s), risks, benefits and alternative therapeutic options/procedures.
4. Recognize monitoring abnormalities and physical signs/symptoms that need immediate attention during a procedure.
5. Demonstrate appropriate post procedure recovery, patient management and follow-up.
6. Demonstrate understanding and appropriate management of certain pharmacological considerations:
  - a. Drug/Contrast Reactions
  - b. Antibiotic Therapy
  - c. Conscious Sedation
  - d. Anesthesia/Analgesia
  - e. Anticoagulation

### **OBJECTIVES: Patient Care**

At the conclusion of fellowship training, the trainee will be able to:

1. Interpret non-invasive imaging studies to determine that the requested procedure is appropriate, and if not, assign the correct procedure.
2. Identify factors from patient history, physical and laboratory values that indicate potential risks for conscious sedation and assign an ASA score.
3. Identify factors from patient history, physical and laboratory values that indicate potential risks for bleeding, renal damage, cardiovascular problems, breathing abnormalities or adverse drug interactions during or after the procedure.

4. Properly evaluate a patient before an interventional procedure using a focused history and physical.
5. Demonstrate proper communication with the referring physician and/or other consulting physicians regarding procedure appropriateness and/or potential risks that need further evaluation.
6. Identify increased risks of blood glucose abnormalities, changes in blood pressure, and infection either before, during or after a procedure and assign the proper medication regimens including, but not limited to, periprocedure food/insulin intake, initiation of a sliding scale of insulin, adjustment of blood pressure medications, adjustment of anticoagulation medications or initiation of prophylactic/therapeutic antibiotic coverage.
7. Administer and maintain effective conscious sedation for patient comfort during and after the procedure.
8. Recognize and treat complications during and after the procedure including but not limited to contrast/anaphylactic reaction, over sedation, pain, nausea/vomiting, arrhythmia, decreased oxygen saturation, sepsis, hypertensive urgency/emergency, low blood pressure, hyper-hypoglycemia or bleeding/hematoma.
9. Provide appropriate patient follow-up in the inpatient and outpatient settings.

**OBJECTIVES: Reducing Occupational Hazards**

At the conclusion of fellowship training, the trainee will be able to:

1. Identify the types of radiation created and their sources during fluoroscopy.
2. Identify the organs especially sensitive to the effects of ionizing radiation and the maximum yearly whole body dose.
3. Understand how radiation exposure is monitored in proper use and care of these devices.
4. List the most common methods of radiation protection, their principles and practical applications.
5. Understand the rationale for lead protective clothing, lead glasses, shields and gloves.
6. Identify periodic maintenance and maintenance schedules for radiation protection devices.

7. Understand methods to decrease radiation dose to the patient and operator during IR procedures.
8. Identify procedures at high risk for radiation skin injuries and how to avoid them.
9. Describe how to limit/reduce work related musculoskeletal injuries in the IR environment.
10. Identify patients at high risk for blood borne pathogens.
11. Know the incidence of hepatitis C, hepatitis B and HIV in the IR patient population.
12. Describe methods to reduce accidental exposure to blood and body fluids in the IR suite.

**OBJECTIVES: Interventional Radiology Team**

At the conclusion of fellowship training, the trainee will be able to:

1. Recognize and promote a team environment in the practice of interventional radiology including radiologic technologists, radiology nurses, nurse practitioners, patient care coordinators and physicians' assistants.
2. Support and participate in the continuing medical education for members of the IR team.
3. Understand the potential responsibilities and limitations of nurse practitioners, physicians' assistants, radiologic technologists and radiology nurses in IR practice.
4. Help to provide a safe and pleasant working environment for the entire IR team.
5. Integrate the various members of the IR team in quality assurance programs and inventory management for the IR practice.
6. Treat all members of the IR team with respect.

**OBJECTIVES: Interventional Radiology Clinical Practice**

At the conclusion of fellowship training, the trainee will be able to:

1. Understand the necessity of developing and maintaining an Interventional Radiology Clinic in order to evaluate patients pre-and-post procedure and to help promote interventional radiology as a clinical practice on par with other surgical subspecialties.
2. Understand the importance of developing referral relationships with primary care physicians.
3. Learn basic principles of evaluation and management coding for outpatient and inpatient consultations.
4. Provide longitudinal care for patients as necessary utilizing the IR clinic.
5. Recognize the value of becoming a hub for two-way patient referrals.
6. Communicate effectively with referring physicians.
7. Integrate patient care coordinators, nurses, nurse practitioners, physicians' assistants and administrative assistants as necessary to staff a functional IR clinic.
8. Keep adequate medical record for interventional radiology patients and integrate with the hospital information systems.
9. Adhere to institutional and federal health information privacy standards with regard to all medical records, correspondence and use of patient information for research purposes.
10. Understand the mechanisms and requirement for continually monitoring quality assurance including regular documentation and classification of complications from IR procedures.
11. Understand the basic principles of CPT coding and the importance of correct coding with regard to proper reimbursement and avoiding Medicare fraud and abuse.
12. Obtain a basic understanding of various reimbursement systems, their variability from practice-to-practice and implications on overall reimbursement and collection rate for the IR practice.

## II. VASCULAR DIAGNOSIS

### **OBJECTIVES: Thoracic Aorta and Upper Extremities**

At the conclusion of fellowship training, the trainee will be able to:

1. Correctly utilize digital subtraction angiography to diagnose the spectrum of disease processes related to the thoracic aorta and upper extremities.
2. Recommend the proper use of ultrasound and CT or MR angiography for the identification of thoracic and upper extremity vascular pathologic disease processes.
3. Identify the normal anatomy of the ascending, transverse arch, and descending thoracic aorta including the great vessels to the head and neck and the intercostals or bronchial arterial anatomy.
4. Understand the basic embryology of the thoracic aorta.
5. List common anatomical normal variants of the thoracic aorta.
6. List congenital variants of the thoracic aorta and great vessels and understand how they may present with clinical abnormalities. Recognize chest radiograph findings in these variant anatomies. In particular, recognize the significance of the following:
  - a. Left aortic arch with aberrant right subclavian artery
  - b. Right aortic arch with mirror image branching
  - c. Right aortic arch with aberrant left subclavian artery
  - d. Cervical aortic arch
  - e. Coarctation of the aorta
7. Describe and demonstrate the ability to utilize alternative means of catheterizing the great vessels in cases where variant anatomy is present.
8. Provide the definition of a thoracic aortic aneurysm.
9. Describe the imaging and pathology findings in atherosclerotic, syphilitic, mycotic, posttraumatic and congenital aneurysms.
10. Understand the clinical presentation of aortic dissection.
11. Categorize aortic dissection using the Stanford and DeBakey classifications.
12. Recognize predisposing factors to aortic dissection such as atherosclerosis, hypertension, collagen vascular disease, and pregnancy.

13. Understand the limitations of catheterization in the diagnosis of aortic dissection.
14. Identify the typical signs of the true and false lumen of a dissection on arteriography, CT and MRI. Understand how intravascular ultrasound can be an adjunct to identifying the true and false lumen and may impact catheter interventions for the treatment of dissection.
15. List chest radiography and CT findings in the setting of traumatic disruption of the aorta.
16. Understand how to perform emergent aortography for suspected traumatic disruption of the thoracic aorta.
17. Recognize the difference between an aortic pseudoaneurysm and a ductus diverticulum.
18. List two theoretical mechanisms for traumatic pseudoaneurysm formation of the thoracic aorta in the setting of a motor vehicle accident.
19. Describe the indications for upper extremity, neck, or thoracic aortic angiography in penetrating or blunt trauma resulting in a proximity lesion or wound.
20. Recognize the findings of arterial trauma with a penetrating or blast injury.
21. List diseases or agents that may cause aortitis.
22. Recognize the angiographic findings associated with different forms of aortitis.
23. Describe angiographic findings and typical distribution of abnormalities in Takayasu's aortitis.
24. Understand the potential causes of dysphagia aortica and dysphagia lusoria.
25. Recognize the angiographic and non-invasive findings in the vascular components of connective tissue disorders including Marfan syndrome and Ehlers-Danlos syndrome.
26. Describe the normal anatomy of the bronchial and intercostals arteries and the common normal variants of these vessels.
27. Describe angiographic techniques and strategies for catheterizing the bronchial arteries.

28. Recognize normal appearance of the bronchial arteries and recognize the angiographic appearance of abnormal vessels that can be seen in patients presenting with hemoptysis from inflammatory versus malignancy.
29. Recognize the angiographic appearance of the artery of Adamkiewicz and understand its clinical significance.
30. Understand the arterial anatomy of the shoulder region including the brachiocephalic, subclavian, common carotid, vertebral, ascending cervical, anterior and posterior circumflex humeral, circumflex scapular, costocervical trunk, dorsal scapular, inferior thyroidal, internal mammary, lateral thoracic, subscapular, superior thoracic, thoracoacromial, thyrocervical, thoracodorsal and transverse scapular arteries.
31. Understand the anatomy of the upper extremity including the brachial, ulnar, radial and interosseous arteries.
32. Recognize an aberrant proximal origin of the radial artery.
33. Describe the anatomy of the hand including the deep and superficial palmar arches and the common and proper digital vessels.
34. List collateral pathways of blood supply to the upper extremity in a case of proximal occlusion.
35. Describe provocative measures for eliciting subclavian steal on non-invasive studies.
36. Describe measures for accentuating thoracic compression syndromes.
37. Recognize the value of CT, US and MR as means of evaluating the causative factors in thoracic compression syndromes.
38. Describe the advantages and disadvantages of axillary, brachial or radial artery puncture as alternatives to common femoral artery puncture for arteriographic procedures.
39. Recognize the clinical signs of angiographically induced complications of the above vessels. Describe imaging findings of puncture site complications with ultrasound and understand how to manage these complications.
40. Define Raynaud disease and Raynaud phenomenon.
41. List disease processes that demonstrate Raynaud phenomenon.

42. Recognize the angiographic signs and distribution of lesions in collagen vascular diseases including scleroderma, periarteritis nodosa, rheumatoid arthritis and systemic lupus erythematosus.
43. Recognize the arteriographic signs of thromboangitis obliterans and its association with smokers.
44. Recognize the angiographic findings in various forms of trauma, including blunt trauma, penetrating trauma, and iatrogenic trauma.
45. List occupations or activities that may contribute to hypothenar hammer syndrome and recognize the associated angiographic findings.
46. Discuss alternatives to contrast angiography for the evaluation of the upper extremity. Understand the role of MRA, CTA, and US in vascular diagnosis of the upper extremity.

### **OBJECTIVES: Vascular Diagnosis of the Abdominal Aorta and Iliac Systems**

At the conclusion of fellowship training, the trainee will be able to:

1. Understand the anatomy of the abdominal aorta and its major branches.
2. Recognize major normal variants in the abdominal and pelvic vascular territories.
3. List collateral pathways for patients with occlusive disease involving the aorta or iliac arteries.
4. Understand alternative means of catheterizing or imaging the major branches of the aortic and pelvic vasculature if a standard femoral approach is not available. Indicate knowledge of CTA and MRA for the evaluation of these areas.
5. Name the major branches of the internal iliac artery.
6. Demonstrate proficiency at selective catheterization of the major branches of the aortic and pelvic vascular territories.
7. Understand the pathophysiology of atherosclerosis involving the aorta and iliac vessels and its manifestations: occlusive disease (including Leriche syndrome) and ecstatic atherosclerosis (arteriomegaly).
8. Describe the clinical signs and symptoms seen with acute occlusions of these vascular territories.
9. List causative factors for aortic dissection.

10. Recognize the angiographic, CT and MR findings with aortic dissection.
11. Recognize the limitations of contrast angiography in diagnosis of aortic aneurysm or dissection.
12. Describe angiographic findings common to many forms of fibromuscular disease that may effect the aorta and its branches.
13. Recognize the manifestations of blunt or penetrating trauma to the pelvis. Understand the role of arteriography in the diagnosis and subsequent emergent treatment of these patients with embolization therapy.
14. Recognize the angiographic findings in patients with post radiation changes to the pelvic vasculature.
15. List angiographic findings present with malignancies of the pelvis and its viscera.
16. Describe the angiographic abnormalities seen with gestational trophoblastic disease.
17. Recognize the difference between uterine and pelvic arteriovenous malformations.
18. Understand the findings on CT or MR of pelvic or uterine AVM.
19. List causes of vasculogenic impotence.
20. Understand the pelvic anatomy of the internal pudendal artery and its role in angiography for vasculogenic impotence.
21. Recognize the angiographic findings with uterine fibroids and the key features which distinguish the uterine artery.
22. Describe the collateral routes of blood flow to the ovaries and uterus.

**OBJECTIVES: Lower Extremity Vascular Disease**

At the conclusion of fellowship training, the trainee will be able to:

1. Outline the normal arterial anatomy below the inguinal ligament.
2. Understand the bony and soft tissue anatomy of the femoral triangle and recognize its importance in avoiding the complications of femoral artery puncture for angiography or interventions.

3. Describe the important branches of the common femoral and profunda femoral artery and their role in collateral pathways of the pelvis, abdomen, and lower extremity.
4. Be able to list common normal variants of lower extremity arterial anatomy including a persistent sciatic artery, high origin of the SFA, duplication of the SFA, high bifurcation of the popliteal artery, and alterations in tibial vessel territories of distribution.
5. List advantages and disadvantages of various forms of angiography of the lower extremity, including bolus chase DSA and incremental stations for DSA.
6. Describe strategies for optimizing lower extremity angiography when only limited amounts of iodinated contrast may be used, or if CO<sub>2</sub> angiography is to be utilized.
7. List strategies for optimizing tibial and foot vessel visualization during angiography including selective angiography, pharmacological vasodilatation and reactive hyperemia.
8. Understand color Doppler flow imaging in the evaluation of lower extremity ischemic disease. Be familiar with the indications for ultrasound imaging in surveillance of vascular grafts and the assessment of post angioplasty patients.
9. Recognize the value of MRA in assessing the lower extremities and especially pedal vessels prior to surgical intervention in cases where DSA has provided suboptimal evaluation of the lower extremity.
10. Describe the sonographic findings of the complications of femoral artery puncture; i.e., iatrogenic pseudoaneurysm and arteriovenous fistulae.
11. Describe the angiographic findings from atherosclerotic disease of the lower extremity vessels with either occlusive or aneurysmal manifestations.
12. Discuss the clinical manifestations of atherosclerotic disease of the lower extremities including accepted classifications of acute and chronic ischemia.
13. Describe the angiographic findings in penetrating trauma to the lower extremity.
14. Understand the use of compartment pressures in diagnosis of compartment syndromes.
15. Understand the emergent nature of treating compartment syndromes.

16. Recognize the angiographic findings in popliteal entrapment syndrome. Describe the anatomic relationships between the popliteal artery and the gastrocnemius or popliteus muscles in the four types of popliteal entrapment.
17. Discuss the role of cross-sectional imaging in further work-up of popliteal entrapment.
18. Describe angiographic and cross-sectional imaging findings in adventitial cystic disease of the popliteal artery.
19. Understand the pathophysiology of thrombangitis obliterans (Buerger Disease) and associated angiographic findings.
20. Describe angiographic findings that help distinguish between atherosclerotic occlusions, thromboembolic occlusions, and low flow states. Recognize the limitations and overlap of these findings.
21. Discuss the clinical findings in Blue Toe Syndrome and the potential angiographic findings. Recognize the role of angiography in determining the etiology of the emboli and the potential role of interventions in treatment of the offending lesion.
22. Describe the angiographic features of vasospasm in the lower extremities.
23. Describe a “standing wave” seen on angiography and discuss its clinical significance.
24. Recognize the angiographic features of congenital or acquired AVM of the lower extremity. Understand the role of MRA in diagnosis of AVM versus a venous malformation.

**OBJECTIVES: Evaluation of Patients after Vascular Reconstructions or Bypass**

At the conclusion of fellowship training, the trainee will be able to:

1. Recognize the angiographic findings in anastomotic pseudoaneurysms for bypass grafts regardless of location.
2. Recognize the angiographic findings in thrombosis of bypass grafts.
3. Describe an imaging strategy for bypass graft surveillance.
4. Understand the role and limitations of ankle-brachial indices in evaluating the patient with a bypass graft.
5. List the sonographic features of a failing bypass graft.

6. List causes of bypass graft failure.
7. Describe angiographic findings seen with the above list of causes for graft failure.
8. Recognize the angiographic features of a clamp injury to a carotid artery or a bypass graft.
9. Understand the role of MRA in graft or other arterial reconstruction evaluation. List potential limitations to MRA due to artifacts.
10. Describe an imaging strategy for aortic endograft evaluation.
11. Understand the role of CT, ultrasound, intravascular ultrasound, and MRA in endograft evaluation. List limitations of each modality in endograft evaluation.

### **OBJECTIVES: Gastrointestinal Tract Vascular Evaluation**

At the conclusion of fellowship training, the trainee will be able to:

1. Name the three major ventral branches of the abdominal aorta that supply the gastrointestinal tract. Identify their approximate origins in relationship to the vertebral column in order to aid in catheterization.
2. Describe the most common branching patterns of the celiac axis and list common normal variants.
3. Identify the major branches of the splenic artery including the dorsal pancreatic artery, pancreatic magna artery, caudal pancreatic arteries, short gastric arteries and left gastroepiploic artery.
4. Identify on angiography the common hepatic artery, gastroduodenal artery, superior pancreaticoduodenal arteries, right gastroepiploic artery, proper hepatic artery, right and left hepatic arteries, supraduodenal artery, cystic artery, left gastric artery, and right gastric artery. Recognize common normal variants of these vascular territories.
5. Describe angiographic techniques and catheters that may help in selective catheterization of the above territories.
6. Identify the superior mesenteric artery, inferior pancreaticoduodenal branches, jejunal branches, ileal branches, middle colic artery, right colic artery and the ileocolic artery. Recognize common normal variants.

7. Identify on angiography the inferior mesenteric artery, left colic artery, sigmoid arteries, and superior hemorrhoidal artery.
8. Discuss and be able to identify on angiography the following anastomotic arteries: marginal artery of Drummond, arc of Riolan, arc of Buehler, arc of Barkow, meandering central anastomotic artery.
9. Recognize major branches of the mesenteric and portal venous systems.
10. Describe major portosystemic collateral venous systems and their significance in patients with portal hypertension.
11. List angiographic strategies for imaging the portal and mesenteric venous systems.
12. List the major blood supplies to the esophagus, stomach, duodenum, jejunum, ileum, colon and rectum.
13. Describe radiographic, CT, US, MR and angiographic findings in splenic artery aneurysms.
14. List common etiologies of splenic artery aneurysms and the most frequently involved patient populations.
15. Understand the significance of splenic artery aneurysms.
16. Recognize imaging findings, presenting symptoms, and common pathophysiology of SMA, gastroduodenal, and pancreaticoduodenal artery aneurysms.
17. Describe signs and symptoms of occlusive disease of the major splanchnic arteries and demonstrate knowledge of intestinal angina.
18. Understand the celiac artery compression syndrome. Discuss the significance of the median arcuate ligament and the celiac neural plexuses. Describe potential treatment.
19. Describe the angiographic techniques involved with evaluation of occlusive disease of the splanchnic vessels or celiac compression syndrome. In particular, recognize the utility of initial lateral aortography in these situations.
20. List causes of mesenteric ischemia.
21. Understand the pathophysiology of non-occlusive mesenteric ischemia.
22. Recognize the angiographic findings in non-occlusive mesenteric ischemia.

23. Discuss the role of angiography in treatment of non-occlusive mesenteric ischemia.
24. Understand that the splanchnic vessels can be involved in a variety of forms of arteritis and autoimmune diseases.
25. Recognize the angiographic findings in arteritis and inflammatory diseases.
26. Describe angiographic findings in angiomatosis.
27. Be aware of the angiographic findings in intestinal volvulus.
28. Discuss major causes of splenic, mesenteric or portal vein occlusion. Recognize imaging findings for occlusion of these vessels with angiography, CT, MRA or US.
29. Understand imaging strategies for the evaluation of upper and lower gastrointestinal bleeding. Discuss the need for selective and superselective angiography for full evaluation of specific bowel territories.
30. Understand the role of anticoagulants, vasodilators, and lytic agents for complete evaluation of occult gastrointestinal bleeding during angiography.
31. Recognize the role of hepatic sources of hemobilia as a source of gastrointestinal blood.
32. Recognize the angiographic findings of angiodysplasia of the bowel.
33. Discuss the imaging strategies for the evaluation of a suspected aorto-enteric fistula including CT and angiography. List common clinical scenarios for suspicion of aortoenteric fistula.
34. Recognize tumor vascularity involving the bowel.

**OBJECTIVES: Liver, Spleen and Pancreatic Angiographic Studies**

At the conclusion of fellowship training, the trainee will be able to:

1. Be familiar with common variant anatomy of the hepatic arteries.
2. Understand the portal venous anatomy and common variants.
3. Describe techniques for imaging the portal system including mesenteric arteriography with portal phase, hepatic vein catheterization with wedge

portography using contrast or CO<sub>2</sub>, and direct percutaneous portal vein puncture. Understand advantages and potential complications of each technique.

4. Recognize normal portal and hepatic venous pressures and expected portosystemic gradients in normal patients and in cases of portal hypertension.

5. Discuss prehepatic, intrahepatic, and posthepatic portal hypertension including etiologies and significance.

6. Describe portal venous findings in portal hypertension.

7. List etiologies for Budd-Chiari syndrome.

8. Recognize cavernous transformation of the portal vein.

9. Outline a strategy for TIPS surveillance using color Doppler ultrasound and list expected shunt velocities in a patent shunt. Describe abnormal findings that would lead to shunt catheterization for further evaluation.

10. Recognize angiographic findings in TIPS and TIPS failure.

11. List frequent surgical locations for the creation of portosystemic shunts and be able to recognize them angiographically.

12. List causes of hepatic artery aneurysms.

13. Recognize that multiple hepatic artery aneurysms can be seen in polyarteritis nodosa and necrotizing angitis.

14. Describe angiographic and cross-sectional imaging findings with arteriovenous fistula of the hepatic vasculature. List etiologies associated with this finding.

15. Recognize pancreatic arterial aneurysms on CT, MR or angiography and list common causes for these aneurysms or pseudoaneurysms.

16. Know the common locations of arterial pseudoaneurysms arising from chronic pancreatitis and discuss the relative frequency in these vascular territories.

17. Recognize the angiographic findings in the sequella of hepatic trauma, including subcapsular hematoma, AV fistula, pseudoaneurysm, contusion, hematoma, laceration, and hemobilia.

18. Recognize the angiographic findings in the sequella of splenic trauma including hematoma, laceration, rupture or fragmentation.

19. Recognize the sequella of blunt or penetrating trauma to the pancreas.
20. Describe angiographic findings in benign and malignant hepatic tumors, including: benign adenoma, focal nodular hyperplasia, regenerating nodules, hemangioma, hepatocellular carcinoma, hepatoblastoma, cholangiocarcinoma, angiosarcoma, and hyper or hypovascular metastases. Discuss the arterial phase as well as neovascularity, contrast pooling, arterial to venous shunting, portal venous invasion in the above entities
21. Recognize the angiographic findings in pancreatic tumors including adenomas, adenocarcinomas and islet cell tumors.
22. Be aware of pitfalls in angiography which may simulate disease of the liver, pancreas, or spleen.

## **II. VASCULAR INTERVENTION – GENERAL**

GOALS: At the conclusion of the fellowship training, the trainee will be able to:

1. Demonstrate learning of topic specific educational objectives.
2. Understand proper patient selection and therapeutic options for the interventional procedures described below.
3. Understand pre-procedure evaluation and post-procedure management and follow-up for these procedures and patients.
4. Obtain complete and appropriate informed consent for all procedures.
5. Demonstrate technical competence in the performance of these procedures.

### **OBJECTIVES: Peripheral Vascular Disease – Extremity Ischemia.**

At the conclusion of fellowship training, the trainee will be able to:

1. Appropriately classify all patients with acute and chronic extremity ischemia.
2. Perform a directed history and physical exam in patients with peripheral vascular disease.
3. Integrate noninvasive testing, vascular imaging, physical findings and past surgical history and plan optimal arterial access.
4. Identify the indications for percutaneous intervention in patients with peripheral vascular disease and understand medical and surgical treatment options in these patients.
5. Demonstrate knowledge of proper puncture site management techniques (see vascular diagnosis).
6. Categorize atherosclerotic lesions as to their appropriateness and expected response for treatment with percutaneous techniques.
7. List the complications of balloon angioplasty, stent placement, mechanical atherectomy and thrombolysis procedures and their incidence as documented in the literature.
8. Demonstrate technical competence in the performance of peripheral vascular interventions including balloon angioplasty, stent placement, recanalization techniques and thrombolysis.

9. Become familiar with a wide range of interventional equipment including but not limited to guidewires, sheaths, balloons, stents, and endografts.
10. Integrate the use of intraprocedural pressure monitoring in performing peripheral vascular interventions.
11. Understand preprocedural, intraprocedural and postprocedural pharmacological management for patients undergoing peripheral vascular interventions and including anticoagulation, use of thrombolytic agents, antiplatelet agents, and vasodilators.
12. List the absolute contraindications to pharmacologic thrombolysis.
13. Recognize embolic occlusion versus in situ thrombosis in cases of acute limb ischemia and tailor therapy based on these findings.
14. Understand the potential advantages and limitations of various pharmacologic and mechanical thrombolytic/thrombectomy techniques including surgical thrombectomy.
15. Recognize the advantages and limitations of puncture site closure devices.
16. Communicate effectively with the referring physicians.
17. Dictate clear and concise procedural reports.
18. Understand proper component coding for basic peripheral vascular interventions.
19. List the indications and results for reintervention in patients with extremity peripheral vascular disease.
21. Recognize nonatherosclerotic causes of extremity ischemia and the therapeutic implications.

**OBJECTIVES: Peripheral Vascular Disease – Renal Vascular Disease.**

At the conclusion of fellowship training, the trainee will be able to:

1. Identify the clinical characteristics of patients with renal vascular hypertension.
2. Perform a directed history and physical examination in patients with renal vascular disease.

3. Understand the indications for percutaneous intervention in patients with suspected ischemic nephropathy and/or renal vascular hypertension and understand the potential medical and surgical treatment options as well.
4. Integrate proper pre-intervention noninvasive imaging in the work-up of patients with suspected renal vascular disease.
5. Recognize the role of renal protective agents in the pre-and-post procedure management of patients with renal vascular disease to minimize contrast nephropathy.
6. Utilize alternative contrast agents in the evaluation and treatment of renal vascular disease.
7. Demonstrate technical proficiency in performing renal vascular interventions including but not limited to angioplasty and stent placement.
8. Understand preprocedural, intraprocedural and postprocedural pharmacologic management in patients undergoing percutaneous therapy for renal vascular disease.
9. List the types and rates of complications of renal vascular interventions and their management including cholesterol embolization.
10. Understand the expected outcomes of percutaneous treatment of renal vascular hypertension and ischemic nephropathy including long-term patency rates.
11. Become familiar with a wide range of balloons, wires, sheaths, guiding catheters and stents used in renal vascular interventions.
12. Integrate the use of intraprocedural intraarterial pressure measurements in assessing the results of renal vascular interventions.
13. Understand the potential role for current and future treatment for restenosis in renal vascular interventions.
14. Recognize the angiographic findings and indications for intervention in patients with fibromuscular dysplasia involving the renal arteries as well as the appropriate treatment and expected results in this specific patient population.
14. Recognize the angiographic findings and indications for intervention in patients with fibromuscular dysplasia involving the renal arteries as well as the appropriate treatment and expected results in this specific patient population.

**OBJECTIVES: Peripheral Vascular Disease – Mesenteric Vascular Disease.**

At the conclusion of fellowship training, the trainee will be able to:

1. Understand the clinical presentation of patients with acute and chronic mesenteric ischemia.
2. Perform a directed history and physical examination in patients with acute and chronic mesenteric ischemia.
3. Understand the indications for percutaneous intervention in patients with acute and chronic mesenteric ischemia as well as the medical and surgical treatment options available.
4. Integrate and direct the noninvasive imaging evaluation in patients with suspected mesenteric vascular disease.
5. List the most common etiologies of acute mesenteric ischemia as well as the etiologies for non-occlusive mesenteric ischemia.
6. Recognize the appearance and appropriate treatment of arcuate ligament compression syndrome.
7. Understand preprocedural, intraprocedural and postprocedural pharmacologic management in patients undergoing percutaneous therapy for mesenteric vascular disease.
8. Demonstrate technical competence in performing mesenteric vascular interventions including but not limited to angioplasty and stent placement for chronic mesenteric ischemia as well as thrombolysis and embolectomy for acute mesenteric ischemia.
9. Identify patients with non-occlusive mesenteric ischemia who will benefit from vasodilator infusion therapy.
10. List the expected immediate and long-term results for percutaneous interventions in mesenteric vascular disease.
11. Understand the role of embolization and other percutaneous therapies in the treatment of mesenteric aneurysms and pseudoaneurysms.

**OBJECTIVES: Aortic Aneurysm and Dissection.**

At the conclusion of the fellowship training, the trainee will be able to:

1. Understand the natural history of thoracic and abdominal aortic aneurysms and the implications for treatment.

2. Perform a directed history and physical examination in patients with thoracic or abdominal aortic aneurysm and aortic dissection.
3. Integrate preprocedural imaging work-up in patients with aortic aneurysm and dissection.
4. Recognize the limitations of endovascular treatment of thoracic and abdominal aortic aneurysms and identify patients who are best suited for surgical repair.
5. Classify abdominal aortic aneurysms with respect to iliac artery involvement and suitability for endovascular repair.
6. Recognize the advantages and limitations of the existing and future endovascular grafts for thoracic and abdominal aneurysms.
7. Apply preprocedural or periprocedural embolization of branch vessels as necessary to successfully exclude aneurysms with endovascular techniques.
8. Recognize patients with anatomy unsuitable for conventional access for endovascular repair and suggest alternative methods of endovascular graft placement.
9. Classify types of endoleaks and understand the implications for management.
10. Integrate preprocedural imaging information in the planning of type of graft chosen for each patient, the appropriate size of the graft and components and appropriate access for the endovascular procedure.
11. Recognize proper imaging follow-up following endovascular repair of aortic aneurysms.
13. Recognize imaging appearance of the various types of endoleaks.
14. Demonstrate facility with various techniques of treatment of endoleaks.
15. List the expected types and rates of complications associated with endovascular repair of thoracic and abdominal aortic aneurysms.
16. Classify patients with aortic dissection and understand the implications for medical, surgical, and endovascular management.
17. Identify patients with aortic dissection and branch vessel compromise who may benefit from endovascular interventions such as fenestration and/or stent placement to restore flow to the ischemic territory.

18. Recognize the emerging role of endovascular grafts in the treatment of aortic dissection.

**OBJECTIVES: Management of Hepatic Malignancy**

At the conclusion of the fellowship training, the trainee will be able to:

1. Understand the proper role of various imaging studies (CT, MRI, PET and ultrasound) and diagnosis and staging in patients with hepatic malignancy.
2. Evaluate hepatic reserve using clinical and laboratory criteria and understand the impact on therapeutic options.
3. Have a working understanding of tumor markers and their role in evaluating tumor response to therapy.
4. Perform a directed history and physical examination in patients with hepatic malignancy.
5. Understand available surgical and medical treatment options in patients with primary and metastatic hepatic malignancy.
6. Categorize patients with cirrhosis according to their MELD, Child-Pugh status and Okuda classification and understand the implications for survival.
7. List the causes of cirrhosis and implications for therapy in patients with co-existing hepatic malignancy.
8. Consult with patients and their families regarding treatment options, risks and benefits of various interventional oncologic therapies for hepatic malignancy.
9. Work within a multidisciplinary team to optimize patient care in this population.
10. Identify tumor types which respond well to chemoembolization.
11. List the absolute and relative contraindications to chemoembolization.
12. Categorize potential chemoembolization complications and their management.
13. Understand pre-and-post procedure care for chemoembolization patients.
14. Demonstrate technical competence in performing lobar, segmental and targeted chemoembolization therapy.

15. Identify patients at high risk for infectious complications following chemoembolization and strategies to prevent them.
16. Recognize arterial anatomic variants which effect feasibility and safety of chemoembolization.
17. Understand the basic principles of local tumor ablation with percutaneous ethanol injection, radiofrequency ablation, cryoablation and other techniques.
18. Select patients with hepatic malignancies who will benefit from local tumor ablation strategies.
19. Integrate local, regional and systemic therapies in combination when appropriate in patients with hepatic malignancies.
20. Orchestrate proper follow-up imaging, laboratory and clinical evaluation after interventional oncologic therapies for hepatic malignancy.
21. Become familiar with emerging interventional oncologic therapies such as targeted gene herapy, intra-arterial brachytherapy and others.

### **OBJECTIVES: Gynecologic Interventions**

At the conclusion of fellowship training, the trainee will be able to:

1. Identify proper indications and patient selection parameters for uterine artery embolization for the following patient groups:
  - a. Uterine fibroids
  - b. Post partum hemorrhage
  - c. Malignancy
  - d. Other less common indications, e.g., trophoblastic disease, uterine arteriovenous malformation.
2. Utilize proper imaging modalities for patient selection, and specific issues regarding appropriate selection (for UFE, fibroid location/pedunculation, presence of adenomyosis, endocavitary lesions).
3. Understand the classic arterial anatomy and variations of uterine blood flow.
4. Understand the presence of collateral blood flow between the uterus and the ovaries, and physiologic ramifications of embolization in these territories.
5. In-depth familiarity with informed consent issues, including specific reproductive/fertility/menopausal effects, symptom resolution, and comparison to standard OB/G techniques, as well as the standard angiographic and embolization risks.

6. Apply the principles and practice of standard angiographic procedures to pelvic angiography and uterine artery catheterization.
7. Become familiar with a wide variety of catheters and embolic agents used in UFE.
8. Understand the principles of post procedure care for UFE with special attention to pain control and post-embolization syndrome.
9. Direct post procedure imaging studies, and appropriate laboratory evaluation.
10. List potential complications of UFE and their management.
11. Be able to identify proper indications and patient selection parameters gonadal vein embolization:
  - a. In males, varicoceles
  - b. In females, pelvic congestion syndrome
12. Utilize proper imaging modalities and clinical history for patient selection, regarding appropriate selection.
13. Understand the classic venous anatomy and variations of gonadal veins.
14. Understand informed consent issues, including specific reproductive/fertility/menopausal effects, symptom resolution, and comparison to standard genitourinary or OB/GYN techniques, as well as the standard angiographic and embolization risks.
15. Understand the principles of post procedure care, post gonadal vein embolization.
16. Become familiar with embolic agents and approaches used in embolization of gonadal veins and provide quality post procedure care in these patients.

**OBJECTIVES: Trauma Intervention**

At the conclusion of fellowship training, the trainee will be able to:

1. Demonstrate a fundamental knowledge of the appropriate triage of patients suffering from blunt or penetrating trauma, with consideration of mechanism of injury and the patient's hemodynamic status.
2. Integrate laboratory data and hemodynamic parameters with knowledge of the location of injury, type of injury, and anatomic considerations in formulating an

appropriate treatment algorithm for patients suffering from potential traumatic vascular injuries.

3. Identify traumatic vascular injuries on diagnostic arteriography, including active extravasation or hemorrhage, pseudoaneurysm, arterial-venous fistula, arterial transection, traumatic occlusion, intimal flap, and intramural hematoma.
4. Demonstrate competence in selective catheterization skills, including the use of microcatheters and guidewires.
5. Demonstrate competence in transcatheter embolization techniques, including the delivery of various embolic materials such as coils, Gelfoam, particulate material (microparticles), and other agents.
6. Become familiar with the various angiographic equipment used in diagnostic arteriography, super-selective arteriography, and vascular embolization, with specific understanding of the characteristics of the different embolic materials with regards to their speed and reliability of delivery, duration of occlusive effect, preservation of normal tissue, and level of blockade of the arterial tree.
7. Recognize the potential role for vascular stents and covered stents in treating traumatic vascular injuries.
8. With regards to blunt and penetrating injuries to the liver and spleen:
  - a. Understand the roles of exploratory laparotomy and non-operative management in patients with traumatic hepatic injuries. List the indications and contraindications for hepatic artery embolization.
  - b. Demonstrate knowledge of the hepatic vascular anatomy, including the anatomic variants of the celiac, superior mesenteric and hepatic arterial anatomy.
  - c. Identify hepatic injuries on CT and angiography that may potentially be treated by transcatheter intervention, including active extravasation, hepatic artery pseudoaneurysm, arterial-venous fistula, or arterial-biliary fistula.
  - d. Become familiar with the success and complication rates for hepatic artery embolization in patients with penetrating or blunt injuries to the liver.
  - e. Understand the roles of exploratory laparotomy, splenectomy, and non-operative management in patients with splenic trauma.
  - f. Become familiar with the complications of splenectomy, including the frequency of overwhelming sepsis post-splenectomy.
  - g. Identify and stage splenic injuries on CT.
  - h. List the indications and contraindications for splenic artery embolization. Demonstrate knowledge of the different strategies for splenic artery embolization.

- i. Identify splenic injuries on CT and angiography that may potentially be treated by transcatheter intervention.
- j. Become familiar with the success and complication rates for splenic artery embolization in patients with splenic injury.

9. With regards to blunt and penetrating renal injuries:

- a. Understand the roles of operative and non-operative management of traumatic renal injuries.
- b. Identify traumatic renal injuries on CT and angiography, including urinoma, arterial extravasation, renal artery pseudoaneurysm, arterial-venous fistula, and traumatic arterial dissection.
- c. List the indications and contraindications for renal artery embolization in patients with renal trauma.
- d. Become familiar with the success and complication rates for renal artery embolization in patients with renal trauma.

10. With regards to blunt and penetrating injuries to the pelvis:

- a. Understand the limitations of surgical exploration in patients with pelvic hemorrhage.
- b. Understand the role of diagnostic arteriography and arterial embolization in hemodynamically stable and unstable patients.
- c. Become familiar with appropriate timing of pelvic arteriography with other interventions such as exploratory laparotomy or external fixation of pelvic fractures in patients with multiple traumatic injuries.
- d. Demonstrate knowledge of pelvic arterial anatomy, including an understanding of commonly injured vessels that are associated with specific patterns of pelvic fracture.
- e. Become familiar with different embolization strategies for pelvic hemorrhage, including both selective and non-selective (empiric) iliac artery embolization.
- f. Recognize the incidence of potential complications of pelvic embolization, such as ischemia, infarction, infection, non-targeted embolization, impotence, and claudication.

11. With regard to blunt and penetrating injuries to the extremities:

- a. Demonstrate competence in identifying various clinical findings of extremity arterial injury, such as pulse deficit, limb ischemia, bruit, or expanding hematoma.
- b. Understand the role of Doppler evaluation in patients with suspected arterial injury of the extremities.
- c. Identify traumatic arterial injury on angiography, with a specific understanding of which vessels are expendable and potential candidates for transcatheter embolization.
- d. Demonstrate knowledge of potential collateral pathways, and identify the role of embolization proximal and distal to the level of arterial injury.

## **OBJECTIVES: Portal Hypertension**

At the conclusion of fellowship training, the trainee will be able to:

1. Demonstrate a fundamental knowledge of chronic liver disease, including its causes and clinical manifestations.
2. Demonstrate a fundamental knowledge of portal hypertension, including its causes, clinical manifestations, and potential complications including ascites, hepatic hydrothorax, gastroesophageal varices, portal gastropathy, hepatorenal syndrome, and hepatic encephalopathy.
3. Evaluate laboratory data in patients with chronic liver disease, with a specific understanding of liver function studies and other parameters useful in classifying liver disease.
4. Perform a directed history and physical exam in patients with liver disease and portal hypertension.
5. Understand hepatic segmental anatomy, hepatic and portal venous anatomy, and common portosystemic collateral pathways.
6. Integrate patient clinical information into a classification scheme including the MELD and Child-Pugh scores.
7. List the medications and contraindications for transjugular intrahepatic portosystemic shunts.
8. Understand the potential advantages and limitations of various medical and surgical treatment options available for managing portal hypertension and its complications. This includes medical management, endoscopic interventions, and surgical shunting procedures for patients with gastroesophageal bleeding.
9. Demonstrate knowledge of the clinical success rates, patency rates, and complication rates reports for TIPS in current medical literature, including data comparing TIPS to endoscopic and surgical treatment options.
10. Demonstrate the role of TIPS in patients being considered for liver transplantation.
11. Demonstrate technical competence in the performance of the TIPS procedure, including venous access, hepatic vein cannulation, transhepatic cannulation of the portal venous system, intra-procedural portal and systemic pressure monitoring, wedge portal venography, and transhepatic tract formation with balloon dilatation and stent placement.

12. Understand the role of variceal embolization in patients undergoing TIPS for variceal bleeding. Demonstrate competence in the performance of variceal embolization.

13. Become familiar with the various interventional equipment used in the TIPS procedure including but not limited to guidewires, sheaths, catheters, balloons, covered stents, stents, embolic materials, and transhepatic cannulation kits.

14. Demonstrate an understanding of the normal ranges for portal venous pressures, central venous pressures, and portosystemic pressure gradients, including target ranges for post- TIPS portosystemic pressure gradients.

15. Recognize and manage intra- and post-procedural complications of TIPS, including but not limited to hemoperitoneum, hemobilia, biliary-shunt fistula formation, progressive liver failure, shunt thrombosis or occlusion, right heart failure, and hepatic encephalopathy.

16. Establish post-procedural shunt surveillance algorithms with an understanding of the appropriate clinical parameters to monitor, including duplex sonography and shunt velocity measurements.

17. Demonstrate competence in the performance of TIPS revision procedures, including but not limited to the management of shunt stenosis or occlusion.

18. Understand proper component coding for the TIPS procedure, including adjuvant interventions and such as variceal embolization and shunt revision.

### **OBJECTIVES: Central Venous Access**

At the conclusion of fellowship training, the trainee will be able to:

1. Appropriately evaluate patients with need for central venous access with regard to the type and duration of access and therapy required and use this information to choose an appropriate venous access device.

2. Evaluate patients who are receiving central venous access devices with physical examination and pre-procedure ultrasound in order to choose appropriate venous conduits.

3. Demonstrate technical competence in using ultrasound guidance to access peripheral veins and central veins for purposes of venous access.

4. Understand the risks and potential complications of each available central venous access device.

5. Properly evaluate patients with central venous access device malfunction and appropriately manage with thrombolytic infusion, catheter repositioning, catheter exchange or other techniques as indicated.
6. Evaluate patients with suspected catheter infection and/or catheter sepsis and manage these patient appropriately.
7. Demonstrate technical competence in placement of subcutaneous chest wall access devices including surgical techniques necessary for placement of these devices.
8. Be able to use adjunctive interventional techniques as necessary when placing central venous access devices such as balloon angioplasty, stent placement and/or thrombolysis.
9. Become familiar with alternative venous access techniques (i.e., translumbar, transhepatic, etc.) when conventional venous access conduits are thrombosed.
10. Recognize the signs and symptoms of air embolization and understand strategies to reduce the incidence of air embolism during placement of central venous access devices as well as acute intraprocedural management in patients with massive air embolization.
11. Recognize the signs and symptoms of venous access device catheter fracture and understand the principles and technique of intravascular foreign body retrieval.

### **OBJECTIVES: Hemodialysis Access Interventions**

At the conclusion of fellowship training, the trainee will be able to:

1. Demonstrate understanding of the general principles outlined in the Kidney/Dialysis Outcomes Quality Initiative for Vascular Access (K/DOQI) including the need for increased creation of autogenous arteriovenous fistulas, surveillance of fistulas with early intervention to prevent access failure and decreased dependence on catheter dialysis.
2. Understand the basic nomenclature for hemodialysis access including a basic understanding of PTFE graft configurations, locations and expective outcomes after creation, basic understanding of autologous fistula creation including types, location and expected outcomes.
3. Identify the preferred order for creation of autologous autogenous fistulas and synthetic grafts.

4. Integrate the pre-operative work-up of a patient having hemodialysis access created including vascular venous ultrasound, contrast venography including alternative contrast agents, MR venography and CT venography.
5. Demonstrate basic understanding of the pathophysiology of arteriovenous access failure including the typical clinical presentation or problem with dialysis identified with the following: central venous lesions, venous anastomotic lesions, arterial inflow lesions, failure of maturation of a native fistula and others.
6. List the surveillance methods for vascular access and their advantages and disadvantages including physical examination, volume flow methods, Doppler ultrasound evaluation, pressure measurements and recirculation.
7. Become familiar with the clinical signs of access failure: prolonged post dialysis bleeding, decreased Kt/V, decreased creatinine clearance, arm edema and steal syndrome.
8. Understand the literature basis for surveillance and prophylactic angioplasty or surgical revision in hemodialysis access grafts or fistulae.
9. Perform a directed history and physical examination in patients with failed or failing hemodialysis access.
10. Identify the indications and contraindications for endovascular and surgical interventions for failing and thrombosed dialysis fistulae and grafts.
11. Understand the various techniques of “declotting” a thrombosed access including pharmacologic thrombolysis, pharmacomechanical thrombolysis and mechanical thrombolysis.
12. List the available mechanical thrombectomy devices and their advantages and disadvantages.
13. Identify the indications for stent placement in this patient population.
14. List the potential complications of percutaneous interventions in dialysis grafts and fistulae and their management.
15. Demonstrate knowledge regarding the incidence of central vein stenosis in this patient population knowledge of the risk factors, prevention strategies and treatment strategies for central venous stenosis.
16. Demonstrate technical competence in the performance of the above-mentioned percutaneous interventions in dialysis grafts and fistulae.
17. Understand the indications and contraindications for placement of temporary

hemodialysis catheters with imaging guidance including the DOQI guidelines for maximum recommended duration of temporary catheters.

18. Understand the preferred venous access sites for placement of hemodialysis catheters. Evaluate patients with physical examination and ultrasound prior to placement of hemodialysis catheters.

19. Become familiar with a number of different tunneled hemodialysis catheters and their advantages and disadvantages.

20. Properly evaluate the patient with a malfunctioning hemodialysis catheter and understand the basic causes of catheter malfunction.

21. Understand the expected outcomes following interventions in patients with malfunctioning hemodialysis catheters.

22. Appropriately treat patients with infected hemodialysis catheters.

23. List alternative access possibilities when conventional venous access conduits are not available for placement of hemodialysis catheters.

24. Understand percutaneous radiologic placement of peritoneal dialysis catheters and their management.

### **OBJECTIVES: IVC Filter Placement/Pulmonary Thromboembolic Disease**

At the conclusion of fellowship training, the trainee will be able to:

1. Perform a directed history and physical exam in patients with thromboembolic disease.
2. Integrate non-invasive testing, vascular imaging, and physical findings to plan optimal access for IVC filter placement.
3. Identify the indications for IVC filter placement and pulmonary angiography in patients with venous thromboembolic disease and understand medical and surgical treatment options in these patients.
4. List the complications of pulmonary angiography, inferior vena cavography, vascular access, and IVC filter placement and their incidence as documented in the literature.
5. Become familiar with a wide range of interventional equipment including but not limited to guidewires, catheters, and IVC filters.

6. Understand the potential advantages and limitations of various types of filters including the maximal caval diameter in which each type of device may be placed.
7. Demonstrate technical competence in the performance of pulmonary angiography, inferior vena cavography and IVC filter placement and retrieval.
8. Understand anatomic variants and pathology identified at inferior vena cavography that will affect the location of the IVC filter deployment.
9. Appropriately classify patients with acute and chronic thromboembolic disease based on history and physical as well as physiologic and imaging findings.
10. Integrate the use of intraprocedural pressure monitoring in performing pulmonary angiography.
11. Understand preprocedural, intraprocedural and postprocedural pharmacological management for patients undergoing IVC filter placement including anticoagulation.
12. Understand proper component coding for vena cavography, pulmonary angiography, and IVC filter placement/removal.

### **OBJECTIVES: Evaluation and Management of Vascular Malformations**

At the conclusion of fellowship training, the trainee will be able to:

1. Classify endothelial malformations according to their clinical presentation and natural history.
2. Understand various classification schemes for vascular malformations.
3. Evaluate patients with vascular malformations and categorize lesions as either high-flow or low-flow based on physical examination and imaging findings.
4. Order appropriate imaging studies to evaluate the extent and nature of patients presenting with vascular malformations.
5. Understand the need for multidisciplinary need for management of patients with vascular malformations.
6. Recognize the clinical presentation of patients with low-flow vascular malformations and the indications for treatment of these lesions.
7. Understand the basic principles of treating patients with low-flow vascular malformations and the potential complications of treating these lesions.

8. Understand the clinical presentation of patients with high-flow vascular malformations and the indications for treatment of these lesions.
9. Understand the basic principles and agents used in treatment of high-flow vascular malformations.
10. List the potential risks and complications of treatment of high-flow vascular malformations.
11. Understand when patients with vascular malformations should be referred to large centers with concentrated experience in treating these patients.

## **NON-VASCULAR INTERVENTIONS**

**GOALS:** At the conclusion of fellowship training, the trainee will be able to:

1. Demonstrate learning of the topic specific educational objectives.
2. Understand proper patient selection and therapeutic options for the interventional procedure described below.
3. Understand pre-procedure evaluation and post procedure management and follow-up for these procedures and patients.
4. Obtain complete and appropriate informed consent for all procedures.
5. Demonstrate technical competency in the performance of these procedures.

### **OBJECTIVES: Image-Directed Biopsy**

At the conclusion of fellowship training, the trainee will be able to:

1. Describe advantages and disadvantages of various imaging modalities for biopsy of the chest, cervical region, abdomen and musculoskeletal lesions.
2. List the indications and contraindications for transthoracic needle biopsy.
3. Identify alternatives to transthoracic biopsy for patients with central subcorinal masses, such as bronchoscopic biopsy.
4. Become familiar with a variety of biopsy needles and techniques including the use of CT fluoroscopy and various targeting technologies for difficult lesions.
5. Appropriately manage pre-procedure work-up including appropriate laboratory values.
6. Recognize which lesions are best approached with fine needle aspiration versus core biopsy as well as when to send the material for microbiologic evaluation if infection is suspected.
7. Appropriately treat patients with post biopsy pneumothorax including placement and management of a chest tube when necessary.
8. Identify safe approaches to percutaneous biopsy of lesions in the abdomen including retroperitoneal lymph nodes, pancreatic lesions, hepatic lesions and others.
9. Become familiar with treatment algorithm of patients experiencing significant

hemorrhage following intra-abdominal biopsy.

**OBJECTIVES: Image-Directed Fluid Aspiration and Drainage**

At the conclusion of fellowship training, the trainee will be able to:

1. Describe the indications and contraindications of diagnostic aspiration of pleural fluid collections and percutaneous chest tube drainage of complicated pleural effusion/empyema.
2. Integrate available imaging modalities (CT, US and fluoroscopy) as needed for accomplishing safely the drainage of thoracic fluid collections.
3. Demonstrate technical competence in imaging-guided placement of tube thoracostomy and become familiar with the various catheters available for this purpose.
4. Demonstrate a fundamental knowledge of chest tube drainage systems including water seal drainage systems and evaluation for persistent air leaks in patients with pneumothoraxes.
5. Properly manage patients following tube thoracostomy with catheter exchange and repositioning as necessary.
6. Explain the role of fibrinolytic agents as an adjunct to treating patients with loculated and/or complex pleural fluid collections.
7. Understand the alternatives to tube thoracostomy including surgical drainage and pleurodesis.
8. Demonstrate basic knowledge of chemical sclerotherapy techniques for pleurodesis.
9. Integrate a variety of imaging modalities (CT, US and fluoroscopy) to optimize percutaneous drainage of intra-abdominal abscesses.
10. Understand the advantages of CT fluoroscopy in accessing difficult fluid collections and placing drainage catheters.
11. Become familiar with a wide variety of drainage catheters and guidewires for the purposes of percutaneous abscess drainage.
12. Identify abscess cavities which may require placement of more than one catheter to provide complete drainage.

13. Identify the safest and most expeditious route of drainage for abscess collections in various anatomic locations throughout the abdomen and pelvis.
14. Provide optimal follow-up care for patients status-post percutaneous abscess drainage with sinograms and repositioning or replacement of abscess drainage catheters as necessary.
15. Understand when percutaneous abscess drainage catheters can be removed.
16. Identify loculated and/or septated collections which may benefit from instillation of fibrinolytic agents to help aide in complete drainage.
17. Understand the evolution of pancreatic fluid collections and the timing and indication for drainage of pancreatic fluid collections.

**OBJECTIVES: Hepatobiliary Interventions**

At the conclusion of fellowship training, the trainee will be able to:

1. Understand the various clinical presentations in patients with benign and malignant biliary strictures including obstructive jaundice, cholangitis and biliary colic.
2. Integrate proper pre-procedure imaging work-up in patients with benign and malignant biliary obstruction.
3. Utilize intraprocedural ultrasound to guide percutaneous transhepatic cholangiography.
4. List the major complications associated with percutaneous transhepatic cholangiography and biliary drainage and management of these complications.
5. Recognize patients at high risk for sepsis following biliary interventions and understand how to treat post procedural sepsis should it occur.
6. Become familiar with a wide array of percutaneous biliary access systems, internal /external biliary stents and internal biliary endoprotheses.
7. Demonstrate appropriate post procedure management following biliary drainage procedures including conversion to internal drainage, biliary stent care and biliary stent exchange.
8. Identify patients who will benefit from metallic biliary stents.
9. Describe various methods for obtaining biopsies and/or cytology of biliary strictures.

10. Demonstrate facility with various techniques of percutaneous management of biliary calculi and including fiberoptic cholangioscopy and electrohydraulic lithotripsy.

12. Describe management of patients with arterial biliary fistulae following percutaneous biliary drainage.

### **OBJECTIVES: Genitourinary Interventions**

At the conclusion of fellowship training, the trainee will be able to:

1. Understand the indications for percutaneous nephrostomy and the advantages and disadvantages of percutaneous approach versus other surgical approaches to this patient population.
2. Integrate the pre-procedure imaging work-up in patients with urinary obstruction, renal calculi or other conditions requiring urinary diversion.
3. Utilize ultrasound to guide percutaneous access into the renal collecting system.
4. Become familiar with a wide variety of percutaneous access systems, nephrostomy tubes, ureteral stents and nephroureteral stents and the indications for each.
5. Demonstrate technical competence in placement of percutaneous nephrostomy tubes and ureteral stents.
6. Identify methods for obtaining pathologic or cytologic analysis of urinary strictures or tumors.
7. Describe management of ureteral strictures in renal transplant patients.
8. List the potential complications for percutaneous nephrostomy and their management.
9. Understand and direct long-term management of patients with chronic benign urinary strictures and/or chronic need for urinary diversion.

### **OBJECTIVES: Gastrointestinal Interventions**

At the conclusion of fellowship training, the trainee will be able to:

1. Identify patients who are candidates for percutaneous gastrostomy and percutaneous gastrojejunostomy.

2. List the contraindications to percutaneous gastrostomy and percutaneous gastrojejunostomy.
3. Consider ethical factors prior to placement of enteral feeding access in this patient population.
4. Demonstrate technical competence in placement of percutaneous gastrostomy and percutaneous gastrojejunostomy.
5. Become familiar with a wide variety of percutaneous gastrostomy and gastrojejunostomy tubes as well as retention systems.
6. Recognize and treat properly complications following percutaneous gastrostomy including gastric bleeding.
7. Identify patients whom may benefit from a direct percutaneous jejunostomy and understand the basic principles of this procedure.
8. List indications for percutaneous cecostomy tube placement.

**OBJECTIVES: Spinal Intervention – Vertebral Body Compression Fractures (VBCF)**

At the conclusion of fellowship training, the trainee will be able to:

1. Understand the pathophysiology of osteoporosis and neoplastic disease as it relates to the spine.
2. Appropriately identify patients with symptomatic VBCF.
3. Perform a directed history and physical exam in patients with VBCF.
4. Integrate non-invasive testing (CT, MRI, Nuclear Medicine Scintigraphy), physical findings and past surgical history to identify symptomatic levels.
5. Identify the indications for percutaneous vertebroplasty (PV) inpatients with VBCF and understand medical and surgical treatment options in these patients.
6. Demonstrate knowledge of proper vertebral body access techniques (transpedicular, parapedicular).
7. Categorize VBCF as to their appropriateness and expected response for treatment with percutaneous techniques.

8. List the complications of PV and their incidence as documented in the literature for VBCF secondary to osteoporosis and neoplastic spinal involvement.
9. Become familiar with interventional equipment used in PV including but not limited to cement delivery systems, needles, bone cements (PMMA), and opacification agents.
10. Understand preprocedural, intra-procedural and postprocedural pharmacological management for patients undergoing PV including conscious sedation, narcotic and nonnarcotic analgesics.
11. List the absolute and relative contraindications to PV.
12. Communicate effectively with the referring physicians.
13. Dictate clear and concise procedure reports.
14. Understand proper component coding for PV.
15. Identify patients who may benefit from kyphoplasty and the differences between kyphoplasty and vertebroplasty.

Modified from the Society of Interventional Radiology Curriculum,  
*Rilling WS, Beres RA, Brown D, Davis A, Gray R, Ho J, Kazanjian S,  
Montgomery M, Morello F, Muetterties K, Murray K, O'Moore P, Thomas J,  
Walser E.*