My Top Tips for a New Fellow Starting in the Cath Lab

Morton J. Kern, MD

Well, it's July again. Last August 2022, our *CLD* editor's page talked about what a new team member (fellow, nurse, technologist) should do on day 1 in the cath lab.[1] It is time to begin again, working with our new fellows, new attendings, and maybe some new cath lab nurses and techs. Interestingly, I have been watching my emails and twitter feeds promoting fellows' education, courses, and boot camps. I particularly enjoy and admire the twitter site of Jay Mohan, DO, FACC (#FellowBootCamp), who has beautifully illustrated several tips on angiography, access, and other keys to success in the cath lab. It is gratifying to see the next generation of cardiologists emerge as clinicians and teachers.

Since many fellows may be overwhelmed in the first weeks of their training, I thought I would share some of my boot camp tips, which are a small part of the annual cath lab orientation lectures for our fellows.

Join the Team

The first step of working in the cath lab is joining the team. Table 1 lists the steps undertaken to learn how to do cardiac catheterization. Becoming a member of the team requires getting to know the staff, their jobs, their routines. Professionalism, courtesy, and curiosity will help you succeed in the cath lab. The nurses and techs have a wealth of knowledge, and they will be pleased to help educate their doctors. Figure 1 shows Dr. Seto and Nurse DeRocco in the VA Long Beach Cardiac Cath Lab. Working in the cath lab is a team sport. The number and complexity of procedures performed in the cath lab is amazing. Fellows cannot learn them all, but should become familiar with the most common in the first weeks of their rotation (Table 2).

TABLE 1. Steps for new fellows to learn cardiac catheterization.

1.	Join the team
2.	Review the patient with the attending
3.	Learn lab setup and routine, assist and observe
4.	Vascular access
5.	Catheter insertion and placement
6.	Angiography
7.	Ventriculography
8.	Hemostasis
9.	Post procedure care
10.	Documentation and billing

Know Your Patient

Review the chart, clinical presentation, and the patient's physical exam, and discuss it with the attending. A major goal of the initial lab experience is to understand the indications and contraindications (Tables 3-5). Review the guidelines supporting the indication. The operating physician or designee should obtain the patient's consent.[2] Recently informed consent for cath lab sites without an on-site center is a statement indicating that emergency transfer for surgery is a possibility.

Most procedures are routine and proceed without delay as scheduled. In some patients, a condition may arise which is a relative contraindication (eg, continued anticoagulation, new electrolyte abnormalities). Good judgment is required before proceeding in the face of a potential problem. While it is often easier to do the procedure, there should always be a clear and defensible indication. Elective procedures should be postponed if any of the relative contraindications are present. Life-threatening presentations requiring cath lab interventions can proceed with the increased risks explained and consent obtained.

Figure 1. Join the team. Part of learning the routine is working with the staff. Get to know the lab staff wherever you go. They are a great source of knowledge. (Left) Dr. Arnold Seto and a fellow at VA Long Beach Cardiac Cath Lab. (Right) Lynn DeRocco, RN, helps fellows get oriented. Working in the cath lab is a team sport.

TABLE 2. Cardiac cath lab procedures.

Diagnostic Studies	Therapeutic Interventions
• Coronary angiography	• PCI – balloon, stents, roto, IVL
• Ventriculography	• Thrombolysis, coil embolization
• Hemodynamics	• CardioMEMS monitor (Abbott Vascular)
• Shunt detection	• EP devices/procedures
• Ao, carotid, peripheral angiography	• Structural heart intervention
• Pulmonary angio	• Valves
• Coronary physiology testing	• Shunts
• Endomyocardial biopsy	• HCM
• EP mapping	• PVD

Ao, aortic; EP, electrophysiology; PCI, percutaneous coronary intervention; roto, rotational atherectomy; IVL, intravascular lithotripsy; HCM, hypertrophic cardiomyopathy; PVD, peripheral vascular disease

Professionalism, courtesy, and curiosity will help you succeed in the cath lab.

TABLE 3. Indications for cardiac catheterization.

•	Determine the extent and severity of CAD
•	Establish causes of chest pain
•	Assessment of valvular heart disease
•	Assessment of cardio-myopathy and pericardial disease
•	Assessment of congenital heart disease
•	Confirm and complement noninvasive studies
•	Pulmonary hypertension and etiology of dyspnea
•	Pre-procedure evaluation re: surgery, EP, other

CAD, coronary artery disease; EP, electrophysiology

TABLE 4. Contraindications to cardiac catheterization.

Absolute contraindications: NONE	
Relative contraindications:	
•	Severe, uncontrolled hypertension
•	Ventricular arrhythmias
•	Acute stroke
•	Severe anemia
•	Active gastrointestinal bleeding
•	Allergy to radiographic contrast
•	Acute renal failure
•	Uncompensated congestive failure (patient cannot lie flat)
•	Unexplained febrile illness and/or untreated active infection
•	Electrolyte abnormalities (eg, hypokalemia)
•	Severe coagulopathy

TABLE 5. Indications for right heart cath and hemodynamics studies.

•	Dyspnea – etiology?
•	Pulmonary hypertension vasoreactivity
•	Confirm echo findings
•	Confirm new clinical findings
•	Routine for teaching centers
•	Special studies and research

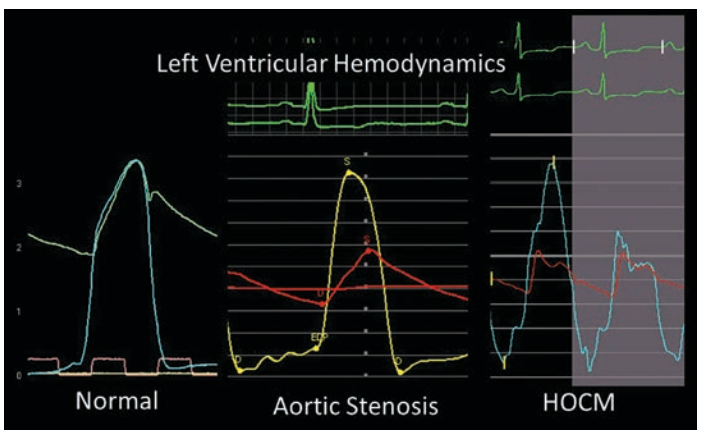

Figure 2. (Left to right) Examples of simultaneous aortic and left ventricular pressures in normal, aortic stenosis, and hypertrophic obstructive cardiomyopathy (HOCM) patients.

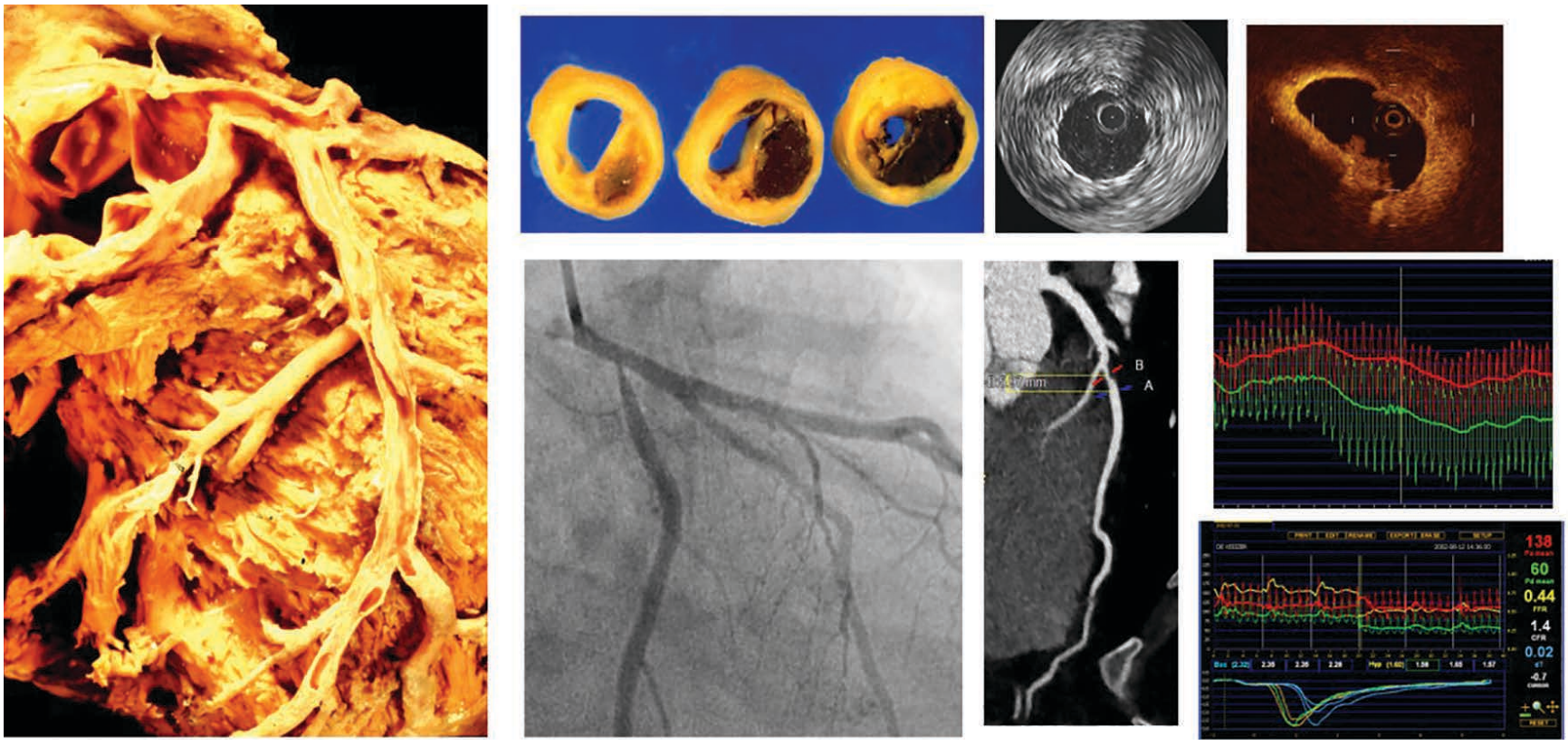

Figure 3. Adjunctive modalities for the assessment of coronary stenoses. (Left) Pathologic specimen showing coronary artery disease and left anterior descending (LAD) stenosis. (Middle top) Ring segments of coronary artery showing a preserved lumen in the left ring, but plaque rupture in the center and right ring segments. The lumenograms may be hard to interpret because of eccentricity. (Top right) Images show an intravascular ultrasound image and optical coherence tomographic image providing enhanced detail of the lumen and vessel wall. Middle bottom is right anterior oblique (RAO) left coronary angiogram frame with an ostial circumflex (Cx) narrowing. (Bottom 2nd from right) Computed tomography angiography (CTA) image. (Far right) Tracing from transluminal coronary pressure to measure fractional flow reserve and (lower far right) thermodilution flow tracings to measure coronary flow reserve and index of microvascular resistance.

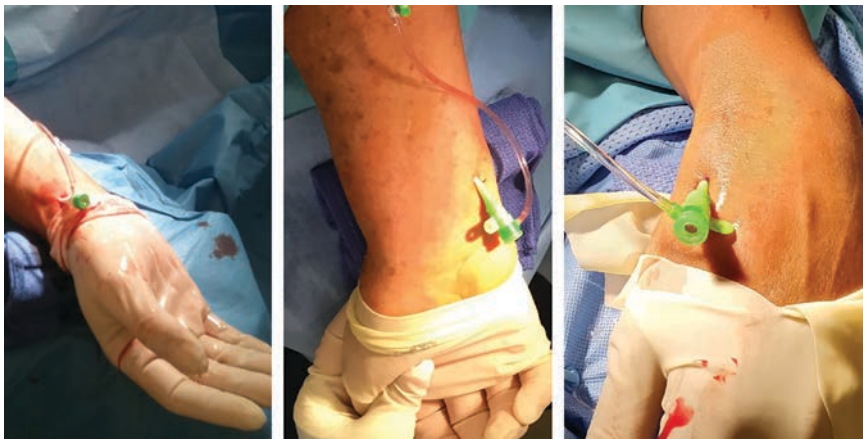

Figure 4. Learn radial and femoral access well. Most morbidity of cardiac cath comes from a vascular access accident, more with femoral than radial. Use vascular ultrasound imaging to facilitate safe, accurate, and quick vascular access. (Left) Radial artery access, (middle) ulnar access, (right) distal left radial access.

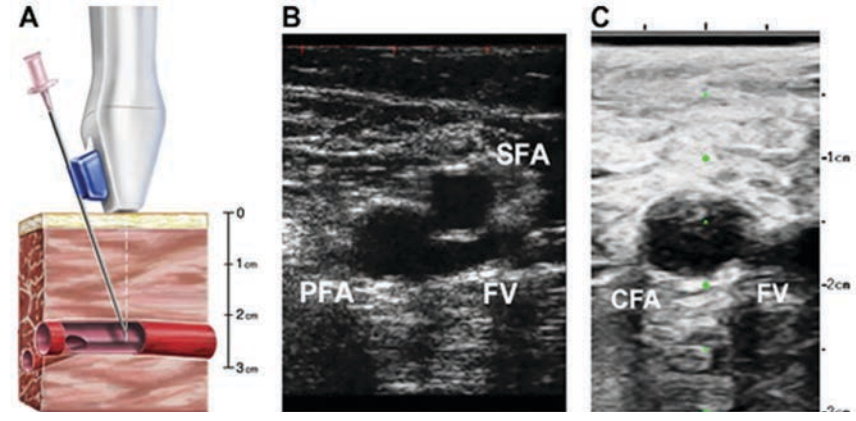

Figure 6. Ultrasound guidance. (A) The attached needle guide fixes the needle's angle of entry to intersect the vessel at the imaging plane 1.5 cm, 2.5 cm, or 3.5 cm below the skin, depending upon the guide chosen. The vessel bifurcation is kept inferior to the probe at the time of insertion. (B) The right femoral artery bifurcation is imaged in the axial plane, identifying the separation of the profunda femoral artery (PFA) and superficial femoral artery (SFA). Compression is used to differentiate arteries from the femoral vein (FV). (C) The probe is moved superiorly until the common femoral artery (CFA) is visualized. During needle advancement, the anterior wall of the vessel is kept under the central target line (green circles), which indicates the path of the needle. *Reprinted with permission from Seto AH, et al. Real-time ultrasound guidance facilitates femoral arterial access and reduces vascular complications: FAUST (Femoral Arterial Access With Ultrasound Trial). JACC Cardiovasc Interv. 2010 Jul;3(7):751-8. doi: 10.1016/j.jcin.2010.04.015*

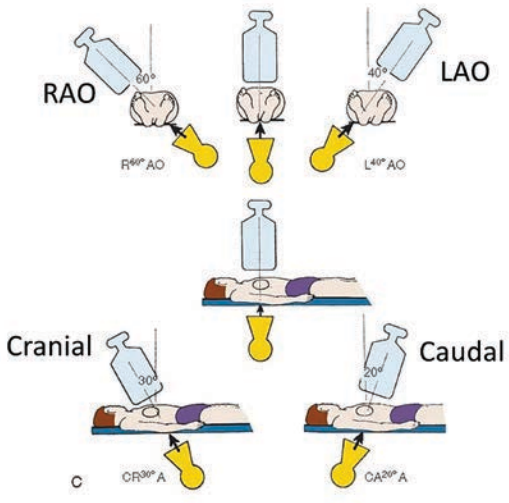

Figure 7. Radiographic nomenclature for angulations for coronary angiography.
Modified from Kern MJ, Kern's Cardiac Catheterization Handbook, 2019.[7]

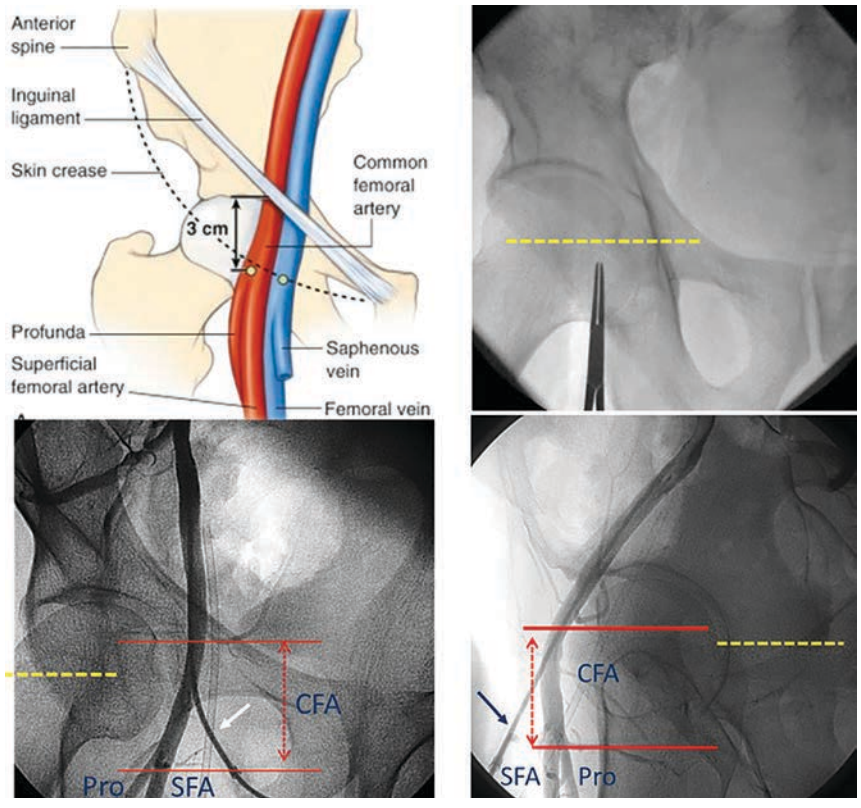

Figure 5. (Top left) Diagram of femoral artery and vein. (Right top) Fluoroscopic localization of the skin nick (marked by the tip of the clamp). The middle of the femoral head is marked by the dashed yellow line. (Bottom left) Frame from angiogram of sheath in the femoral artery with a catheter (open arrow) inserted in the common femoral artery (CFA). The CFA is bounded by the lower red line of the bifurcation of the superficial femoral artery (SFA) and profunda (PRO) branches, and the upper red line of the inferior epigastric artery. (Bottom right) Lateral view of Cx (bounded by red lines) showing the relationship between the CFA and the bony femoral head, making manual compression effective.
Modified from Kern MJ, Kern's Cardiac Catheterization Handbook, 2019.[7]

Learn Lab Routine

As a new member of the cath team, come into the lab with an open mind, open ears, and closed mouth. Observe how things are done. Participate in the setup of the table and equipment so you know what is there and what you might have to ask for. Share what you know about the patient. Highlight what might be potential problems. Outline your plan for the procedure.

To the novice, each study will provide a new stimulus to ask the "what, why and when" of techniques. I also suggest to the curious fellow that there is a time during a procedure for conversation and there is a time when questions to the operators may be distracting. You will quickly learn when to ask and when to wait. As the month progresses, fellows will have a chance to perform hemodynamic studies[3] (Figure 2), physiologic lesion assessment, and intravascular imaging (Figure 3). For interventional fellows, your focus will be on percutaneous coronary intervention (PCI) and structural procedures. In the periods between interventional cases, the interventional cardiology fellow can hone his diagnostic cath and hemodynamic measurement skills.

Vascular Access

For every cath case, safe vascular access is the key to reducing morbidity and in some cases mortality. Learn both radial and femoral access well (Figures 4-5). Become an expert with ultrasound imaging, needle handling, sheath insertion, and hemostasis. Use vascular ultrasound imaging to facility safe, accurate, and quick vascular access (Figure 6). Watch how your attending overcomes the challenges of access, and how catheters are introduced and manipulated. Sometimes you may feel a need to rush through the steps. Employ the U.S. Navy SEAL Team motto, "Slow is smooth, smooth is fast", which means that taking the time to master the fundamentals results in the best possible outcome.

For femoral artery access, use fluoroscopy for initial localization of the site for a skin nick (marked by the tip of the clamp).[4] Then apply ultrasound to visualize the common femoral artery, defined by the bifurcation of the superficial femoral artery and profunda branches, and the inferior epigastric artery.

Coronary Angiography

Fellows should focus on learning coronary angiography and all its components in detail. Start with understanding the angulations, projections, and develop good radiation safety habits. Figure 7 depicts x-ray angulations that are used to separate

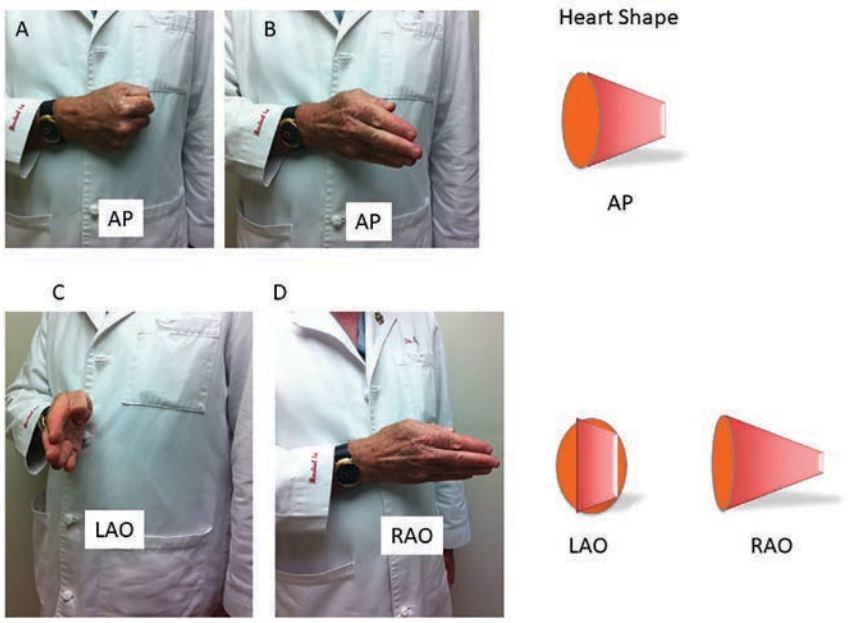

Figure 8A. (A) Anterior-posterior (AP) view of heart (closed fist) in chest. (B) AP view of left ventricular (LV) shape (open hand) in chest. Diagram to right shows approximate shape as might be seen on x-ray. (C) Left anterior oblique (LAO) (left shoulder forward) rotation causes foreshortening of LV with apex toward viewer and rounding of cardiac silhouette (diagram at right, LAO). (D) Right anterior oblique (RAO) (right shoulder forward) causes the heart to elongate as it rotates with tip of heart to the left side. Diagram on right shows LV image as it might appear on x-ray.

Reprinted with permission from Kern MJ. Cath Lab Digest 2011 Aug. Copyright HMP Global.

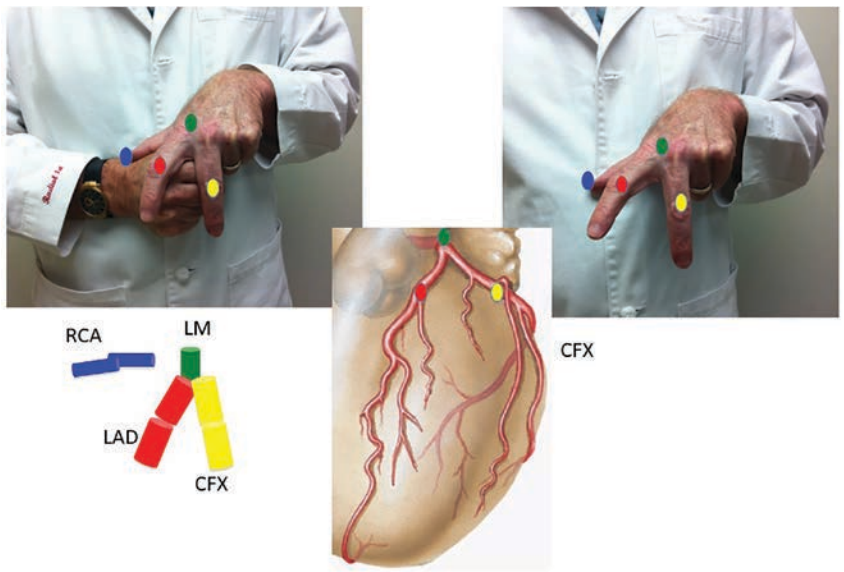

Figure 8B. (Top left) The fingers of the left hand represent the coronary arteries. The colored bars depict the coronary arteries of the drawing in the center. When placed over the heart (fist), the left anterior descending (LAD) (red, index finger) runs down the anterior interventricular groove. The circumflex artery (yellow, middle finger) runs over the left side of the fist. The proximal portion of the right coronary artery (RCA) (blue, thumb) starts at the top of the fist and runs to the wrist then down the atrioventricular (AV) groove (wrist). The posterior descending artery (PDA) will be shown below. (Top right) The coronary arteries (fingers) are shown with the heart (fist) removed in the anterior-posterior (AP) projection. The green block represents the left main artery (LM) segment position.

Reprinted with permission from Kern MJ. Cath Lab Digest 2011 Aug. Copyright HMP Global.

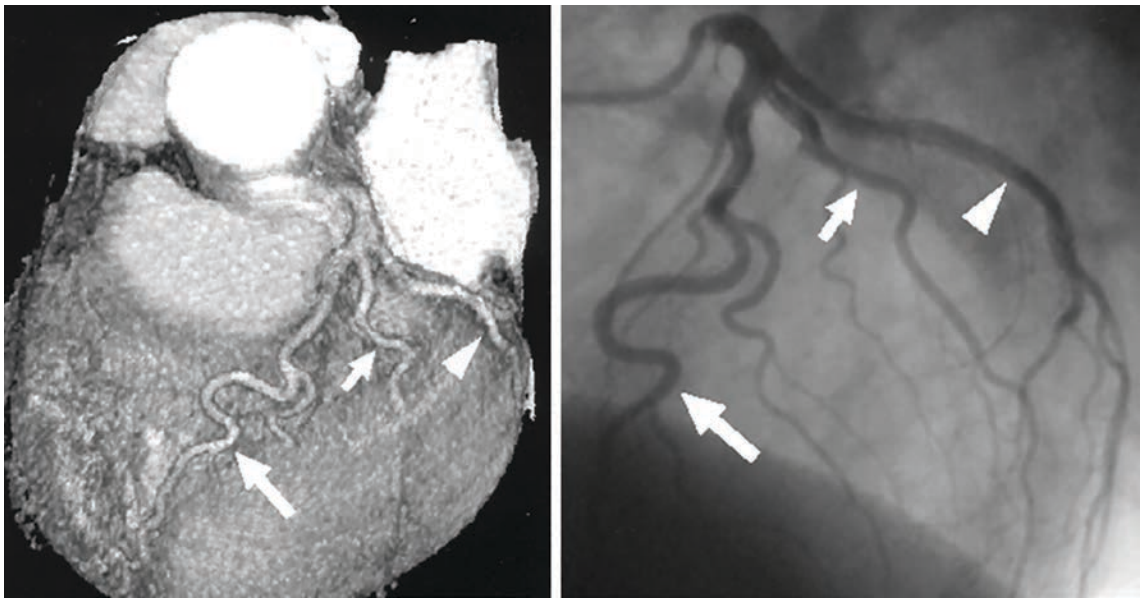

Figure 9. Coronary anatomy can be demonstrated by computerized tomography (CTA) (left) or by contrast-filled coronary by catheter cannulation techniques (right). CTA is a 3-dimensional representation of the arteries, the vessel walls and lumen, and the surrounding structures. In contrast, the lumenograms of contrast catheter angiography show only the lumen of the artery and require multiple views to define the course of the vessels.

vessels and more clearly demonstrate the angiographic anatomy. Each angiographic view should be described in 2 planes, ie, left anterior oblique (LAO)/right anterior oblique (RAO) and cranial/caudal/anterior-posterior (AP). Use the correct nomenclature to eliminate confusion about what you are trying to convey about coronary disease. There are several excellent aids to seeing the pathways of the arteries around the heart[5] (Figure 8). Become an expert at coronary and cardiac chamber anatomy.

Coronary anatomy (Figure 9) can be demonstrated non-invasively by computerized tomography (CTA) or invasively by contrast catheter cannulation techniques. Recall that CTA is a 3-dimensional representation of the arteries, the vessel walls and lumina, and the surrounding structures. In contrast, contrast catheter angiography is a 2-dimensional image or lumenograms showing the artery in a single plane without vessel wall detail. Coronary angiography requires multiple views to define the course of the vessels.

The names of coronary branch anatomy are straightforward. The left coronary artery (Figure 10A) has 7 named branches; the left main trunk gives rise to the left anterior descending (LAD) and circumflex (Cx) arteries. Subbranches from the LAD are the septals and diagonals. The circumflex subbranches run transversely to the margin of the heart, hence the name, obtuse marginals.

The right coronary artery branches are named after structures supplied (Figure 10B). Beginning at the sinus of Valsalva, the sinoatrial branch runs posteriorly to the top of the right atrium and the conus artery runs anteriorly over the pulmonary outflow tract. Along the course of the right coronary artery (RCA), marginal branches supply the anterior aspect of the right ventricle. On the bottom of the heart, the RCA branches into the posterior descending, running the inferior intraventricular groove, and the posterior lateral branches, supplying the inferior lateral wall.

Contrast left ventriculography is still part of coronary angiography but information on left ventricular (LV) function comes from the echocardiogram. The LV end diastolic pressure (LVEDP) is also informative and easy to obtain after the angiogram. The LVEDP can be obtained with an end hole coronary catheter but only pigtail catheter should be used for ventriculography.[6] Contrast ventriculography provides additional information about the ejection fraction, any mitral regurgitation, and LV wall motion abnormalities. Ventriculography is mostly performed in the RAO view. The septal and lateral LV walls can be visualized in the LAO view with cranial angulation (Figure 11).

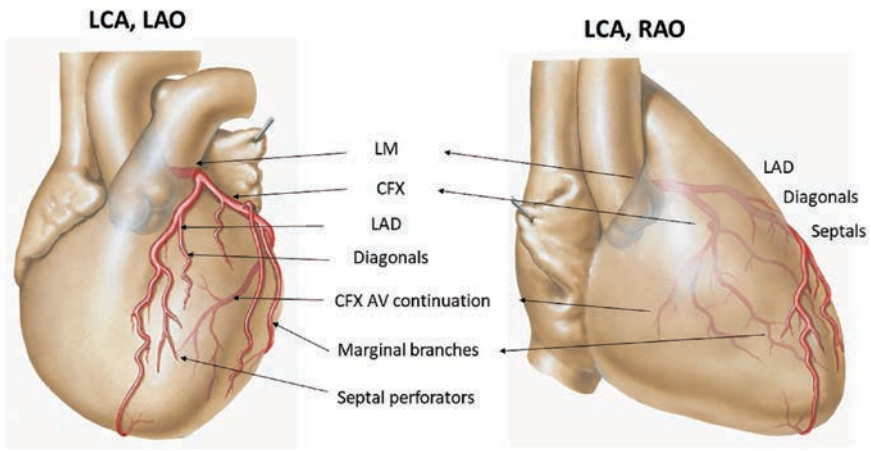

Figure 10A. The left coronary artery (LCA) shown in the left anterior oblique (LAO) and right anterior oblique (RAO) views. *Reprinted with permission from The Netter Collection (Images #62241, 62244). © 2005–2023 Elsevier. All Rights Reserved.*

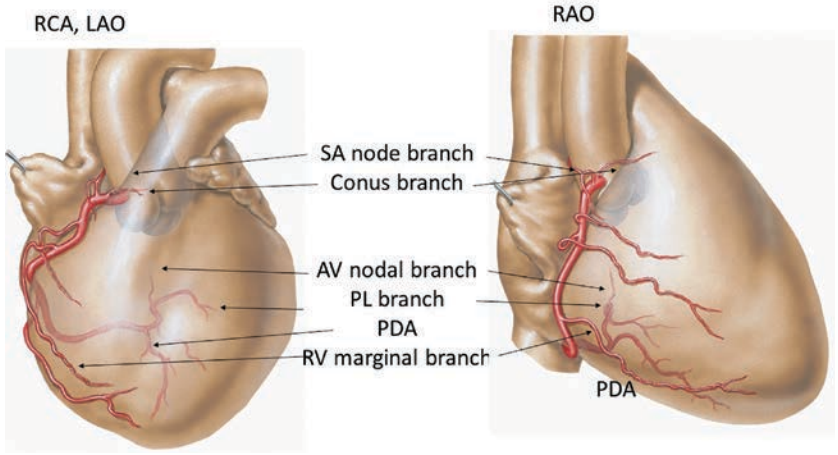

Figure 10B. The right coronary artery (RCA) in LAO (left) and RAO (right). SA, sinoatrial branch, AV, atrioventricular branch, PL posterior lateral branch, RV, right ventricle, PDA, posterior descending artery. *Reprinted with permission from The Netter Collection (Image #52110). © 2005–2023 Elsevier. All Rights Reserved.*

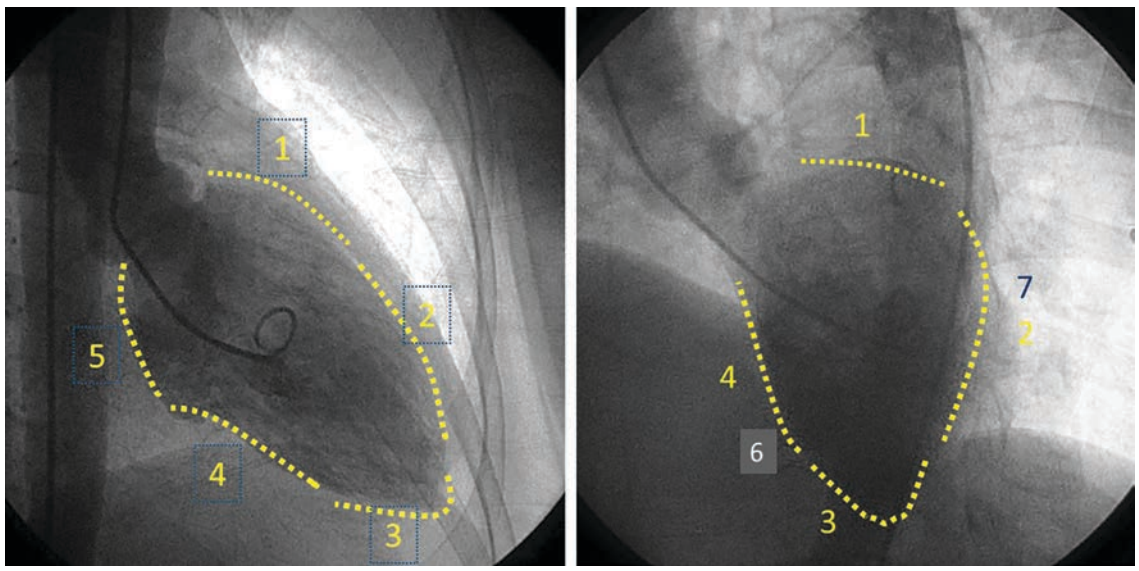

Figure 11. Nomenclature of the left ventricular silhouette. Left ventriculograms in right anterior oblique (RAO) (left) and left anterior oblique (LAO) with cranial angulation (right). The RAO segments are (1) anterior basal, (2) anterior, (3) apical, (4) inferior, (5) inferior basal. In the LAO projection, the apex of the heart is tipped downward. The LAO segments are (1) basal, (2) lateral, (3) apical, (6) septum, (7) lateral wall.

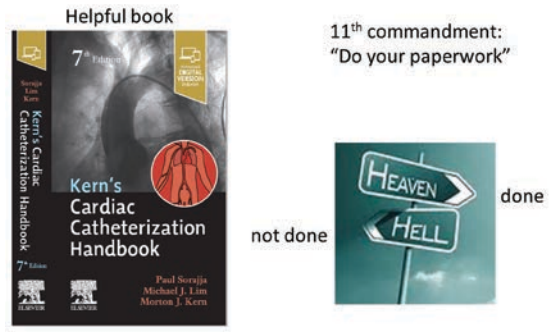

Figure 12. A helpful book[7] and the fellow's 11th commandment of cath lab operations, "Do your paperwork".

Adjunctive Tools for Angiography

Because angiography does not always demonstrate severe lesions that cause ischemia, adjunctive tools that provide lesion-specific anatomic and physiologic information are available. Figure 3 illustrates the pathology of coronary disease, limitations of angiography and intravascular imaging (intravascular ultrasound [IVUS] and optical coherence tomography [OCT]) and translesional coronary physiology (fractional flow reserve [FFR], nonhyperemic diastolic pressure ratio [NHPR], and thermodilution coronary flow). As the fellow learns angiography, application of these important adjunctive modalities will be critical for best decision making.

The Bottom Line

For new fellows, the initial cath lab experience is daunting. With time, merging into the team, becoming adept at angiographic techniques, and ultimately, becoming an independent operator will occur. Knowledge to support the invasive cath lab experience will come from your colleagues, your reading, the lecturers, the internet and other media, and the cath lab staff. From a personal point of view, I hope the fellows will grow to love the lab as much as I and my teams do. Finally, despite a bit of shameless promotion, I recommend *Cardiac Catheterization Handbook*[7] as a good reference and advise all fellows to follow the cath lab's 11th commandment (Figure 12). ■

References

1. Kern MJ. What should a new team member do on day 1 in the cath lab? *Cath Lab Digest*. 2022 Aug; 30(8): 6-8. https://www.hmpgloballearningnetwork.com/site/cathlab/clinical-editors-corner/what-should-new-team-member-do-day-1-cath-lab
2. Kern MJ, et al. Who should get the consent for cardiac cath in your lab? *Cath Lab Digest*. 2018 Mar; 26(3): 6-8. https://www.hmpgloballearningnetwork.com/site/cathlab/article/who-should-get-consent-cardiac-cath-your-lab
3. Dean LS, Kern MJ. Pearls in hemodynamics: measuring valve gradients and areas. *Journal of the Society for Cardiovascular Angiography & Interventions*. 2022 Sept; 1(5). https://doi.org/10.1016/j.jscai.2022.100433
4. Kern MJ. Back to basics: femoral artery access and hemostasis. *Cath Lab Digest*. 2013 Oct; 21(10): 4-10. http://www.cathlabdigest.com/articles/Back-Basics-Femoral-Artery-Access-Hemostasis
5. Kern MJ. Angiographic projections made simple: an easy guide to understanding oblique views. *Cath Lab Digest*. 2011 Aug; 19(8): 4-8. https://www.hmpgloballearningnetwork.com/site/cathlab/articles/angiographic-projections-made-simple-easy-guide-understanding-oblique-views
6. Kern MJ. Conversations in cardiology: The end of the end-hole LV gram. *Cath Lab Digest*. 2013 Nov; 21(11): 4-14. https://www.hmpgloballearningnetwork.com/site/cathlab/articles/conversations-cardiology-end-end-hole-left-ventriculography-consensus-operators
7. Sorajja P, Lim MJ, Kern MJ. *Kern's Cardiac Catheterization Handbook. 7th ed*. Elsevier; 2019.

Morton J. Kern, MD, MSCAI, FACC, FAHA
Clinical Editor; Chief of Cardiology, Long Beach VA Medical Center, Long Beach, California; Professor of Medicine, University of California, Irvine Medical Center, Orange, California

Disclosures: Dr. Morton Kern reports he is a consultant for Abiomed, Abbott Vascular, Philips Volcano, ACIST Medical, and Opsens Inc.

Dr. Kern can be contacted at mortonkern2007@gmail.com
On Twitter @MortonKern