Catheter Selection

The initial left heart catheter in most cases is a pigtail catheter with end- and multiple side-holes (Fig. 4.9). This catheter usually can be flushed in the descending aorta and then advanced to the ascending aorta without difficulty. If left ventricular and femoral arterial (sheath side-arm) pres- sures are being monitored (as in catheterization to evalu- ate aortic stenosis), the rough equality of central aortic and femoral arterial pressure should be confirmed at this time (Fig. 4.10; 3,4,14). The systolic peak in the femoral wave- form may be slightly delayed and accentuated compared with the ascending aortic pressure trace, but the diastolic and mean pressures should be virtually identical. A greater

Figure 4.9 Left heart catheters used from the femoral approach. **Left to right.** Pigtail, 145° angled pigtail, and Teflon Gensini catheter (no longer in common use). All three catheters have an end hole to allow placement over a guide wire and multi- ple side holes to minimize the tendency for catheter whipping or intramyocardial injection during power injection of contrast.

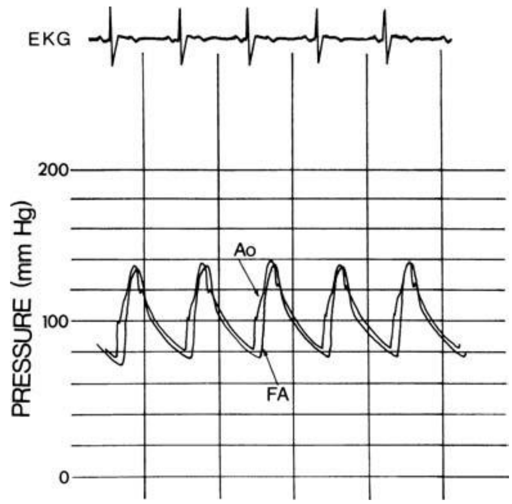

Figure 4.10 Central aortic pressure (Ao) measured through a 7.3F pigtail catheter (Cook) and femoral artery (FA) pressure measured from the side arm of an 8F arterial sheath (Cordis). Only minimal damping of the femoral artery pressure is seen, blunting its systolic overshoot, which frequently exceeds central aortic systolic pressure (see Chapter 7). With larger (8F) catheters, more damping may occur in the side-arm pressure.

difference in mean pressure between the catheter and the sheath may be seen in a patient with a small or extensively diseased iliac artery, which may require the use of a longer sheath, as described above. For the highest pressure fidelity, the sheath size should be one F size larger than the intended left heart catheter (e.g., a 5F pigtail advanced though a 6F sheath). Alternatively, catheters can be advanced from separate arterial entry sites to record left ventricular and ascending aortic pressure; a specially designed pigtail with a separate end-hole lumen and side-hole lumen may be used to perform such pressure recordings (15), or only a pullback pressure recording from left ventricle to ascending aorta can be analyzed.

Crossing the Aortic Valve

After measurement of the ascending aortic pressure, the pigtail catheter is then advanced across the aortic valve and into the left ventricle. If the aortic valve is normal and the pigtail is oriented correctly, it will usually cross the valve directly. In many cases, however, it may be necessary to advance the pigtail down into one of the sinuses of Valsalva to form a secondary loop (Fig. 4.11). As the catheter is withdrawn slowly, this loop will open to span the full diameter of the aorta, at which point a very subtle further withdrawal will often cause the pigtail to fall across the valve.

If significant aortic stenosis is present, the pigtail must be advanced across the valve with the aid of a straight 0.038-inch guidewire. Approximately 6 cm of the guidewire is advanced beyond the end of the pigtail catheter, and the catheter is withdrawn slightly until the tip of the guidewire is leading (Fig. 4.11). The position of the tip of the guidewire within the aortic root can then be controlled by rotation of the pigtail catheter and adjustment of the amount of wire that protrudes; less wire protruding directs the wire tip more toward the left coronary ostium, whereas more wire protruding directs the wire more toward the right coronary ostium. With the wire tip positioned so that it is directed toward the aortic orifice, the tip of the wire usually quivers in the systolic jet. Wire and catheter are then advanced as a unit until the wire crosses into the left ventricle. If the wire buckles in the sinus of Valsalva instead of crossing the valve, the catheter–wire system is withdrawn slightly and readvanced with or without subtle change in the length of protruding wire or the orientation of the pigtail catheter. Alternatively, some operators prefer to leave the pigtail catheter fixed and move the guidewire independently in attempts to cross stenotic aortic valves. In either case, the wire should be withdrawn and cleaned and the catheter should be double-flushed vigorously every 3 minutes despite systemic heparinization. If promising wire positions are not obtained, the process should be repeated using a different catheter: an angled pigtail or left Amplatz catheter if the aortic root is dilated or a Judkins right coronary catheter if the aortic root is unusually narrow (16). Other catheters have been proposed for this purpose (17), but we have found these standard catheters to suffice in virtually all cases.

When the tip of the guidewire is across the aortic valve, additional wire should be inserted before any attempt is made to advance the catheter itself. Otherwise the catheter may be diverted into a sinus of Valsalva, causing the wire to flip out of the left ventricle. The straight wire should be advanced carefully, since there is a potential (admittedly small in the hypertrophic left ventricle of a patient with aortic stenosis) to perforate the left ventricular wall if the guide wire is advanced farther when it has become trapped in an endocardial surface feature. Once the catheter is in the left ventricle, the wire is immediately withdrawn and the catheter is aspirated vigorously, flushed, and hooked up for pressure monitoring, so that a gradient can be measured even if the catheter is rapidly ejected from the left ventricle or must be withdrawn because of arrhythmias. When using a left Amplatz catheter to cross a stenotic valve, however, we prefer to cross the valve with a full exchange length (260-cm) guidewire. Once the tip of this wire has entered the left ventricle, it is left in position as the Amplatz catheter is removed, and a conventional pigtail catheter is substituted before an attempt is made to measure left ventricular (LV) pressure.

The same approach applies to retrograde catheterization across a porcine aortic valve prosthesis, although it is more common to use a J-tip guidewire to help avoid the area between the support struts and the aortic wall. Ball valves (Starr-Edwards) can be crossed retrograde with this approach, but use of a small (4F or 5F) catheter will minimize the amount of aortic regurgitation resulting from

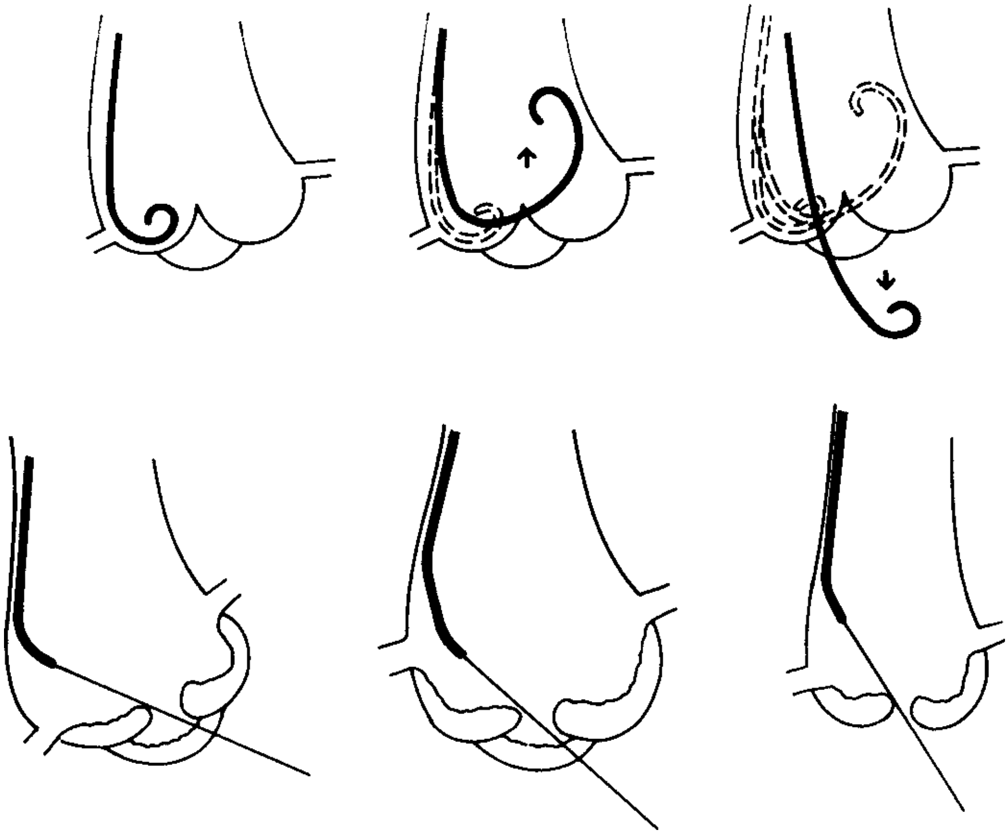

Figure 4.11 Crossing the aortic valve with a pigtail catheter. **Top left.** Although a correctly oriented pigtail catheter will frequently cross a normal aortic valve directly, it may also come to rest in the right or noncoronary sinus of Valsalva. **Top center.** Further advancement of the catheter enlarges the loop to span the aortic root and positions the catheter. **Top right.** Slow withdrawal causes the catheter to sweep across the aortic orifice and fall into the left ventricle. **Bottom left.** To cross a stenotic aortic valve, the pigtail catheter must be led by a segment of straight guidewire. Increasing the length of protruding guidewire straightens the catheter curve and causes the wire to point more toward the right coronary ostium; reducing the length of protruding wire restores the catheter curve and causes the wire to point more toward the left coronary ostium. Once the correct length of wire and the correct rotational orientation of the pigtail catheter have been found, repeated advancement and withdrawal of both the catheter and guidewire as a unit will allow the wire to cross the valve. **Bottom center.** In a dilated aortic root, an angled pigtail provides more favorable wire positions. **Bottom right.** In a small aortic root, a Judkins right coronary catheter may be preferable.

catheter interference with diastolic ball seating. Tilting disc valves (Bjork-Shiley, St. Jude, Carbomedics), however, should not be crossed retrograde because of the potential for producing torrential aortic regurgitation, catheter entrapment, or even disc dislodgement if the catheter passes across the smaller (minor) orifice. Although safe passage through the major orifice may be possible under careful fluoroscopic control (18), we still prefer a trans-septal or even apical puncture approach (see below) when it is necessary to enter the left ventricle in a patient who has a tilting disc valve in the aortic position.

Control of the Puncture Site Following Sheath Removal

Originally, standard groin management required the effect of heparin to wear off or be reversed by protamine to an ACT <160 seconds before the arterial catheter and sheath were removed and manual pressure applied. Manual pressure method is best applied using three fingers of the left hand that are positioned sequentially up the femoral artery beginning at the skin puncture. With the fingers in this position, there should be no ongoing bleeding into the soft tissues or through the skin puncture, and it should be possible to apply sufficient pressure to obliterate the pedal pulses and then release just enough pressure to allow them to barely return. Pressure is then gradually reduced over the next 10 to 15 minutes, at the end of which time pressure is removed completely. The venous sheath is usually removed 5 minutes after compression of the arterial puncture has begun, with gentle pressure applied over the venous puncture using the right hand. To avoid tying up the catheterization laboratory during this period, patients were usually taken to a special holding

room in the catheterization laboratory or back to their hospital beds before the sheaths were removed. If such relocation is to be performed prior to sheath removal, it is important that the sheaths are secured in place (suture, or at least tape) to prevent them being pulled out during transport.

When procedures are performed using larger arterial sheaths or with thrombolytic agents or IIb/IIIa receptor blockers, more prolonged (30- to 45-minute) compres- sion is typically required. To avoid fatigue of the operator or other laboratory personnel performing compression, we typically use a mechanical device (Compressar [Applied Vascular Dynamics, Portland, OR] or FemoStop [Radi Medical, Wilmington, MA]) to apply similar local pressure. These devices can be equally or even more effec- tive in prolonged holds (19), but manual compression may be preferred for removal of smaller (6F) sheaths or in patients with peripheral vascular disease or prior periph- eral grafting surgery where occlusive compression or flow restriction might cause arterial occlusion. In every case, however, it should be emphasized that a trained person must be in attendance throughout the compression to ensure that the device is providing adequate control of puncture site bleeding and is not compromising distal perfusion.

After compression has been completed, the puncture site and surrounding area are then inspected for hematoma formation and active oozing, and the quality of the distal pulse is assessed before application of a bandage. The patient is usually kept at bed rest with the leg straight for 4 to 6 hours following percutaneous femoral catheterization (20), with a sandbag in place over the puncture site for the first few hours after catheter removal. In patients at higher risk for rebleeding (those with hypertension, obesity, or aortic regurgitation), application of a pressure bandage in addition to the sandbag may be of value. Elevation of the head and chest to 30 to 45° by the electrical or manual bed control, without muscular effort by the patient, will greatly increase the patient's comfort and will not increase the risk of local bleeding. The only reason to insist that the patient lie completely flat is if there is significant orthostatic hypotension. Before ambulation and again before dis- charge, the puncture site should be reinspected for recur- rent bleeding, hematoma formation, development of a bruit suggestive of pseudoaneurysm or A-V fistula forma- tion, or loss of distal pulses.