3. Large sideholes are sometimes cut into the side of PTCA guider catheters in order to:
   a. Disperse angiographic contrast more evenly
   b. Utilize a second guide wire (Kissing wire technique)
   c. Prevent catheter damping (occlusion of the coronary ostium)
   d. Reduce guider trauma and dissection at the coronary ostium

   ANSWER c. Prevent catheter damping (occlusion of the coronary ostium). Cutting sideholes in a guider allows you to monitor the aortic pressure accurately. Since the sidehole will admit aortic pressure, it will not be damped. But, it can be a false sense of security. Now, you are monitoring the aortic pressure, not coronary. The guider can still occlude the ostium. You just won’t see it on the pressure monitor. Another benefit of sideholes is they allow additional blood flow out the tip, to perfuse the artery.

   You may purchase guiders with side-holes or cut your own. This is done with a special needle with no bevel. It is drilled into the side of the catheter. Do not continue drilling through the other back wall. Two opposing holes would weaken the catheter at that point.

   See: Tilkian and Daily, chapter on "Tools for Catheterization."

   Keywords: Guider catheter  sideholes = less damping

4. This diagram shows the construction of a typical PTCA guiding catheter. What material is labeled at #2 on the diagram?
   a. Polyurethane (PU)
   b. Hypothrombogenic coating
   c. Teflon
   d. Braided steel or Kevlar fiber

   ANSWER a. Polyurethane. CORRECTLY MATCHED ANSWERS ARE:

   1. Teflon: This smooth slippery plastic forms the inner lumen or core of the catheter. It makes it easier to slide the balloon catheter through the lumen.
   2. Polyurethane polymer forms the body of the catheter in which the wire or fiber braid is imbedded. Many new guiders include Nylon within the thermoplastic.
   3. Braid: Stainless steel imbedded within the plastic jacket makes the catheter strong and torqueable.
   4. Coating: The slippery hypothrombogenic surface that coats many catheters may include Silicone, heparin, etc.

   See: Tilkian and Daily, chapter on "Tools for Catheterization."

   Keywords: Guider catheter construction = Teflon
5. Which type of plastic has the least memory and torque control, and is so soft that it is used in construction of most balloon floatation catheters?
   a. Polyurethane (PU)
   b. Teflon
   c. Polyethylene (PE)
   d. Poly Vinyl Chloride (PVC)

   ANSWER d. Polyvinyl Chloride (PVC). Balloon floatation catheters need to be soft and float with the current. PVC is like a "wet noodle" in the warm blood stream. It has almost no torque control or memory. Some Swan-Ganz catheters will admit a guidewire to stiffen them if necessary. Since, PVC's bursting pressure is much lower than other plastics (250 PSI) they are never pressure injected.
   See: Tilkian and Daily, chapter on "Tools for Catheterization."
   Keywords: softest plastic, Swan = PVC

14. In the USA what type of cardiac catheters (Single Use Devices) may be resterilized by 3rd party reprocessor companies?
   a. PTCA balloon catheters
   b. Polyurethane (PU) catheters
   c. Teflon Guider catheters
   d. Diagnostic EP electrodes

   ANSWER d. Diagnostic EP electrodes. With current concerns over blood transmitted diseases, the only catheters now commonly reused are the diagnostic EP pacing and sensing electrodes. This is a controversial medico-legal issue, because catheter manufacturers place “For Single Use Only” disclaimers on all catheters. Doubtless, this is to protect them from legal repercussions. But, several studies have demonstrated the safety of EP electrode reuse.
   EP electrodes are a Class II non exempt device temporarily approved by the FDA for reprocessing. Since they have no lumen (technically not a catheter) EP electrodes are much easier to inspect, clean and sterilize. EP ablation catheters and angioplasty balloons are not yet approved. The FDA requires that each item reprocessed and resterilized be tracked, forms submitted, and strict quality control procedures followed. They say: "Despite a lack of clear data that directly link injuries to reuse, FDA has concluded that the practice of reprocessing SUDs merits increased regulatory oversight. . . .Our plan is to phase-in additional oversight based on assessment of current practice and potential risk."
   See: www.my.premierinc.com & www.fda.gov.cdrh/reuse/index
   Keywords: reusable EP electrodes
15. Catheters with side-holes (e.g., Pigtails) provide better injection dynamics and pressure measurement than single end-hole catheters. The chief DISADVANTAGE of multiple side-holes in angiographic flood catheters is that they:
   a. Hang up on guide wires and valves
   b. Traumatize the vessel wall
   c. Tend to clot unless flushed frequently
   d. Cannot be used with a leading guidewire

   ANSWER c. Tend to clot unless flushed frequently. Pigtail catheters are especially prone to clotting, because of their many holes. A normal hand flush only exits the proximal holes and the distal holes remain full of blood. Judkins said, “A pigtail catheter should have no more than four sideholes...the extra ports serve no purpose and provide sites for accumulation of formed blood elements.

   Unless flushed frequently and forcefully these side-holes provide an eddy location for blood to stagnate and clot. Then these small clots can embolize during pressure injection and produce a stroke.

   See: Johnsrude, chapter on "Equipment."

   Keywords: disadvantage side-holes = clots

CATHETER SIZING

16. If a 1 mm. ID catheter will transmit contrast at a rate of 1 ml/sec at 500 PSI, how much will a 2 mm ID catheter theoretically transmit at the same pressure?
   a. 2 ml/sec
   b. 4 ml/sec
   c. 8 ml/sec
   d. 16 ml/sec

   ANSWER d. 16 ml/sec. According to Poiseuille's law as the radius is doubled the flow increases as the fourth power of this change. 2 to the 4th power is 2 x 2 x 2 x 2 = 16. 16 x 1 ml/sec = 16 ml/sec. Poiseuille's Law is shown above.

   Catheter radius is obviously the most important factor in limiting flow though catheters. That is why most flood catheters have a large lumen and selective catheters tend to have a smaller lumen. However, as you see from the formula many other factors come in to play, such as contrast viscosity, pressure, length of catheter, turbulent flow through sideholes, etc.

   See: Berne & Levy chapter on Hemodynamics

   Keywords: double cath ID increases flow 16 times

21. How is the curve of Judkins Right coronary catheters measured?
   a. Across the shortest diameter of the ellipse
   b. Across the longest diameter of the ellipse
   c. From primary to Secondary curves
   d. From secondary to tertiary curves
ANSWER c. From primary to Secondary curves. The Judkins coronary catheter bend size is measured between the steepest portions of the primary and secondary curves. Note where the Judkins (JL6 cm) left coronary catheter is measured compared to the Judkins (JR) catheters. Again, The longer bends are for more dilated aortas or more inferiorly directed coronary ostia.

See: Grossman, chapter on "Cardiac Ventriculography."

Keywords: Judkins bend measured = primary - secondary bends

27. Which type of catheter is necessary for optimal WEDGE pressures?
   a. End-hole only
   b. 4 Side-holes
   c. 4 Side-hole + end-hole
   d. 6 side-holes + distal balloon

ANSWER a. End-hole only catheters are the best wedge catheters. The one end-hole then looks through the capillary bed and only measures distal pressure (Pulmonary capillary wedge = LA pressure).

   Side-holes may allow the PA pressure to enter and contaminate the wedge. However, Multipurpose and birds eye 2 side-hole + end-hole catheters can be used to obtain adequate wedge pressures if precautions are taken. This is because the distal sideholes are quite close to the tip and are usually covered by arteriolar tissue.

   Most wedge pressures are now taken with balloon floatation catheter with the balloon inflated. But a balloon is not necessary. In fact, where an accurate wedge waveform is critical, as in mitral disease, a stiff single-end-hole catheter is much more accurate (most like LA). A single end-hole catheters can be pushed out as far as it will go until it ends "wedged" into the capillary bed. It's really wedged in small arteries, not capillaries. The resulting wedge pressure gives a better LA pressure.

See: Tilkian and Daily, chapter on "Tools for Catheterization."

Keywords: Optimal wedge = end-hole only

29. Which of the following RV/PA flood catheters will recoil the LEAST during a high flow pressure injection?
   a. Multipurpose/Gensini
   b. Pigtail/Van Tassel Pigtail
   c. Lehman/Cornand
   d. NIH/Berman

ANSWER d. The NIH has little kickback because it has no end-hole. The Berman angiographic catheter is now more commonly used because it has no end-hole, is softer, and has the added balloon floatation feature.

A. MULTIPURPOSE/GENSINI: ANGIOGRAPHIC. MP catheters should not be injected at rates over 10 ml/sec.

B. PIGTAIL/VAN-TASSEL PIGTAIL:
With up to 12 sideholes a pigtail evenly disperses the contrast within the LV. Although, with high pressure injection the pigtail straightens and may slightly recoil or accidentally inject some aortic vessel.

**C. LEHMAN/CORNAND:** THESE woven Dacron catheters are for hemodynamic measurements only. They are not designed for angiography. They are single end-hole catheters which may kickback badly with rapid injection.

**D. NIH/BERMAN:** THE NIH is a "No End-hole" catheter. The absence of an end-hole makes them very stable during pressure injection. The Berman is a PVC balloon floatation catheter with side-holes and is usually the Rt. ht. angiographic catheter of choice in infants and children.

See: Grossman, chapter on "Cardiac Ventriculography."

**Keywords:** Least recoil = NIH/Berman

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35. Identify the Pigtail catheter labeled at #3 on the diagram.
   a. Pigtail angiographic
   b. Quanticor (Cardio-marker pig.)
   c. Grollman PA
   d. Van Tassel pigtail
   e. Tennis Racquet
   f. Elliptical or Oval

Types of Pigtail catheters
ANSWER d. is a Van Tassel angled pigtail catheter.

CORRECTLY MATCHED ANSWERS ARE:

1. QUANTICOR (Cardiomarker pig): This is a standard pigtail with radiopaque markers set 2 cm apart. These act to calibrate distance for quantitative angiography. Exact LV distances, volumes and stroke volume can then be calculated using these markers as a "ruler."

2. PIGTAIL ANGIOGRAPHIC: The pigtail catheter is the most commonly used LV gram catheter. With up to 12 sideholes it evenly disperses the contrast within the LV.

3. VAN TASSEL angled pigtail: This is a Nylon core or woven steel high-flow pigtail. The 145-155 degree angle is 7 cm from the tip. This angle lifts the catheter off the inferior LV wall for a more centrally located LV gram. Also, it is useful for dilated aortas.

4. GROLLMAN PA: is an angled pigtail catheter with the curve generally on the reverse side. It is designed for RV and selective PA angiography by the femoral approach.

5. ELLIPTICAL or OVAL: Designed to pass small aortic valves or vessels with the curve intact.

6. TENNIS RACQUET: The central shaft was designed to reduce the risk of vessel wall extravasation.

See: Johnsrude, chapter on “Equipment.”

Keywords: types of pigtail catheters

37. Which of the following is a flow directed, balloon tipped, pediatric flood angiographic catheter?

a. Berman
b. Fogarty
c. Swan Ganz
d. Dotter

ANSWER a. Berman. This is a PVC balloon floatation catheter with side-holes proximal to the balloon tip. It is usually the Rt. ht. angiographic catheter of choice in infants and children. Review all the catheter shapes and their uses.

See: Tilkian chapter on “Equipment.”

Keywords: Berman catheter
38. Identify the type of Multipurpose catheter labeled #2 in the diagram.
   a. B-1 MP
   b. B-2 MP
   c. A-1 MP
   d. A-2 MP (King)

   ANSWER d. A-2 Multipurpose (MP).
   CORRECTLY MATCHED ANSWERS ARE:
   1. A-1 MP: Polyurethane (PU) with incorporated wire braid. The A bend is like a hockey stick with a straight tip. The 1 refers to one end-hole only.
   2. A-2 MP (King): Same as A-1 except it has 2 sideholes and an end-hole. It was modified by Dr. Spencer King at Duke University.
   3. B-1 MP: Polyurethane (PU) with incorporated wire braid. The B bend is a gradual 90° curve up to the tip. The 1 refers to one end-hole only.
   4. B-2 MP: The same as B-1 except has 2 sideholes and end-hole.

See: Tilkian and Daily, chapter on "Tools for Catheterization."
Keywords: types multipurpose catheters

41. Which catheter is designed to do a complete LV and coronary angiography study from the femoral artery without exchanging catheters?
   a. Amplatz
   b. Multipurpose
   c. Judkins
   d. Castillo

   ANSWER b. Multipurpose catheter technique for doing both LV and coronary arteriography using the percutaneous femoral approach. This uses the standard A-2 Multipurpose catheter. Catheter manipulation is similar to using the Sones catheter. Slight advances of the catheter in the coronary cusps forms a “J” with the catheter and the tip rises to enter the coronary artery.
   The standard A2-MP has 2 sideholes and has a 1½ inch small diameter unreinforced soft tip. This makes the catheter J very easily. By impinging it on the aortic valve cusps it is “J’d” and then hooked back until the coronary ostium is engaged.
   The incorrect distractors Amplatz, Judkins, and Castillo are selective end-hole only coronary arteriography catheters unsuitable for LV flood angiography.
   See: Tilkian and Daily, chapter on "Tools for Catheterization."
Keywords: Single catheter method LV & Corns = Multipurpose & Sones
42. Identify the diagnostic femoral coronary catheter labeled at # 4 on the diagram.

a. Amplatz Rt. (modified)
b. Amplatz Rt. (original 3 curve design)
c. Amplatz Lt.
d. Judkins Lt.
e. JR4
f. JL4

ANSWER a. Amplatz Rt. (Modified) coronary catheter.

CORRECTLY MATCHED ANSWERS ARE:

1. JUDKINS RT: A Polyurethane (PU) single end-hole braided steel catheter. It has a blunt reduced diameter tip with a 90° bend allowing it to enter the coronary ostium. The secondary bend is a gradual 30° that provides backup support from the opposing aortic wall.

2. JUDKINS LT: A Polyurethane (PU) single end-hole braided steel catheter. It has a blunt reduced diameter tip with a 90° bend allowing it to enter the coronary ostium. The secondary bend is 180° which provides backup support from the opposing aortic wall.

3. AMPLATZ LT: This is a Polyurethane (PU) end-hole braided steel catheter. It is usually the second choice if a Judkins Left coronary is unsuccessful. Its duck bill shape is shaped to fit the sinus of Valsalva. The curve comes in 2-3 sizes all of which are larger than the Amplatz Rt. curve.

4. AMPLATZ RT. (MODIFIED): This is a Polyurethane (PU) end-hole braided steel catheter. It is usually the second choice if a Judkins right coronary catheter is unsuccessful. It's duck bill shape is shaped to fit the sinus of Valsalva. The curve comes in 2-3 sizes all of which are smaller than the Amplatz left curves. The “AR” resembles the Amplatz Lt. except with a tighter curve radius. Just like the Judkins Left coronary, the Left Amplatz has a larger bend because it must reach further across the aortic root. The Rt. and Lt. Amplatz catheters are usually displayed together (as shown). Then it is easy to distinguish the Larger bends as Lt. Amplatz and the smaller as Rt. Amplatz.

5. AMPLATZ RT. (ORIGINAL 3 CURVED DESIGN): Most manufacturers do not make Amplatz's original 3 curved design. Cordis' original AR catheters have a gradual tertiary (3rd) curve which allows it to sit over the aortic arch. Then by pulling the catheter it would rock the tip into the RCA. It unloads excessive tension that could "deep throat" the catheter in the RCA.

See: Grossman, chapter on "Coronary Arteriography."

Keywords: Types coronary catheters
43. Identify the Rt. Coronary PTCA guider catheter labeled at #5 on the diagram.

a. Internal Mammary  
b. El Gamal  
c. Arani (Double Loop)  
d. Left Amplatz  
e. Rt. Amplatz

Answer: c. Arani (Double Loop)

Correctly matched answers are:
1. Rt. Amplatz  
2. Left Amplatz  
3. JR4  
4. Internal Mammary  
5. Arani (Double loop)  
6. El Gamal  
7. Hockey Stick

See: Pepine, chapter on "Intro. to Coronary Angioplasty."

Keywords: Identify Rt. PTCA Guiders

44. Identify the left Coronary PTCA guider catheter labeled at #4 on the diagram.

a. Judkins Femoral Left  
b. Judkins Femoral Left short tip  
c. Voda Left  
d. Amplatz Left  
e. A-1 Multipurpose

Answer: b. Judkins Femoral Left short tip

Correctly matched answers are:
1. A-1 MULTIPURPOSE  
2. KING OR B-1 MULTIPURPOSE  
3. JUDKINS FEMORAL LEFT  
4. JUDKINS FEMORAL LEFT SHORT TIP  
5. VODA LEFT  
6. AMPLATZ LEFT

See: Pepine, chapter on "Intro. to Coronary Angioplasty."

Keywords: Identify Left PTCA Guiders
45. Identify the guider catheter used for a Shepherd's Crook Right coronary #1 on the diagram.
   a. JR4
   b. El Gamal
   c. Right Voda
   d. Arani 75°
   e. Amplatz

   ANSWER d. Arani 75°

   CORRECTLY MATCHED ANSWERS ARE:
   1. ARANI 75°: For Rt. superiorly angulated right coronary (Shepherd's Crook). Has a 75° or 90° horizontal angled tip off a Z shaped body. Freed says: "Although the double loop Arani catheters provide excellent back-up, they are often very difficult to engage."
   2. AMPLATZ: Gentle S duckbill shape
   3. EL GAMAL: Hockey stick shape. For Rt. superiorly angulated right coronary (Shepherd's Crook). Has a 75° or 90° horizontal angled tip off an S shaped body.
   4. RIGHT VODA: Similar to Judkins Left for backup support.
   5. JR4: Standard Judkins 4 cm. bend

   See: Freed, Chapter on PTCA Equipment

   Keywords: Identify Rt. guider catheters

46. Identify the Coronary bypass catheter labeled #1 on the diagram.
   a. Left coronary bypass
   b. Internal mammary bypass
   c. Coronary Bypass II
   d. Rt. coronary bypass
   e. Multipurpose A-1

   Coronary Bypass & IMA catheters
ANSWER c. Coronary bypass II by Cordis.

CORRECTLY MATCHED ANSWERS ARE:

1. **CORONARY BYPASS II**: For Rt. coronary venous bypass grafts on the superior Aorta. Has a 90° angled tip off an S shaped body.
2. **RT. CORONARY bypass**: Designed for right coronary venous bypass grafts attached to the right coronary artery. Tip and secondary bends approximate 120°. It is shaped much like a Judkins Rt. Coronary catheter with a shallower tip bend.
3. **LEFT CORONARY bypass**: Designed for left coronary venous bypass grafts attached to the LAD or circumflex artery. Tip has 90° bend with 70° secondary bend. It is shaped much like a cobra.
4. **INTERNAL MAMMARY bypass**: Designed for both Rt. and left Internal Mammary arteries. Shaped much like a Judkins Rt. coronary catheter with a steeply angled tip (80 to 85°)
5. **MULTIPURPOSE A-1** since it has a straight tip it often falls into right coronary bypass grafts easily.

See: Pepine, chapter on "Intro. to Coronary Angioplasty."

Keywords: Identify bypass graft catheters & IMA caths

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56. Care of indwelling right heart catheters is different from the care of arterial catheters in that right heart catheters:

a. Require pressurized flush bags
b. Require a continuous heparinized saline drip
c. Safely allow injection of small air bubbles
d. Are inserted by the Seldinger technique

ANSWER c. Air bubbles are not usually a problem on the right side of the heart. Small air bubbles will be effectively filtered out by the lungs that then slowly absorb the air. It may take a hundred cc's of air to cause a critical pulmonary embolism. This is NOT true on the left side where air emboli lodges in peripheral capillaries and obstructs critical flow, leading to tissue infarction or the "bends." Even so, technologists should get in the habit of keeping bubbles out of all catheter lines.

Rt. heart (venous) lines can be dripped continuously with a gravity drip. But a continuous drip on Rt. Ht. catheter is not necessary. Many Rt. Ht. caths are done without heparin. However, frequent hand flushing of these catheters is necessary.

Arterial pressure will "back up" an IV because arterial pressure is so great. Pressure bags are necessary. Pressure bags are often used in Swan-Ganz long term monitoring lines as well. This is because the catheter may be in place for a week. Heparin flush is essential to prevent clotting for this long term monitoring.

See: Grossman, chapter on "Cardiac Ventriculography."

Keywords: Rt. ht. caths = small air embolus no problem
57. Long term Swan-Ganz and Arterial lines should be connected to a continuous flush device which at 300 mmHg infusion pressure will deliver approximately:

a. 1-2 ml flush/min
b. 5-10 ml flush/min
c. 3-8 ml flush/hour
d. 20-40 ml flush/hour

ANSWER: c. 3-8 ml flush/hour. These continuous flush devices have made extended hemodynamic monitoring possible. At this low flow rate catheters can be kept open while simultaneously measuring pressure through the transducer. The pressure increase due to this slow infusion is negligible in most catheters.

See: Daily, Bedside Hemodynamic Monitoring, chapter on "Arterial Pressure Monitoring."

Keywords: continuous flush device = 3-8 ml/hr

60. Catheters with a closed end CANNOT BE INTRODUCED by the ______ method.

a. Femoral Cutdown
b. Brachial Cutdown
b. Seldinger over-the-wire
d. Femoral Sheath

ANSWER: c. Seldinger over-the-wire method. Clearly "No End-hole" catheters like the NIH and Berman cannot be introduced percutaneously over a guide wire - since they have no end-hole. They must be introduced by the sheath or cutdown methods.

Swan-Ganz catheters are not introduced over the wire, because of their blunt tip and their delicate rubber balloon. They usually require a sheath one Fr. size larger than the catheter Outside Diameter (O.D.) Small diameter guide wires may be placed though the distal lumen after catheter insertion.

See: Tilkian and Daily, chapter on "Tools for Catheterization."

Keywords: Closed end caths cannot be inserted over wire Seldinger technique