Guiding Catheter Back-up for Complex Cases (Transradial Approach)

Masahiko Ochiai, MD, FACC, FESC, FSCAI
Associate Professor, Division of Cardiology and Cardiovascular Surgery
Showa University Northern Yokohama Hospital

Guiding Catheter Back-up via the Transradial Approach

1. "Passive" vs. "Active" Back-up

First, let me start with a question of terminology. There are two types of back-up for a guide catheter; "passive" back-up and "active". Passive back-up is obtained when a catheter is inserted into the coronary artery and left where it is. Active back-up entails the operator manipulating the catheter in some way, such as when a JR catheter is inserted into the right coronary artery, is deeply engaged to the end of segment 3, and stronger back-up is obtained. This is called active back-up.

Depending on their shape, some catheters are mainly suitable for passive back-up although active back-up may still be obtained (depending on the situation), and others are better suited to passive back-up with active back-up almost impossible. There are still others that are better for active back-up than for passive back-up. The decisive factors are not only the catheter's shape, but also the size and characteristics of the shaft, whether the right or left radial artery is to be approached, or the shape of the aorta or the site of the coronary artery ostium of each individual patient.

2. Using Passive Back-up

To what extent should you try to obtain passive back-up in transradial coronary intervention (TRI)? In the days when we were implanting rigid inflexible Palmaz-Schatz stents using bare mounts, there is no doubt that strong passive back-up made handling easier. When the stent can't reach the lesion, it's extremely difficult to get the bared Palmaz-Schatz stent back into the guide catheter. This procedure demands sureness of touch and allows no room for failure. With the recent great improvements in the performance of stents, some commentators suggest that passive back-up is rarely required once the catheter is fixed in the coronary artery and the sufficient advance and engagement of the stent assured, and even if your stent cannot pass through the stenosis, it can be retracted. However, it remains essential that the wire and balloon cross the lesion in the first place to ensure complete distal engagement and then rely on active back-up.

I have long opted for a long-tip catheter with strong passive back-up. With the benefit of strong passive back-up, I find it easy to complete procedures even when crossing the wire and balloon through a chronic total occlusion or when wiring with Shepherd's crook. When using "kissing" balloons or doing rotablation with a 6F guide-catheter, your devices are much easier to insert when you have strong passive back-up. Performing TRI with strong passive back-up gained by careful selection of a guide catheter can be compared to winning a game of chess by making a clever move at the beginning, even it makes life difficult at first, and then using that advantage later on in the middle and the end stages.

I consider coming to terms with the factors inherent in the two kinds of back-up to be an important part of the TRI learning curve. It is also important to familiarize yourself with the techniques for obtaining strong passive back-up, for use when necessary.

3. Sizing your Guiding Catheter

The guide catheter most commonly used for TRI is the 6F, which can be used in the majority of patients without the need to measure the diameter of the radial artery using echography. If the radial artery diameter is large and a large guide catheter is required for the procedure, a 7F or 8F catheter may be used. Similarly, in some case, a 5F guide will allow less invasive intervention.

Based on my experience, the 6F guide catheter may be used for both passive and active back-up. With the 7F or larger, it is possible to obtain stronger passive back-up than with the 6F as long as the shape of the catheter is the same. This size, however, is not suitable for deep engagement and active back-up is unlikely to be obtained. With a 5F, passive back-up is very weak because the catheter is merely "hung" onto the coronary artery. This soft catheter, however, is suitable for deep engagement and active back-up is easier to obtain.

4. Judkins vs. Long-tip

The theory of the relationship between guide catheter shape and the back-up they provide have been described in detail by Voda[1]. Catheters are classified into "over-bent" and "under-bent" types according to their shape in and outside the body. For instance, the JL and Extra Back-up types (EBU) are over-bent because of the sharp bend at their tip which is straightened when inserted into the coronary artery. The Amplatz Left, on the other hand, is inserted into the left coronary artery with the tip bent somewhat more than when it is outside the body, hence the term under-bent (Fig. 1). Generally speaking, the shape of over-bent catheters inside the body is easy to predict, and their manipulation easier. Not a few complications associated with the Amplatz have been reported, but the more important point about the Amplatz is that its shape makes deep engagement very difficult and active back-up cannot be obtained when passive back-up is insufficient. Basically, I avoid using the Amplatz whenever possible. The next issue is the difference between the Judkins and Long-tip catheters.

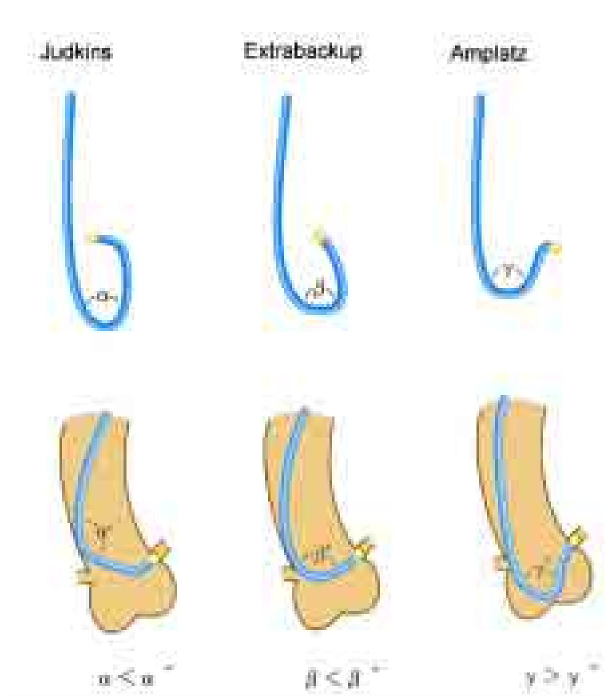


Fig. 1 Difference between over-bent catheter and under-bent catheter
The Judkins left (JL) or extra back-up (EBU) catheters are called over-bent because the angle of the catheter tip is smaller when outside the body than when it is inside (i.e. the curve is sharper outside the body). On the other hand, the Amplatz catheter is called under-bent because its angle is longer when outside the body.

Long-tip catheters represented by the EBU and Voda are straight, from the contra- lateral aorta (i.e. the point of support) to the tip of the catheter, unlike the JL that has a short and bent tip. Catheter shape factors that determine passive back-up include the following: 1) whether or not the guide catheter is engaged co-axially to the proximal coronary artery; 2) whether or not the catheter is supported at the contra- lateral wall of the coronary ostium; and 3) whether or not a certain length of the catheter is in contact with the aorta to prevent dislodging. Theoretically, long-tip catheters can provide much stronger passive back-up than the JL (Fig. 2). In other words, the JL needs more maneuvering to obtain the same amount of back-up.

In terms of ease of manipulation, however, there is no question that the JL is superior. This is because the long-tip catheter is very restricted in size, as it connects the coronary artery ostium and the contra- lateral aortic wall in a straight line. To illustrate the point, consider what size to select to engage the LCA from the right radial artery? The obvious answer is to select a JL 3.5 whereas for the EBU, whether to go for a 3.5, 3.75, or 4.0 poses more of a dilemma.

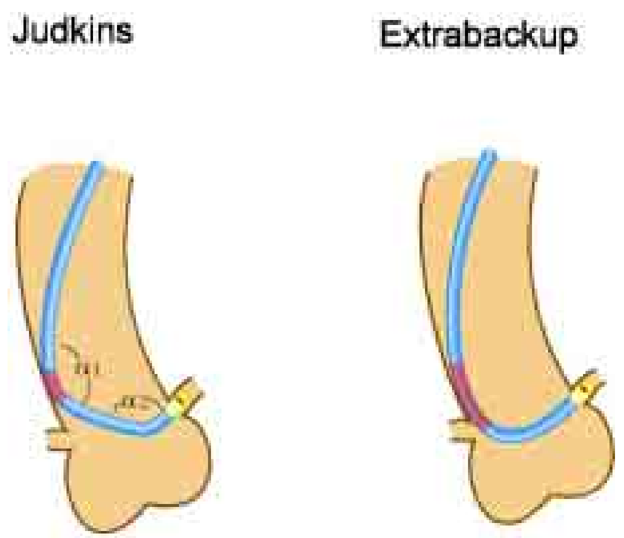


Fig. 2 Difference in passive back-up in Judkins and a long-tip catheter (extra back-up: EBU)
With the JL, the catheter comes into contact with a "point" on the contra-lateral aortic wall that is further up than the left coronary artery ostium. Passive back-up basically is restricted by the force of the extended second curve (a1) to return to its original shape, and it is further reduced due to the first curve (a2) at the catheter tip.
On the other hand, EBU comes into contact with a "line" on the aortic wall and is supported by the contra-lateral part of the left coronary artery ostium. As the EBU is a straight line without the first curve of Judkins, the support obtained at the contra-lateral aortic wall is directly transmitted to the catheter tip. Also, the linear contact of the catheter with the aortic wall means larger resistance to it slipping up or down.

5. Right vs. Left Radial Approach

A catheter inserted from the femoral artery approaches the coronary artery from its right side, whereas one inserted via the right radial artery approaches it more from the left. This difference is not so important when the ascending aorta is vertical, but when it is horizontal, as may be the case, say, with an obese patient with a long history of hypertension, the difference is more marked and makes manipulation difficult (Fig. 3). As will be explained later, the left radial approach is comparatively closer to the femoral artery approach when the aorta is vertical; however, the catheter will approach the coronary artery more from its left side when the aorta is horizontal and support to the LCA becomes an clinical issue (Fig. 3). Different selection and manipulation of guide catheters is needed for the right and left radial approaches.

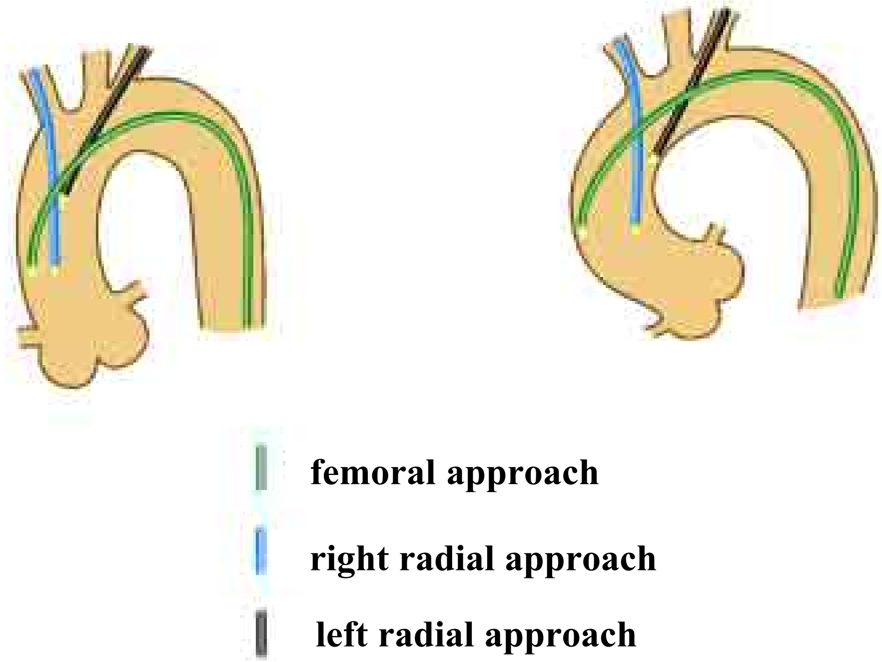


Fig. 3 The position of the catheter in the ascending aorta: difference between the femoral approach and right/left radial approach

Compared with the femoral approach, a catheter inserted via the right/left radial approach approaches the coronary artery more from the left. The difference will become greater when the ascending aorta is in a horizontal position and makes the catheter manipulation more difficult.

Anatomic Variation of the Radial Artery/Origin and Tortuosity of the Bracio-cephalic Trunk, Left Subclavian

1. Anatomic variation of the radial artery

The radial artery is the ideal access site if its inner diameter (i.e. the inside lumen of the guide catheter) is sufficient for the procedure you wish to attempt, because of the following: 1) its superficial anatomy enables easy hemostasis by compression, 2) no other nerves or vascular systems exist around it; 3) as distal blood flow (i.e., to the hand) is also supplied by the ulnar artery, occlusion of the radial artery does not result in ischemia as long as the Allen test is positive. There are, however, several anatomical variations in the radial artery, and it is very important for safe TRI to be familiar with the potential variations[2-4]. Anatomical variations may occur in either left or right radial artery, but the right TRI is described below because it is more often selected as the approach.

A) Anatomical variation encountered up to sheath insertion

An open needle is commonly used, outside of Japan, to puncture the radial artery, but a venous needle of 20G or 22G would appear to be then norm in institutions in Japan. I personally only have experience with the venous needle. After confirmation of good reverse blood flow from the outer syringe of the venous needle, a 0.025-inch wire will be smoothly inserted into the artery. Pay close attention for any kind of resistance upon further insertion. Resistance may be either due to hypoplasia or to a bend in the radial artery. In these cases, it is important to insert the outer syringe of the venous needle firmly into the radial artery using an indwelling wire and to conduct radial arteriography with your contrast medium diluted to roughly half strength. If the 0.025-inch wire is forced regardless of this kind of resistance, the radial arteriola may easily be perforated (Fig. 4: video). Although this kind of complication is to be avoided, it is not a serious problem if the forearm around the perforation is compressed with the inflatable cuff of a sphygmomanometer, or by other means.

Fig. 4 ~~(video)~~ Perforation of the radial artery by a 0.025-inch straight wire.
A 79-year-old female patient with unstable angina. Upon sheath insertion, a 0.025-inch straight wire was pushed from the outer syringe of the venous needle, although some resistance was felt. As a consequence the bend of the radial artery was perforated. The area around the perforation was then compressed with the inflated cuff of a sphygmomanometer. A crossover to the femoral artery approach was then opted for and rota-stenting was performed to the LAD. This brought about no more than a slight suggillation in the upper arm.

(1) Hypoplasia of the radial artery (Fig. 5): This is an anatomical variation, in the literal sense, which prevents insertion of a sheath. Either the contra-lateral radial artery should be punctured, or an approach taken from the brachial or femoral artery. Even in the case of hypoplasia of the radial artery, however, the radial artery can be punctured using a venous needle near the styloid process, because the pulse of the radial artery is palpated if the Allen test is positive and sufficient blood flow is supplied from the ulnar artery via the palmar arch.

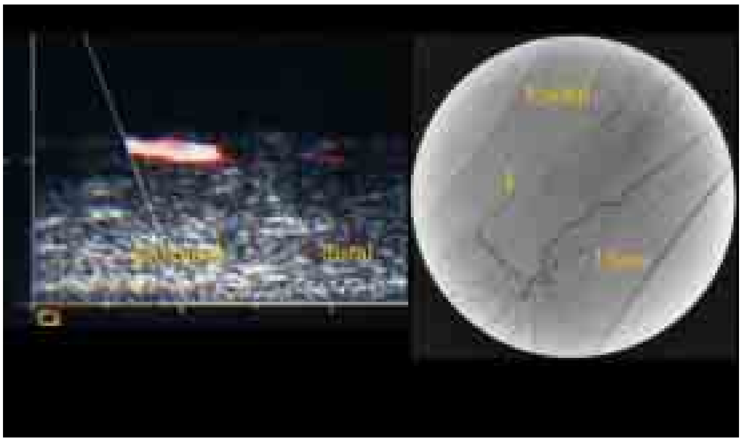


Fig. 5 Hypoplasia of the radial artery
A pre-procedural echogram suggested hypoplasia of the radial artery; the femoral artery approach was taken instead. Radial arteriography confirmed the hypoplasia. In this case, the Allen test was positive and the radial artery palpitated, but no sheath insertion was possible.

(2) Tortuously of the radial artery (Fig. 6): It is often possible to cross tortuous vessels by manipulating the wire under fluoroscopic control. Once the wire passes through, the tortuosity is straightened and the subsequent procedure is relatively simple.

Fig. 6 Bend in the radial artery
A 79-year-old female patient with old inferior myocardial infarction. Weak resistance was felt when a 0.025-inch straight wire was inserted from the outer syringe of the venous needle. Angiography was conducted from the outer syringe and revealed tortuosity of the radial artery. This patient's lesion was crossed with a 0.025-inch J-tip Radifocus wire (Terumo).

B) Anatomical variation encountered during the catheter insertion up to the ascending aorta

Various options are available for wire selection and fluoroscopic control when the catheter is advanced from the radial artery to the ascending aorta. The 0.035-inch J-tip Radifocus wire with hydrophilic coating (Terumo Corporation) is the easiest to get through. With this wire, however, it is hard to feel resistance even when it is advanced into an arteriole and can easily lead to perforation when not used under fluoroscopic control. You should therefore do all the processes in the upper arm under fluoroscopic control, which can be very tedious. The ordinary 0.035-inch J-tip spring wire presents no risk of perforation but is not so easy to get across. I prefer to use a 0.032-inch J-tip spring wire because it is well balanced with respect to safety, easy in procedures and very crossable. It can be safely advanced without fluoroscopic control, carries almost no risk of perforation and has good crossability. The catheter can be advanced into the ascending aorta in 90% or more of patients. Sometimes the use of a 300-cm wire is recommended to facilitate the exchange of catheter, but an ordinary 180-cm wire is generally sufficient. Even if the catheter is retracted, the wire remains in place to allow the insertion of another catheter when there is some bend in the bracio-cephalic artery. If in a patient with a straight bracio-cephalic artery, the wire and catheter fall out together, reinsertion is easy and poses no problems.

In principle, when a wire or a catheter will not advance, never force it them. Look at the angiogram of the area at the tip of the catheter and identify the anatomical variations. Possible major variations include a radio-ulnar loop, a high radial artery take-off, a tortuous brachial artery, or an arterial lusoria (right retro-esophageal subclavian artery).

(1) Radio-ulnar loop (Fig. 7): There is a loop at the proximal end of the radial artery, where an arteriola, or remnant artery, branches straight out from the radial artery towards the proximal side. As a 0.025-inch straight wire inserted from the outer syringe of the venous needle is advanced into this remnant artery without any resistance, the procedure up to sheath insertion progresses smoothly. When inserting the catheter, however, resistance is felt around the elbow joint and further insertion becomes impossible. Angiography from this point will reveal the loop. Various measures can then be considered depending on the angle of the loop. It is essential to perform such procedures under fluoroscopic control, and this kind of loop will probably be crossable with combined use of a JR and Terumo's 0.035-inch J-tip Radifocus wire. In this case, the loop may be straightened by slightly pulling the Radifocus wire. I had one patient in whom a loop was crossed with a 0.014-inch BMW wire to reduce curvature and allow the passage of the Radifocus wire to straighten the loop; however, an accordion phenomenon developed and the catheter could not be advanced (Fig. 8). In any event, a different approach should be considered if the catheter cannot be advanced over the loop.

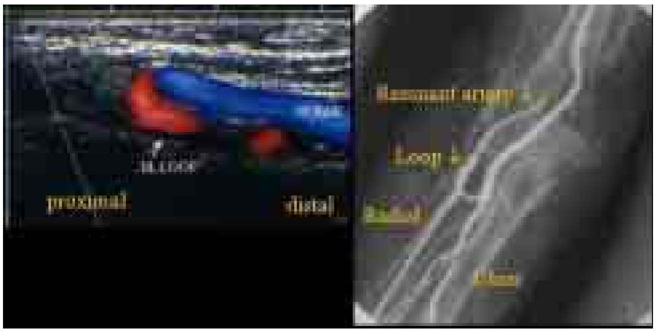


Fig. 7 Radio-ulnar loop
A 59-year-old female patient with an old inferior myocardial infarction and angina pectoris. A pre-procedural echogram of the radial artery suggested a radio-ulnar loop. This abnormality is not necessarily contra-indicated for the transradial approach; however, the femoral artery approach was taken to ensure the safety. Radial arteriography confirmed the loop.

Fig.8-1

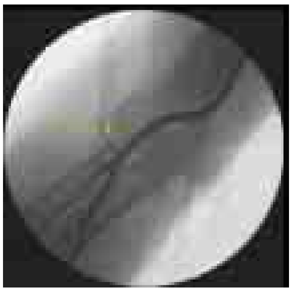


Fig.8-2

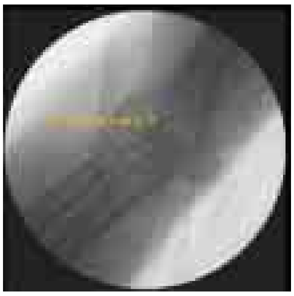


Fig.8-3

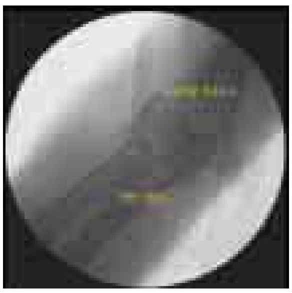


Fig.8-4

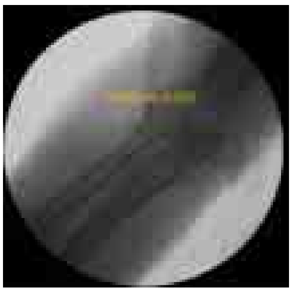


Fig.8-5

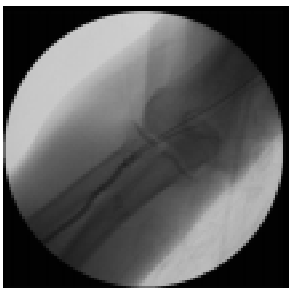


Fig.8-6

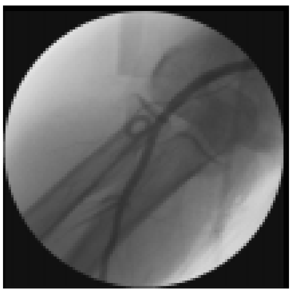


Fig. 8 Radio-ulnar loop
A 70-year-old male patient with an acute anterior myocardial infarction. While a catheter was being inserted, resistance was felt near the elbow joint and a radio-ulnar loop was confirmed (Fig. 8-1). A small remnant artery was found in the late phase angiography (Fig. 8-2). A 0.025-inch straight wire used for sheath insertion appeared to have entered this remnant artery. The loop could not be crossed with a 0.025-inch J-tip Radifocus wire (Terumo) and it was finally passed after combined use of a 5Fr JR4 and BMW-0.014 (Fig. 8-3). The curvature of the loop was reduced by the BMW-0.014 so that a 0.025-inch J-tip Radifocus wire could pass. The loop was straightened out by pulling the Radifocus wire (Fig. 8-4) but strong resistance was felt again at the elbow joint when the catheter was inserted. The loop straightened out by the Radifocus wire was completely obstructed by a strong accordion phenomenon (Fig. 8-5). Once the Radifocus wire was removed, the loop reappeared (Fig. 8-6). This case was crossed over to femoral approach.

(2) High radial artery take-off (Fig. 9): when the radial artery branches out more to the proximal side rather than at the elbow joint. In the majority of cases the branching out occurs from the brachial artery. A branching out from the axillary artery is possible in rare cases. In a patient with high take-off, the radial artery is generally underdeveloped. There will be no resistance upon insertion of the wire as long as it is straight. When there is unexpected resistance in the mid part of the brachial artery upon insertion of the catheter, or when torque transmission becomes impossible after insertion of the catheter into the ascending aorta, this kind of variation may well be the culprit. As a countermeasure, downsizing the guide catheter from 6 to 5F may allow better manipulation. If insertion or manipulation remains still difficult, however, a different approach should be tried.

(3) Tortuous brachial arteries (Fig. 10): Manipulation of the Radifocus wire under fluoroscopic control may allow enhanced crossability.

(4) Arterial lusoria (right retro-esophageal subclavian artery): This is a very rare variation. The brachio-cephalic artery winds from behind the esophagus and opens at the distal end of the aortic arch. Catheter handling is usually impossible and a different approach should be taken.

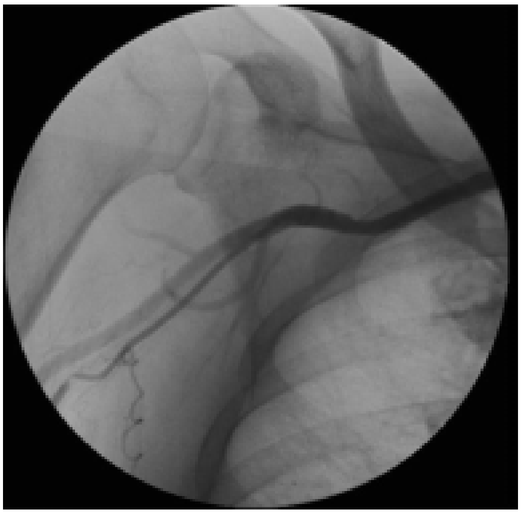


Fig. 9 High radial artery take-off
A 49-year-old male patient with angina pectoris. While the 6Fr ZUMA2 EBU was being advanced, strong resistance was felt halfway up the upper arm. Angiography was conducted and revealed high radial artery take-off. This case was crossed over to the right brachial approach.

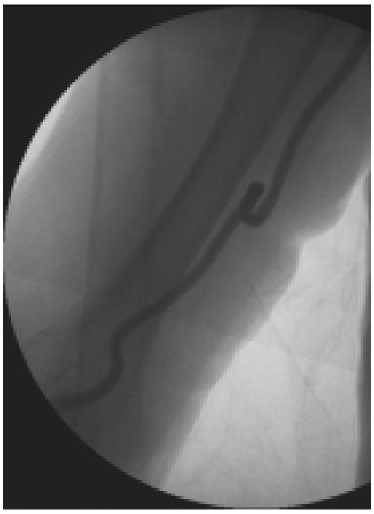


Fig. 10 A tortuosity in the brachial artery
A 87-year-old female patient with acute anterior myocardial infarction. While advancing the 5F diagnostic catheter, strong resistance was felt halfway up the upper arm. Angiography was conducted and revealed tortuosity in the brachial artery.

2. Tortuous brachio-cephalic trunks

Tortuous bracio-cephalic trunk should be recognized as one of the major obstacles to successful TRI. Figure 11 shows the incidence of crossover in initial TRI and TFI in the one-year period, the calendar year 2000. The rate of crossover is significantly higher with TRI, and the main cause is a tortuous bracio-cephalic trunk. A dozen years ago when I was first studied TFI, it was not rare for catheter manipulation to become difficult due to tortuosity of the femoral artery. With the availability of a 30-cm long sheath, made from excellent quality material, most bends in the femoral artery can now be straightened out and catheter manipulation is not difficult. On the other hand, the sheath used in TRI will be 20-cm at the longest and the sheath cannot be advanced further beyond the elbow joint. Therefore, the catheter itself, one with a small diameter and a fragile shaft, should take care of the tortuous bracio-cephalic artery.

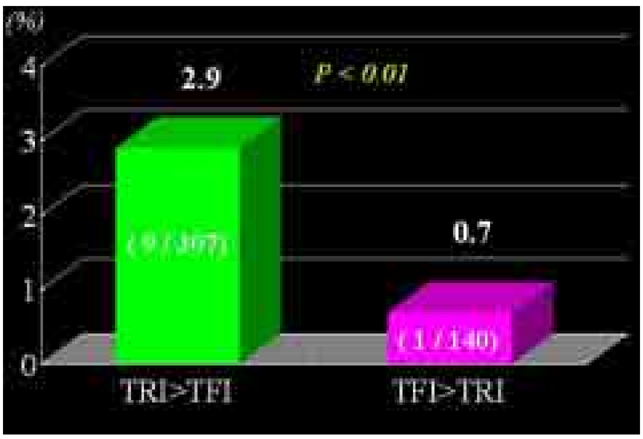


Fig. 11 Ratio of crossover from TRI to TFI during the period January-December 2000
Seven out of nine cases subject to crossover from TRI to TFI were due to tortuosity in the bracio-cephalic artery.

(1) Advancing the wire: The following describes the procedure with a 0.032-inch J-tip spring wire. The simplest method when a wire is caught in the bracio-cephalic artery is to have the patient take a deep breath. This will extend the bracio-cephalic artery somewhat. Then, advance the catheter close to the bracio-cephalic artery and increase support of the wire. Otherwise, replace the wire with 0.035-inch J-tip Terumo Radifocus wire.

(2) Getting the catheter to the ascending aorta when the wire advances only to the descending aorta even after the patient has taken a deep breath (Fig. 12): Manipulate using a LAO 45° view. Drop the wire into the descending aorta and advance the catheter along with it. When the catheter tip is in the aortic arch, have the patient take a deep breath and rotate the catheter counterclockwise so that the tip faces the ascending aorta. Then advance the wire. This process is possible with a JL or EBU but, if difficult, JR will probably be the easiest alternative.

(3) Basics of catheter manipulation: For TRI where a small diameter catheter alone has to cope with tortuosity in the bracio-cephalic artery, the wire, as a rule, should be left in the catheter to prevent kinking until the catheter is engaged in the coronary artery. In the case of procedures in the RCA where the catheter has to be rotated, or of the use of 5F catheters which are more fragile, this is a mandatory part of the procedure. When rotating the catheter, its curve will be affected if the wire is inserted up to the very tip. As a general rule, the tip of the wire should be at the middle of the ascending aorta.

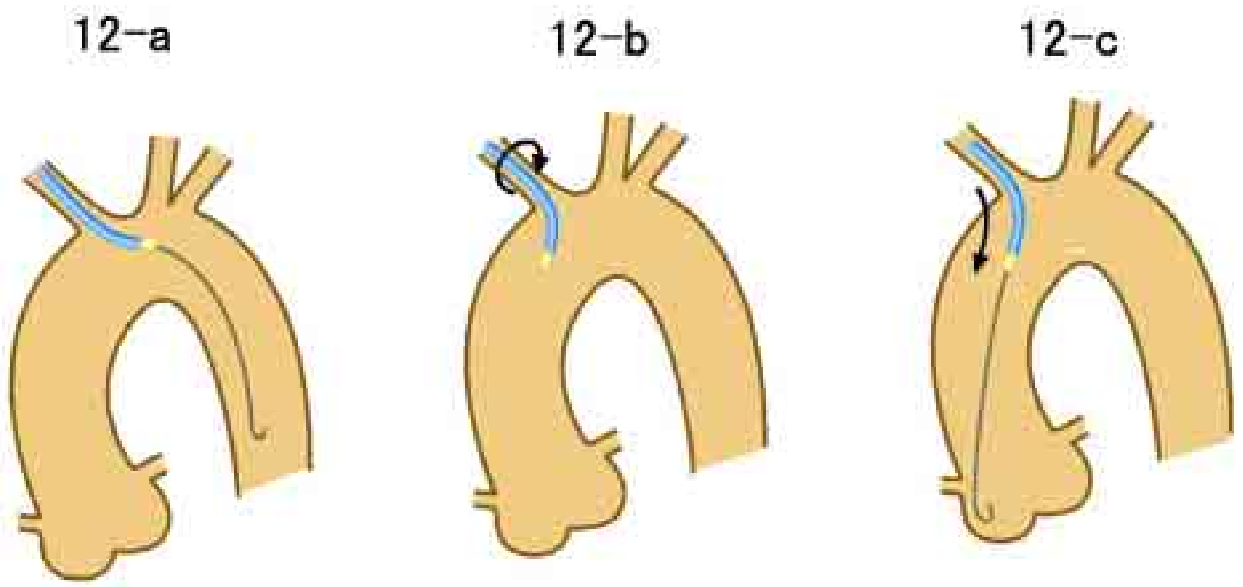


Fig. 12 Measures to take when the wire enters only to the descending aorta
12-a. Drop the wire into the descending aorta and advance the catheter along it.
13-b. Remove the wire with the catheter tip in the aortic arch. Have the patient take a deep breath and rotate the catheter counterclockwise.
12-c. Face the catheter tip toward the ascending aorta and advance the wire.

(4) Coping with extremely tortuous bracio-cephalic trunks (Fig. 13): When manipulation or rotation is difficult with a 0.032-inch J-tip spring wire, try to alleviate tortuosity by using a 0.035-inch wire instead. If it is possible to get a wire through the vessel, up-size to a 7F guide and insert 2 wires into it. At this point, if the procedure is still not feasible, take another approach rather than persisting with TRI.

Fig.13-1

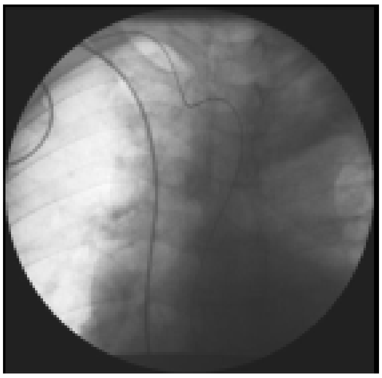


Fig.13-2

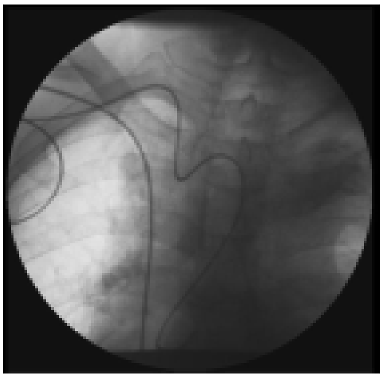


Fig.13-3

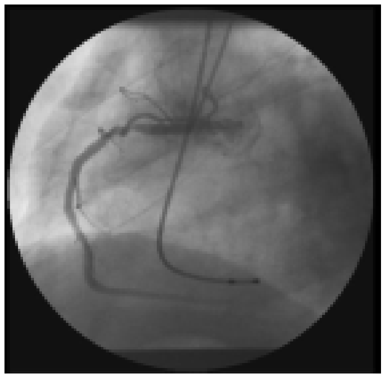


Fig.13-4

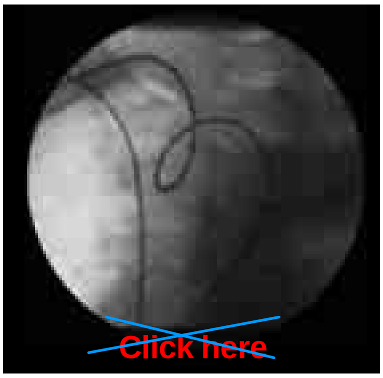


Fig.13-5

Fig.13-6

Fig. 13 Highly tortuous bracio-cephalic artery
A 67-year-old male patient with acute inferior myocardial infarction. Prior to TRI, a temporary pacemaker was inserted from the right subclavian vein. The extremely tortuous bracio-cephalic artery was crossed with a 0.035-inch J-tip Radifocus wire (Terumo), but could not be straightened out only with the wire (Fig. 13-1). The bend remained even after the insertion of a 5F diagnostic catheter (Terumo) (Fig. 13-2). It was somehow rotated and inserted into the left and right coronary artery under wire insertion. A 99% stenosis was observed at the proximal RCA (Fig. 13-3). The 6-Fr ZUMA2 FR4 that had been inserted for TRI showed strong kinking probably due to the thin catheter wall. It could not be rotated at all (Fig. 13-4, ~~motion pictures~~). The patient was crossed over to the left radial approach. When the catheter was inserted, there was resistance near the left subclavian artery. Arteriography revealed high tortuosity (Fig. 13-5). Fortunately, it could be straightened out with a 0.035-inch J-tip Radifocus wire. FR4 was then inserted to implant a NIR stent 4.0-16mm and the procedure completed (Fig. 13-6).

Selection and Usual Manipulation of your GC according to the Anatomy of the Coronary Origins

1. Right radial approach

Fig. 14 shows the frequency of use of each guiding catheter during the period January to December 2000 at the author's institution. During this period, 6- and 7F guide catheters accounted for 88% and 12%, respectively, of total use. No 5F guide catheters were used. For 6F, ZUMA2 (Medtronic) was the first choice because of its inner diameter. The fact that I preferred the long-tip catheter greatly affected the frequency of use of each guide catheter.

Fig.14-1

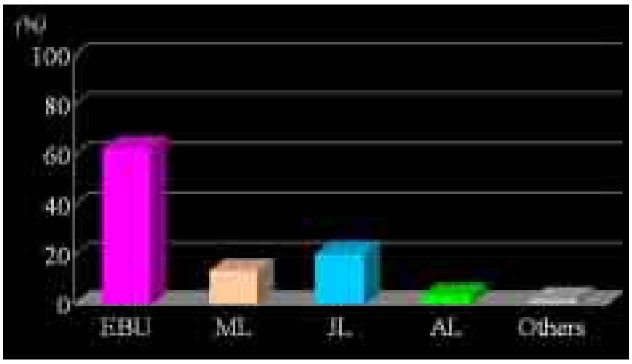


Fig.14-2

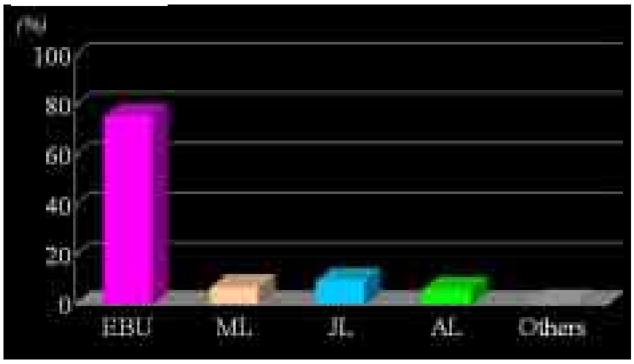


Fig.14-3

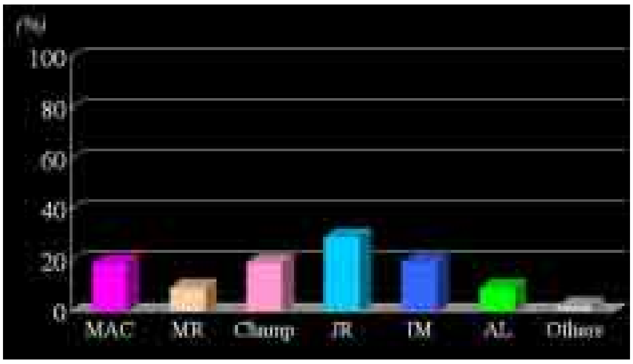


Fig. 14 Frequency of use of various guide catheters

Fig. 14-1: LAD, Fig. 14-2: LCx, Fig. 14-1: RCA

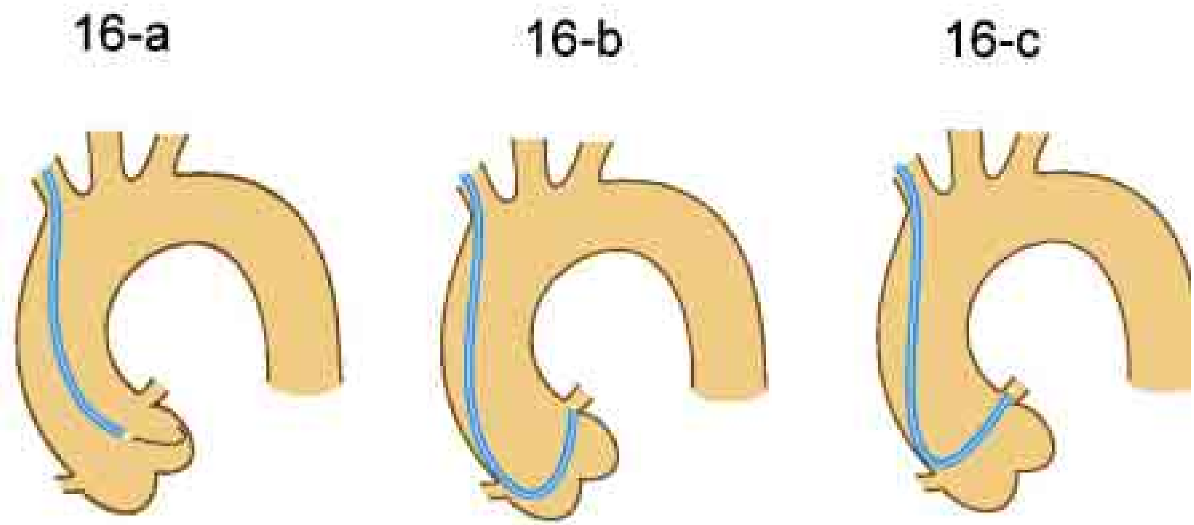
EBU: extra back-up,
ML: Muta left
JL: Judkins left
AL: Amplatz left
MR: Muta right
JR: Judkins right
IM: Internal mammary

1) LAD: In the case of the right radial approach, select a smaller size catheter than for the femoral approach. The contact point of the catheter and the contra-lateral aorta becomes lower and the distance to the LCA ostium shorter (Fig. 15). When a JL-4.0 is used as a diagnostic catheter via the femoral approach, a standard choice in the right radial approach would be short-tip JL-3.5, or EBU-3.75 or -4. for male patients and an EBU-3.5 for females.

(1) Manipulation of the JL: Using a wire, drop the catheter tip into the left sinus of Valsalva. Pull the wire out and rotate the catheter clockwise. The catheter can be inserted easily. If passive back-up appears to be insufficient for stent implantation, deep engagement is probably necessary.

Fig. 15 Difference in the position of the Judkins left depending on whether the access is from the femoral artery or the right radial artery

(2) Manipulation of the EBU (Fig. 16): Using a wire, drop the catheter tip into the left sinus of Valsalva. It may sometimes be necessary to rotate it a little clockwise. If the ascending aorta is vertical, the catheter is most likely to enter the LCA by pulling out the wire and then the catheter. It may need to be rotated slightly clockwise. Manipulation may be more difficult when the ascending aorta is horizontal. Manipulate using a LAO 45° view. Pull out the wire and push the catheter tip onto the left of Valsalva sinus. Confirm its position against the LCA ostium using a test shot, and rotate the catheter clockwise while pushing against it. Pull up the catheter when it gets closer to the LCA ostium, so that the catheter is inserted. It may need to be rotated slightly counter-clockwise when it gets closer to the left coronary artery ostium. When strong passive back-up is required, and an EBU cannot be inserted due to a horizontal ascending aorta and tortuous bracio-cephalic artery, Muta (Boston Scientific) or JFL (Jean-Fajadet Left: Cordis) may be good choices because they are curved to correct the angle between the bracio-cephalic artery and the ascending aorta (Fig. 16)[5]. At our institution, the inner diameter of the shaft means we do not use these very often. They would, however, be used more frequently if the diameter was the same as that of ZUMA2 because that would make it easier to insert them into the LCA. Unlike the Amplatz, these long-tip catheters can easily facilitate deep engagement when required.



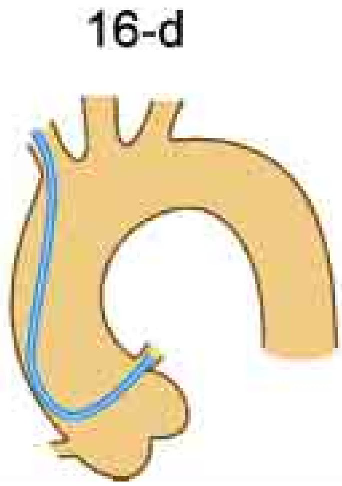


Fig. 16 Insertion of an extra back-up (EBU) to the left coronary artery

16-a Slightly rotate the catheter tip clockwise toward the left sinus of Valsalva
16-b Retract the wire to the middle of the ascending aorta and push the catheter while slowly rotating it clockwise
16-c Pull up the catheter at the moment it gets close to the left coronary artery ostium, and the catheter is inserted.
16-d It is easier for the Muta left and JFL (Jean-Fafadet Left) catheters to be inserted because they are curved to correct the angle between the bracio-cephalic artery and the ascending aorta.

2) LCx: As stated earlier, because the contact point of the catheter and the contra-lateral aorta becomes lower than it would be via the femoral approach, the JL catheter should be inserted as if the ceiling of the left main trunk is pushed up from below. Good back-up for LCx cannot be expected with a JL (Fig. 15). Even with the improved stents available today, the standard choice would be the long-tip or Amplatz. The Long-tip catheter can be used for deep engagement as and when required.

(1) Manipulation of the EBU: this is basically the same as described above. When the LMT is short, an EBU of a slightly

bigger size may be used to engage the LCx super-selectively. The reverse is also possible and the smaller EBU may be used to aim for the LAD super-selectively. Also, without changing the size of your EBU, the LCx or LAD may be selected by gentle pulling or pushing on the catheter. (Fig. 17).

(2) Manipulation of the Amplatz: Using a wire, drop the catheter tip into the left sinus of Valsalva. Pull out the wire. Rotate the catheter counter-clockwise while pushing it onto the left sinus of Valsalva.

Fig.17-1

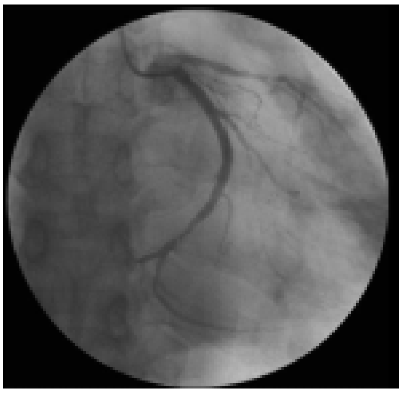


Fig.17-2

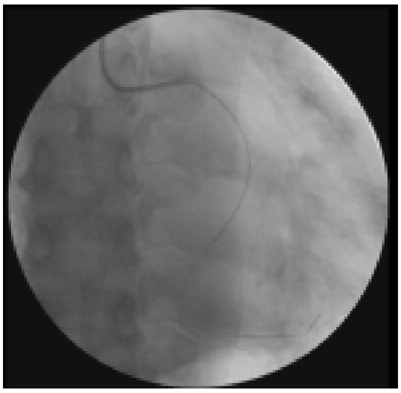


Fig.17-3

Fig.17-4

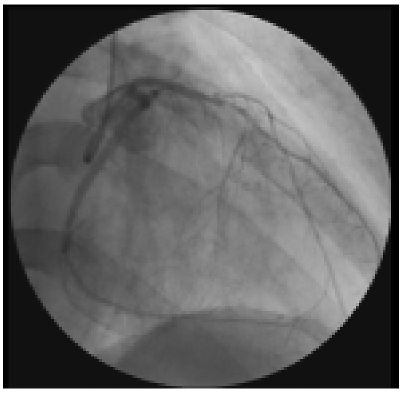


Fig.17-5

Fig.17-6

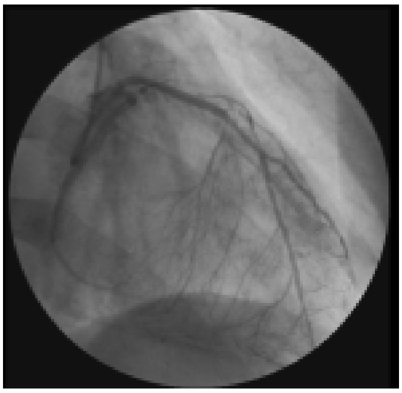


Fig. 17 Use of an extra back-up (EBU) in a patient with short LMT
A 49-year-old male with effort angina. Two-vessel disease with mid LCx 90% and proximal LAD 99%. The 6Fr ZUMA2 EBU-3.75 was used as described above. The catheter was selectively entered into the LCx when pulled (Fig. 17-1). The stenosis at mid LCx was crossed with a Transit and Neos Intermediate (Fig. 17-2). After predilatation with a 2.5 mm balloon, a S670 3.0-18 mm was implanted (Fig. 17-3). Then, the catheter was selectively inserted into the LAD (Fig. 17-4). The stenosis at proximal LAD was crossed with the Transit and Neos Intermediate. The wire was changed to a Rotafloppy-0.009 to perform ablation with a 1.75 mm-burr (Fig. 17-5, ~~motion pictures~~). Finally good expansion was obtained by implanting a NIR 3.0-15 mm. (Fig. 17-6). In this case, super-selective insertion to the LAD and LCx was made possible by use of the same size catheter. It is also possible to use an EBU-3.5 for the LAD and an EBU-4.0 for the LCx.

3) RCA: Go for either a JR, Amplatz, or long-tip. They all have both advantages and disadvantages. For basic catheter manipulation for insertion into the RCA, a clockwise rotation is mandatory with any of them. A wire should be left inside the catheter to prevent kinking.

(1) Manipulation of a Judkins: A JR 3.5 would be the standard choice. If the ascending aorta is vertical, this catheter is best inserted by clockwise rotation with passive back-up expected as well. One of the advantages of selecting the JR is

that a favorable active back-up is obtained by deep engagement once the wire and balloon have passed. On the other hand, if the ascending aorta becomes horizontal, the catheter cannot be secured and no passive back-up is obtainable (Fig. 18). Also, if the angle between the ascending aorta and the proximal end of the RCA becomes acute, insertion itself will be difficult because the curve of the catheter tip does not match. The typical example is an RCA with Shepherd's crook. In this case, the use of a catheter for the internal mammary artery would make the insertion and fixation easier, because the angle between the catheter tip and shaft is smaller than that of the JR (Fig. 18). For the RCA without a Shepherd's crook, it is also difficult in my experience to obtain passive back-up with a JR when the proximal horizontal segment is long.

(2) Manipulation of the Amplatz: Select either an Amplatz left (AL) 1 or 2. Rotate the catheter clockwise while pushing slightly, to insert. Although Amplatz provides a stronger back-up than the JR, its shape does not allow deep engagement and that can sometimes be a problem. For instance, if a stent does not cross following pre-dilatation, that constitutes a difficult problem.

(3) Manipulation of a long-tip: The following long-tip catheters can be used in the RCA: Champ (Medtronic), MAC (Medtronic), or Muta Right (MR: Boston Scientific). The basic concept is to obtain strong passive back-up from the contact of the catheter with the contra-lateral aortic wall. Manipulation is easiest with the Champ and becomes harder with the MAC and MR, in that order. In contrast, the strongest back-up can be obtained with an MR. Refer to the Table for selection of catheter size (Table 1). With respect to basic manipulation, face the catheter tip toward the left sinus of Valsalva and rotate clockwise while slowly pulling it to introduce the catheter tip into the right sinus of Valsalva.

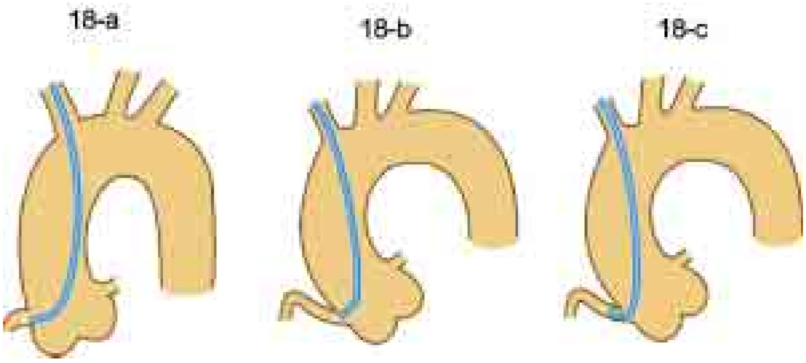


Fig. 18 Position of a JUDKINS RIGHT and the ascending aorta/right coronary artery

18-a The Judkins Right is firmly fixed when the ascending aorta is vertical
18-b The Judkins Right cannot be firmly fixed when the ascending aorta is horizontal with a Shepherd's crook RCA.
18-c In such cases, the use of a catheter for the internal thoracic artery will result in good secure positioning. However, the catheter does not touch the contra-lateral aortic wall because of its short tip. Strong passive back-up is not obtained.

Size selection for long-tip catheters to the RCA via the right radial approach

	Ordinary RCA	So-called Shepherd's crook
Champ	1.5 – 2.0	2.5 – 3.5
MAC	3.5	4.0
Muta	2.0	2.0 – 3.0

Once the catheter is in the right sinus of Valsalva, it can be inserted into the RCA by a further rotation and sometimes a slight push (Fig. 19). Deep engagement is easily obtained, when necessary, with these catheters. It should not be selected, however, if there is a lesion near the ostium, because it can easily end up in the distal end of the proximal RCA.

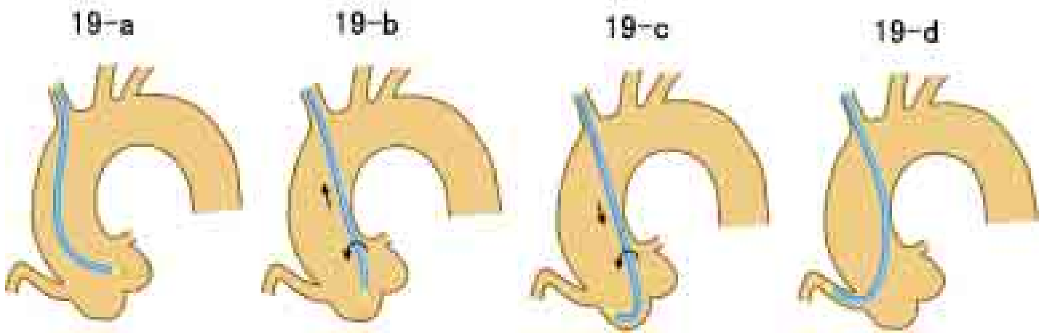


Fig. 19 Insertion of a MAC into the right coronary artery

19-a. Rotate the catheter tip to face the left sinus of Valsalva.

19-b. Retract the wire to the middle of the ascending aorta, rotate the catheter clockwise slowly while pulling it, and introduce the tip into the right sinus of Valsalva.

19-c. Keep slowly rotating the catheter clockwise and push the catheter to the sinus of Valsalva.

19-d. The catheter instantly enters the right coronary artery ostium when its tip gets to the same level.

2. Left radial approach

Some say that the left radial artery approach is similar to the femoral approach, but I believe that they are totally different. In the LAO 45° view, a catheter inserted from the left radial artery usually comes into contact with the left (i.e. inner) side of the ascending aorta upon the aortic valve. Major restricting factors such as the curve of the left subclavian artery, the angle at which it merges the aortic arch, and the presence of the ascending aorta determine the point of contact. The insertion of a JR into the RCA is easy, for this reason, and reasonable passive back-up can be obtained. The problem lies with the LCA.

For instance, for a patient in whom a JL 4.0 is used for TFI, the 4.0 size is determined by the distance between the LCA ostium and the contra-lateral aortic wall. With right-side TRI, the contact point of the catheter and the contra-lateral aorta (i.e. the hinge of the catheter) is slightly lower than that with TFI, and the JL-4 may be too large. It is often the case that the JL-3.5 is an exact fit and the tip pushes the ceiling of the LMT slightly upwards. When a JL-3.5 is selected for left-side TRI in such a patient, however, the catheter turns out to be too large and the tip of the JL comes below the LCA when viewed with LAO 45° view. I have been puzzled not a little by this fact and have been thinking about the reason for it. In these patients, the ascending aorta is almost horizontal and a catheter passed through the left subclavian artery comes out into the ascending aorta from the left. The hinge point of the JL, which should contact with the contra-lateral aortic wall in the case of TFI, comes at the middle of the ascending aorta. In other words, because the JL is bent at the middle of the ascending aorta, even the JL-3.5 is too large (Fig. 20). As the contra-lateral aortic wall does provide a point for support of the catheter inserted into the LCA, several precautions are required when the catheter is placed in this position.

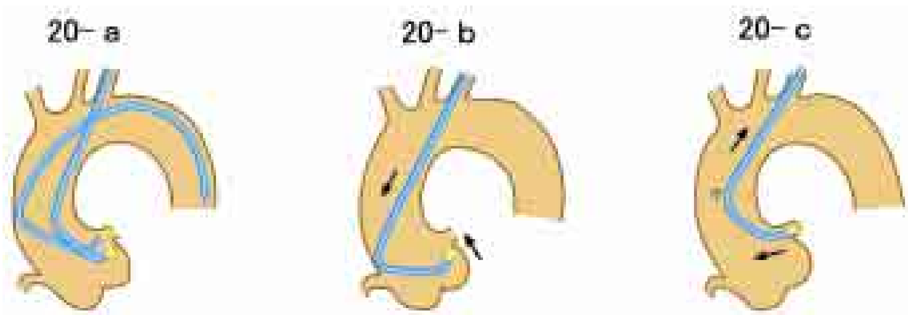


Fig. 20 Problems with Judkins left and the left radial approach

20-a When the ascending aorta is horizontal and the subclavian artery is vertical, the catheter comes into contact with the left side of the ascending aorta. Even if a catheter smaller than that for the femoral approach is used, it is still too large and cannot enter the left coronary artery.

20-b Rotate the catheter clockwise to make it vertical on the LAO 45ß projection (with the tip directly below the left coronary artery ostium) and push it while conducting a test shot.

20-c Pull the catheter at the moment its tip reaches the height of the left coronary artery ostium, and it will enter the left coronary artery. In this case as well, the support point (*) of the Judkins left does not touch the contra-lateral aortic wall. Hardly any passive back-up is obtained although it appears to be co-axially engaged.

The first of this involves the method for inserting the JL. When a smaller catheter is used, even if it enters the LCA, it is only hooked to it without coming into contact with the contra-lateral aortic wall, and no passive back-up will be obtained. Therefore, try to use a size 3.5 at least. Then, introduce the tip of JL into the lower part of the LCA using an LAO 45° view. Move the wire up to the subclavian artery, keeping a position that enables a test shot. Rotate the catheter appropriately to make it vertical to your 45° LAO projection. When the catheter is vertical to the LAO 45° projection, the tip should basically be located precisely below the LCA ostium. Slowly push the catheter at this point. Then, quickly pull the catheter at the moment the tip becomes level with the LCA ostium, after a test shot. As the tip is facing upward, it should rotate sideways and advance toward the LMT facilitating insertion (Fig. 20). Similar technique is also effective for inserting the EBU. If insertion is not possible even after several attempts, there is no other way but to try the Amplatz.

Now that the JL seems to be firmly inserted, confirm under fluoroscopic control whether it is in contact with the contra-lateral aortic wall or just floating in the ascending aorta. Even in the latter case, once a wire and a balloon can be crossed under weak passive back-up, a stent can be implanted by deep engagement of a JL utilizing the balloon as an anchor. The problem lies with cases where a complex procedure such as rotablation or opening the CTO has to be performed. Exchange guide catheters in the middle of a procedure is tedious and risky; so carefully assess whether your procedure can be accomplished with the passive back-up obtained. If it cannot, consider up-sizing the catheter, using an Amplatz, or a different approach. My present partner, a cardiac surgeon, frequently uses a left radial artery graft with excellent patency results. I therefore try to avoid the left radial approach as much as possible in multiple vessel disease patients for whom a future CABG is considered.

Special techniques for difficult cases

1) Obtaining active back-up by deep engagement

In TRI, a small-diameter catheter is often inserted deeply into the coronary artery to prevent the stent dislodging while maintaining active back-up. Deep engagement is a spectacular procedure sometimes referred to as “the essence of TRI.” Once I was quite experienced with TRI, I attempted complex lesions. At that time, I rather recklessly attempted deep engagement, but it was not successful for all cases. When I pushed the catheter alone, it dislodged from the coronary artery. Deep engagement also seemed more difficult when complex lesions required this procedure. I then began opting for TRI to avoid deep engagement, whose success is not guaranteed, and then got involved in the development of a long-tip catheter to give strong passive back-up. There are, however, lesions for which these procedures cannot be completed without deep engagement. I will therefore now discuss various conditions that may facilitate deep engagement. I am well aware that many other doctors may disagree with me, but these opinions are mine, and based on my personal experiences.

(1) Types of catheter: As described earlier, deep engagement is not possible with an Amplatz but is with a JL, JR or long-tip (Figs. 21 and 22).

(2) Condition 1: Deep engagement is possible only when the wire passes through a lesion and goes into the distal part of the coronary artery. Most of the wires available today are treated with a hydrophilic coating: it has never been easier to cross lesions and to advance wires to the distal vasculature. In a CTO or a highly tortuous RCA, however, strong passive back-up may be required just to get the wire to the distal part of the coronary artery. In these cases, it is easier

Fig.21-1 **Fig.21-2** **Fig.21-3** **Fig.21-4**

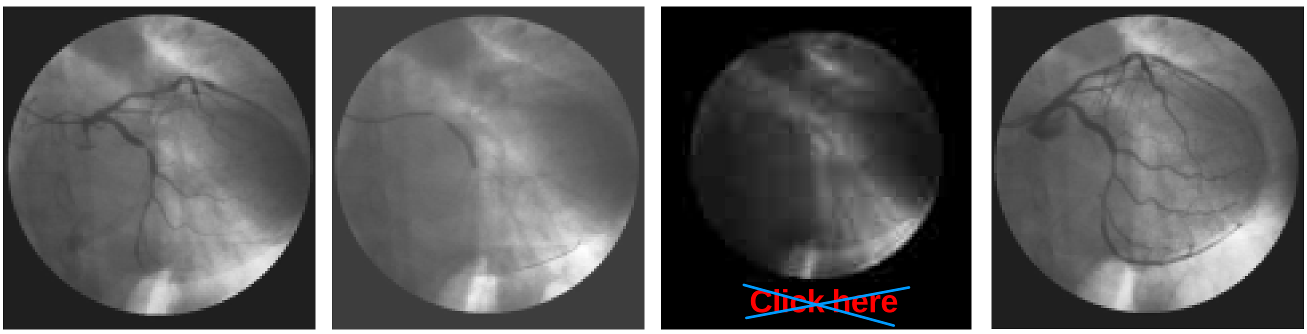


Fig. 21 Deep engagement of the EBU catheter in the LCx
A 57-year-old female patient with unstable angina. Single vessel disease with a 90% mid LCx lesion. The 5Fr ZUMA2 EBU-3.75 was selected (Fig. 21-1). The lesion was inflated with a 3.0mm balloon (Fig. 21-2). EBU was successfully deeply engaged by anchoring on the balloon (Fig. 21-3, ~~motion pictures~~). Then a S670 3.0-15 mm was implanted at the lesion (Fig. 21-4).

Fig.22-1 **Fig.22-2** **Fig.22-3** **Fig.22-4**

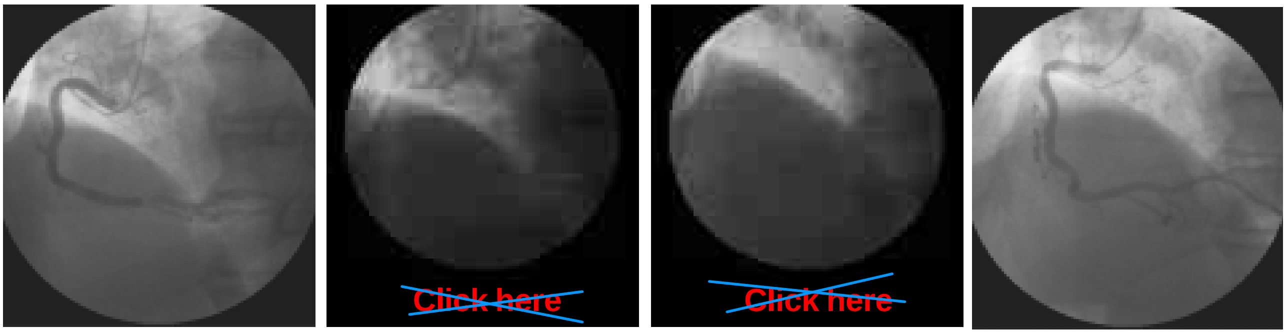


Fig. 22 Deep engagement of the MAC catheter to the right coronary artery
A 64-year-old male patient with unstable angina. A diagnostic 5Fr IM was used. The right coronary artery showed Shepherd's crook and 99% stenosis was observed at the distal portion (Fig. 22-1). The Shepherd's crook can be seen to be somewhat straightened with the engagement of a long-tip catheter such as the 6Fr ZUMA2 MAC 4.0. (Fig. 22-2, ~~motion pictures~~). The MAC was deeply engaged with a 3.5-mm balloon used as an anchor (Fig. 22-3, ~~motion pictures~~). Then a Multilink 3.5-15 mm was implanted into the lesion (Fig. 22-4).

to obtain deep engagement with a long-tip catheter rather than with a Judkins. Using a transit catheter may be useful for reducing friction with the coronary artery wall as well as for increasing support.
(3) Condition 2: This, too, is largely a question of common sense. The inner diameter of the proximal coronary artery should be bigger than the outer diameter of the catheter. At the ostium of the LAD or LCx, a moderate lesion may be sometimes overlooked depending on the quality of the angiography. If this happens, the catheter does not advance when deep engagement is attempted. This can be frustrating.
(4) Condition 3: Upon deep engagement, unexpected force may be placed on the wire. As the operator is concentrating on the proximal coronary artery, the wire tip at the distal part may not be under fluoroscopic control and its whereabouts can become unclear. For this reason, a spring wire should be used when attempting deep engagement, because its tip will not perforate the coronary artery. It is also necessary to have the wire tip under fluoroscopic control. There may be cases where the highly tortuous RCA can only be approached with the Choice PT plus, which is very slippery with minimum friction with the coronary artery wall. Even in such a patient, however, it is better to straighten out the tortuosity of the coronary artery with a Choice and try to pass the spring wire as a parallel wire. Then make sure you remove your Choice before trying deep engagement (Fig. 23).
(5) Manipulation 1: In straightforward cases, deep engagement is obtained by pulling the deflated balloon into the catheter while slightly pushing the catheter. When deep engagement is imperative, and there is no room for failure, as with , for instance, a Shepherd's crook RCA, this method is not recommended because the catheter often falls out.
(6) Manipulation 2: The surest method is to use the inflated balloon as an anchor. First, inflate the lesion with the right size balloon at 6 to 8 atm. Fully open the Y-connector and pull the balloon shaft with the right hand while simultaneously pushing the catheter with the left hand, this will give you deep engagement (Figs. 22 and 23). To remove the catheter, pull it while pushing the wire into the distal coronary artery.

Fig.23-1 **Fig.23-2** **Fig.23-3** **Fig.23-4** **Fig.23-5**

Fig. 23 Deep engagement of the Muta catheter to the RCA
A 65-year-old male patient with effort angina. The RCA showed a marked Shepherd's crook and calcification was observed as well (Fig. 23-1). The 6Fr Muta right 3 catheter was inserted (Fig. 23-2). The procedure was started with an BMW at first, but strong friction with the tortuous coronary artery wall prevented its insertion further than to the mid portion. It was finally crossed with a Choice PT plus (Fig. 23-3, ~~video~~). Then, the coronary artery was slightly straightened with the Choice PT and the BMW inserted. A balloon over the BMW was used for pre-dilatation. Muta right was deeply engaged with the balloon used as an anchor and S670 4.0-12 mm was brought into the lesion (Fig. 23-4, ~~video~~). Ultimately, good expansion was obtained (Fig. 23-5).

2) Other: To deal with an RCA originating in the left sinus of Valsalva, a comparatively common ostial anomaly, take the left radial approach and select the AL-1 or –2. This is my empiric advice (Fig. 24).

Complications

With respect to the complications associated with guide catheters, the Judkins is very safe because it provides weak passive back-up and is not likely to damage the coronary artery. With a long-tip catheter, while it has the advantage of providing strong passive back-up, it has the disadvantage of being sensitive to sizing. If too big a size is used, the coronary artery may be injured. There are reports of LMT injury caused by the Voda left. If not certain what size to select, go for a smaller size on the basis of safety.

Fig.24-1 **Fig.24-2** **Fig.24-3** **Fig.24-4** **Fig.24-5**

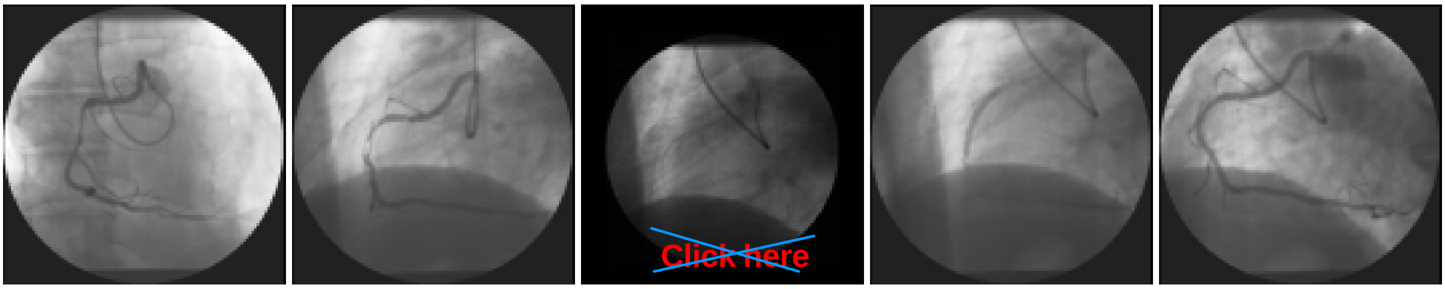


Fig. 24 Left transradial artery approach to RCA originating from the left sinus of Valsalva.
A 75-year-old male patient with unstable angina. After failures with the right radial approach and the right femoral approach, the author attempted the left radial. The right coronary artery branched out quite close to the left coronary artery and a diagnostic catheter, 5Fr Amplatz left2, could barely be engaged (Fig. 24-1). A 95% stenosis at the proximal RCA was observed. Although a 6Fr ZUMA2 Amplatz left 2 was used as a guide catheter (Fig. 24-2), no passive back-up was obtained. A Transit was therefore employed to increase wire support and to reduce the friction with the coronary artery wall (Fig. 24-3, ~~video~~). After crossing the wire, the Transit was retracted by Nanto's method and the lesion was expanded with a 3.5-30 mm long balloon (Fig. 24-4). Good expansion was obtained and the procedure was completed (Fig. 24-5).

The Amplatz, a typical under-bent catheter, is not stable and there have been not a few accidents reported with respect to coronary artery injury by this catheter even via the femoral approach. I also had one particularly bitter experience where the catheter became somewhat dislodged from the LCA during a rotablator procedure. It resulted in placing a non-coaxial force on the ostium and led to dissection at the LMT; bail-out stenting was my only option (Fig. 25).

The above represents my own experiences and opinions on the selection and manipulation of a guide catheter in TRI. It will be a great pleasure if this article is of any help to other physicians in their own daily TRI practice.

Fig.25-1 **Fig.25-2** **Fig.25-3** **Fig.25-4** **Fig.25-5**

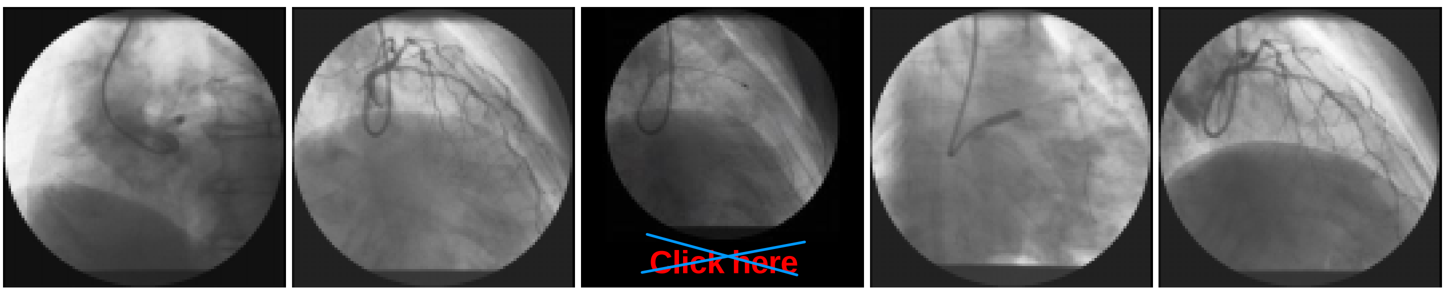


Fig. 25 Dissection of the LCA main trunk due to an Amplatz catheter
A 76-year-old female patient with effort angina. As a 7Fr Judkins left 3.5 could not be engaged from the left radial approach (Fig. 25-1), an Amplatz left 1.5 had to be used (Fig. 25-2). Ablation with the 1.5mm burr was conducted on the 90% stenosis at mid LAD accompanied by severe calcification. During ablation, the guide catheter became slightly dislodged from the left coronary artery. This caused dissection of the LMT and resulted in a threatened closure (Fig. 25-3, ~~video~~). A NIR 4.0-16 mm was implanted immediately after the completion of ablation, bailing out the threatened closure (Fig. 25-4). A favorable result was obtained for the mid LAD with an additional 2.0-20 mm balloon angioplasty.

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