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Radical Radial: Pearls and Pitfalls in Transradial Yttrium-90 Liver-Directed Therapy

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The frequency of transradial access in interventional radiology has been steadily increasing, including for yttrium-90 (Y-90) selective internal radiation therapy to treat hepatic malignancies. The aim of this article is to detail an optimized approach to transradial Y-90 (TRY-90), showing it to be a safe and feasible first-line approach to hepatic selective internal radiation therapy. Salient preprocedural considerations to enable appropriate patient selection for TRY-90 are discussed and a detailed equipment list is provided. The article will describe our approach to TRY-90 in addition to a discussion around technical pearls and pitfalls.
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Introduction

The use of transradial access (TRA) for image-guided coronary interventions has been steadily increasing since its introduction in 1989.[1] TRA has advantages over transfemoral access (TFA), including lower risk of major access site hemorrhage,[2] decreased overall mortality,[2,3] shorter patient recovery period, earlier patient ambulation, and patient preference.[4] The superiority of TRA over TFA is overwhelming in the cardiology literature and in 2015 the European Society of Cardiology recommended TRA as the standard of care for all coronary interventions in Europe. TRA has also become the standard of care in many countries across Asia.[5] More recently, the technique has gained rapid adoption in interventional radiology (IR) with several large cohort studies demonstrating the safety and efficacy of TRA for these IR-specific procedures.[6-8]

Yttrium-90 (Y-90) selective internal radiation therapy (SIRT) is an established locoregional treatment method for both primary and secondary hepatic malignancy. It has traditionally been performed via TFA; however, numerous institutions have since transitioned to performing this procedure implementing TRA as the first approach to access.[6-8] Herein, we will describe our approach to transradial Y-90 (TRY-90).

Preprocedure Assessment

As the primary center for hepatic oncology patients in the province of British Columbia, our institution receives many patient referrals through a weekly multidisciplinary tumor board. Patients for whom Y-90 is deemed appropriate are seen in our IR clinic prior to the procedure. A standard assessment is performed to ensure the patient is indeed suitable to receive Y-90 SIRT, well summarized by Bilbao and Reiser.[9]

Considerations specific to optimizing a TR approach in the clinic include: (1) ensuring the left radial artery has not been compromised due to prior trauma or graft harvesting, and (2) performing a Barbeau test to ensure there is adequate collateral circulation to the left hand.[6] The latter is easily performed in a clinic setting with a portable, battery operated pulse oximeter (Fig. 1). A portable ultrasound (US) unit can also be used to assess radial artery size and a general recommendation of a radial artery diameter of at least 2 mm is suggested when introducing TRY-90 (the minimum threshold can be decreased to 1.4 mm in conjunction with the use of lower profile sheath/catheter combinations once the operator becomes more experienced at TRA). Patient height is another consideration. A patient presenting 6′3″ or taller may exceed

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Figure 1 Battery operated, portable pulse oximeter that can be easily used in a clinic setting.

the ability of a 125-cm base catheter to access the hepatic circulation. In these situations, measuring patient arm length and torso length from neck base to umbilicus can more accurately help determine whether TRA is feasible.

All patients who present for Y-90 consultation in our center receive a computed tomography (CT) scan the same day, following the Optimized Computed Tomographic Angiography Vessel Evaluation (OCTAVE) Protocol.[10] Careful assessment of this CT scan, particularly the thin collimation arterial phase images, is beneficial regardless of a radial or femoral approach as any variant hepatic arterial anatomy, such as a replaced right hepatic artery or gastrohepatic trunk, is easily identified. The origins of hepatic to extrahepatic vessels that may require embolization, such as the right gastric artery or supraduodenal artery, may also be detected.

CT identification of any potential parasitized extrahepatic arteries to the liver tumors, which may require selective embolization to facilitate redistribution, can be of particular importance in the preprocedural setting. Extrahepatic parasitization is more frequent in hepatocellular carcinomas in a subcapsular location or in the high hepatic dome, especially if the lesions have already undergone prior embolotherapy. In general, vessel selection and more robust purchase is gained when utilizing a TRA approach, though specific cases are dependent on the angle at which the target vessel arises from the base vessel (clearly delineated with the OCTAVE Protocol).

If there is strong suspicion that the right internal thoracic artery has been parasitized, it may be more prudent to opt for a femoral approach. A left TRA would necessitate traversing the aortic arch and catheterizing 2 of the arch vessels in order to reach the internal thoracic artery for embolization. A right TRA is possible but comes with its own disadvantages, including having to navigate across the aortic arch after embolization of the internal thoracic artery to enter the hepatic arterial circulation, as well as loss of working catheter length. If TRA is preferred for administration, a dual access right and left TRA can be performed; the right internal thoracic artery can be addressed from the right radial artery while the mapping can be addressed from the left.

Involvement of the inferior phrenic artery (IPA) may pose a challenge for both TFA and TRA. The IPA often arises superiorly from the celiac trunk at less than 1 cm from the celiac trunk origin, which can prove difficult to select from TRA due to relative instability of the base catheter when its tip is positioned at the most proximal portion of the celiac trunk. Selection of these vessels from TFA may be easier achieved with the use of reverse curve catheters specifically designed to select cranially oriented celiac branches (ie, Rosch left gastric, Cook Medical, Bloomington, ID). The IPA can be accessed from the radial artery using a catheter with a more vertical primary curve (Ultimate-1; Merit Medical Systems, South Jordan, UT). The decision to access the IPA from radial or femoral is therefore based on the operator's experience and preference as well as the availability of appropriate equipment (Fig. 2).

With respect to potential parasitization of distal branches of the gastroduodenal artery, such as the gastroepiploic or omental arteries, standard microcatheter lengths—even at up to 150 cm—may be unable to reach such distal vessels from TRA, in which case TFA may be preferred (Fig. 3). If TRA is still chosen in these circumstances, the operator should aim to advance the base catheter deep into the gastroduodenal artery in order to gain more working microcatheter length.

Equipment List (Basic)

Sheaths – Use of radial-specific hydrophilic sheath access kits, including the 4Fr-7Fr IDeal and Prelude Ease (Merit Medical Systems, South Jordan, UT) as well as the 5Fr-7Fr Glidesheath Slender (Terumo Medical Corporation, Somerset, NJ) kits, is strongly advised.

Arm boards – There are 2 types of arm boards commonly used to support the left arm during TRY-90. One is a smaller

Figure 2 (a) Cranially arising right inferior phrenic artery (IPA) from the proximal celiac trunk selected with a reversed curve catheter from a TFA approach. (b) Cranially arising common IPA from the proximal celiac trunk selected with the Ultimate-1 catheter from a TRA approach.

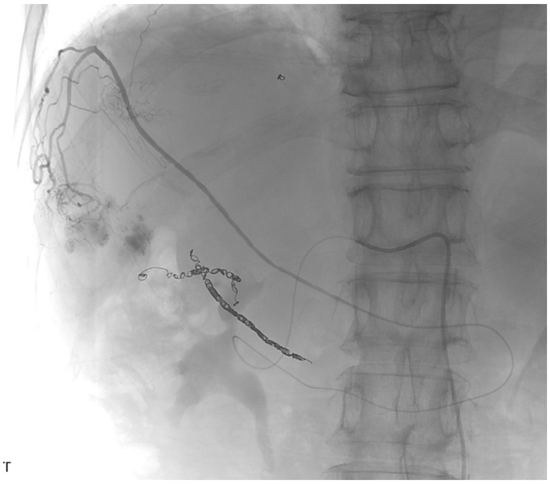

Figure 3 Distal omental branches of the gastroepiploic artery parasitized by a hepatocellular carcinoma, requiring considerable microcatheter length to reach them for embolization; these were detected on preprocedure CT and a TFA approach was chosen.

profile swivel or pivot capable arm board and the other is a fixed, larger plexiglass arm board. The swivel arm board is ideal for use during TRY-90 mapping as it can be easily pivoted out of the way for any cone beam CT acquisitions that are performed. The larger arm board is ideal for TRY-90 administration as it provides a larger and more stable working area to support the connection between the Y-90 administration system and the delivery catheter. We place a soft, ergonomic sponge support (Rad Support, Merit Medical Systems, South Jordan, UT) on both boards to aid in patient comfort (Fig. 4).

Base catheters — Our catheter of choice is the 5Fr Ultimate-1 (Merit Medical Systems, South Jordan, UT) catheter, which is available in 100-, 110-, and 125-cm lengths (Fig. 5). In the authors' experience, the 5Fr size has more torque-ability for maneuvering into the visceral aortic branches than the 4Fr version. The shape of the Ultimate-1 catheter is also such that when the secondary curve is oriented posteriorly, it stably deflects the catheter tip anteriorly to where the celiac trunk and Superior mesenteric artery (SMA) origins are positioned. Simple single angled tip catheters do not have a

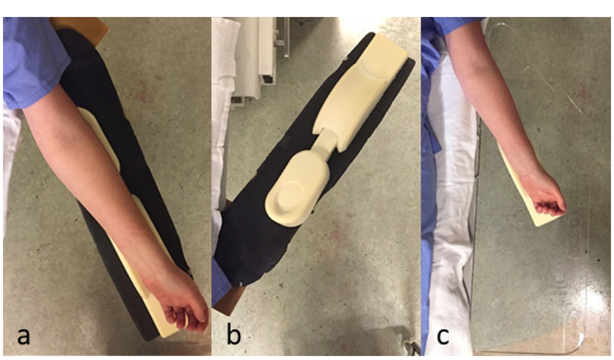

Figure 4 (a) Swivel arm board in place and (b) moved out of the cone-beam CT arc, best used for TRY-90 mapping where cone-beam CT will be performed. (c) Fixed plexiglass arm board, best used for TRY-90 administration where a larger, stable working space is beneficial. Note the Rad Support sponge used for patient comfort.

Figure 5 Ultimate-1 catheter tip shape.

stabilizing secondary curve and consequently visceral aortic branch selection may prove technically challenging. The Jacky/Sarah (Terumo Medical Corporation, Somerset, NJ) catheters have a similar shape to the Ultimate-1 catheter. The Ultimate-1 catheter is our preference for 2 main reasons: (1) the Jacky/Sarah catheters are only available up to 110-cm length, limiting maximum working catheter length; and (2) the extra curve at the tip of these catheters (which the Ultimate-1 shape does not have) means the tip almost always deflects caudally when visceral aortic vessels are initially catheterized, resulting in more difficult selection of any cranially directed branches such as a gastrohepatic trunk (Fig. 6).

Base guide wires — An atraumatic soft tipped 0.035″ wire such as the Bentson wire (Cook Medical, Bloomington, IN) or Wholey wire (Medtronic, Minneapolis, MN), coupled with a hydrophilic 0.035″ wire such as the Glidewire (Terumo Medical Corporation, Somerset, NJ) are recommended for primary access and subsequent selection.

Microcatheters — A variety are available with a range of inner diameter (ID) sizes (0.021″-0.027″); the critical feature is that they be at least 150 cm in length. At our institution, we utilize the Maestro (Merit Medical Systems, South Jordan, UT), Progreat (Terumo Medical Corporation, Somerset, NJ), and Renegade or Direxion (Boston Scientific, Marlborough, MA) microcatheters in 150-cm lengths.

Valve adaptor — Our preference is the FLO30 (Merit Medical Systems, South Jordan, UT) adapter for use at the base

Figure 6 Jacky catheter tip shape; note the additional curve at the tip, which is absent on the Ultimate-1 catheter.

Figure 7 FLO30 valve adaptor.

catheter to microcatheter transition (Fig. 7). It is considerably shorter than standard Y-adaptors, therefore saving 5 cm or more of working microcatheter length. The FLO30 does not allow for flushing while connected to the base catheter; however, from a practical perspective, this has not proven to be of clinical relevance.

Hemostasis — Our institution has developed a rapid hemostasis protocol Percutaneous Radial hemOstasis using a Truncated dEflation Algorithm (PROTEA),[11] which uses the combination of a StatSeal disc (Biolife, Sarasota, FL) and the Safeguard radial band (Merit Medical Systems, South Jordan, UT). The PROTEA protocol allows for a 25-minute deflation for cases using up to 5000 IU heparin and 6Fr sheaths.

Equipment List (Advanced)

The following are required, in addition to equipment in the "Basic" list, if delivery systems larger than a conventional microcatheter, such as the Surefire Infusion System (Surefire Medical Inc, Westminster, CO), are being considered. The Surefire does not pass through all standard angiographic catheters and therefore a guide catheter or sheath is necessary to facilitate its use.

Guide catheters — The sizes commonly used in the radial artery range from 5Fr to 6Fr. The ConcierGE line (Merit Medical Systems, South Jordan, UT) comes in Ultimate tip shapes but these guide catheters are currently only available up to 100 cm in length. A 125-cm 6Fr option is available (Cordis, Cardinal Health, Dublin, OH), as well as a 110-cm guide catheter (Medtronic, Minneapolis, MN), though these do not have Ultimate/Jacky type tips.

Guide extenders — These devices are useful in extending the working length of a guide catheter by 25-40 cm in instances where the guide catheter is of insufficient length to reach the target visceral aortic branch. The 6Fr-7Fr Guidezilla (Boston Scientific, Marlborough, MA) and 5Fr-6Fr GuideLiner (Vascular Solutions, Minneapolis, MN) are 2 examples of these extenders.

Sheathless guide catheters — These can be used in lieu of a standard sheath and guide catheter combination to facilitate device delivery. Their sizing corresponds to their outer diameter (OD); they have a larger ID than a vascular sheath of similar OD. The most well-known are manufactured by Asahi Intecc (Asahi Intecc, Santa Ana, CA) with ODs ranging from 6.5Fr to 8.5Fr and a variety of tip shapes. Asahi Intecc produces 2 sheathless guide catheter lines, the Eucath (100-cm long) and Sheathless PV (120-cm long). For reference, note that the ID of an 8.5Fr sheathless guide catheter is equivalent to that of a 6Fr standard vascular sheath.

Surefire Infusion System — It is important to ensure that the radial-specific length of 150 cm is available.

Periprocedural Care, Room Set-Up

Ideally, TRY-90 is initiated in an environment where TRA is well accepted not only by the interventional radiologists but also the auxiliary staff, where standardized preprocedure TRA protocols and standardized postprocedure patent hemostasis protocols are consistently followed. At our institution, approximately 30 minutes before the procedure, a local anesthetic mixture (EMLA cream, APP Pharmaceuticals Inc, East Schaumburg, IL) and a nitroglycerin patch are applied to the skin overlying the left radial artery to promote artery dilation following confirmation of TRA intent. A standardized patent hemostasis protocol is critical to minimizing rates of radial artery occlusion, thereby safely allowing repeated interventions through radial access.[6]

In contemporary angiography suites that are designed symmetrically (ie, the operator can stand on either side of the patient with identical monitor/screen visualization and lead protection), the patient can be positioned head first into the room. However, in older angiography suites where monitor positioning and lead protection have been optimized for a traditional right femoral approach, this may require positioning of the patient feet first into the room (Fig. 8).

Procedural Steps

Basic

The patient is positioned appropriately within the angiography suite. Two different styles of arm boards can be used to support the left arm: a smaller but moveable swivel board, and a larger stationary board such as the Rad Board (Merit Medical Systems). As mentioned earlier, the swivel board is ideal for TRY-90 mapping as it enables rapid transition to cone-beam CT, while the stationary board is appropriate for TRY-90 administration procedures—assuming no additional cone beam CT will be done—as it provides a larger and more stable working space for connecting the Y-90 delivery apparatus to the delivery catheter (Fig. 9).

Figure 8 Patient is positioned feet into room first for TRY-90 in order to maximize operator ergonomics and radiation protection. Note sterile preparation of nearly the entire left arm.

The left hand, forearm, and upper arm are prepared and draped in a sterile fashion to allow for exposure and access from the wrist as well as US interrogation to the mid upper arm. US assessment of the radial artery to its brachial insertion should be done to identify variants such as a radial loop or high radial artery origin that may predispose to radial artery spasm. Tumescent anesthesia with a lidocaine and nitroglycerin mixture (100 mcg nitroglycerin in 10 mL 1% lidocaine) followed by US-guided single-wall micropuncture access, sheath insertion, and spasmolytic cocktail administration (2000 IU heparin, 200-mcg nitroglycerin, and 2.5-mg verapamil) have been well described previously by Thakor et al.[6]

The 5Fr catheter is then preloaded with an atraumatic tip 0.035″ wire and slowly advanced through the left radial, brachial, axillary, and subclavian arteries under fluoroscopy. At the aortic arch, an LAO projection can help facilitate wire and catheter advancement from the left subclavian artery into the descending thoracic aorta. Identification of the target visceral aortic branch origin on preprocedure CT enables accurate selection of the vessel origin. The pullback technique consists of advancing the catheter several centimeters caudal to level of the vessel, then slowly pull the catheter back with intermittent

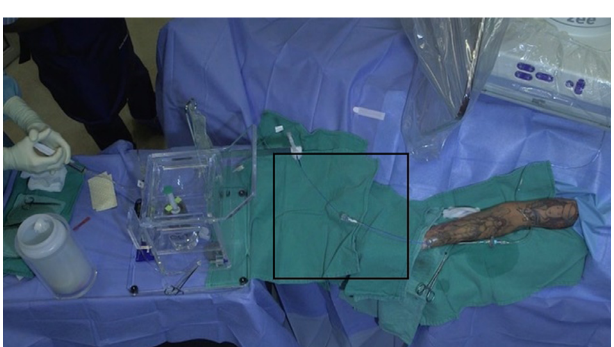

Figure 9 The box highlights the added working space that the plexiglass type arm board provides, which ensures support area for the connection between the Y-90 apparatus and the delivery catheter.

Figure 10 Basic access into the hepatic circulation with a 5Fr 110-cm length Ultimate-1 catheter, followed by placement of an endhole microcatheter just beyond the GDA for Y-90 microspheres delivery. Note coil embolization of the GDA and right gastric artery.

contrast injection until the catheter tip engages the vessel origin. An alternate second technique is to select the target vessel with a hydrophilic wire, then advance the base catheter over the wire. If the patient is shorter than 5′5″, a 110-cm length base catheter is sufficient; if the patient is taller, a 125-cm length base catheter is preferred.

Once the base catheter is in a secure position, a FLO30 valve adaptor is placed and a microcatheter is then advanced, followed by the standard steps in conventional Y90 mesenteric angiography and mapping, with or without vessel embolization (Fig. 10). The cone-beam CT arc on many angiography machines can be narrow; therefore, patients are often required to reposition their arms, so the C-arm can rotate unperturbed. In TRY-90, we have the patient place their right arm above their head and their left arm positioned against/partly over their left torso to yield sufficient room for the C-arm rotation (this position does not substantially affect image quality). The swivel arm board is easily moved out of the way to accommodate cone beam CT acquisitions. For Y-90 administration, the Y-90 delivery system is connected to the delivery catheter and Y-90 microsphere injection is performed as per standard protocol.

Following administration, the delivery catheter is removed and disposed of as per institutional radioactive waste management. Additional in situ catheters and the sheath are subsequently removed and patent hemostasis is achieved following a standardized postradial access protocol.

Advanced

The use of guide catheters and/or sheathless guide systems is often necessary when larger dimension Y-90 delivery devices, such as the Surefire Infusion System, are used. Two approaches can be used to facilitate guide catheter or sheathless guide catheter cannulation of the proximal hepatic circulation.

Approach 1: Shealthless Guide

After access is obtained into the target vessel as described in the "Basic" section, the conventional catheter is exchanged

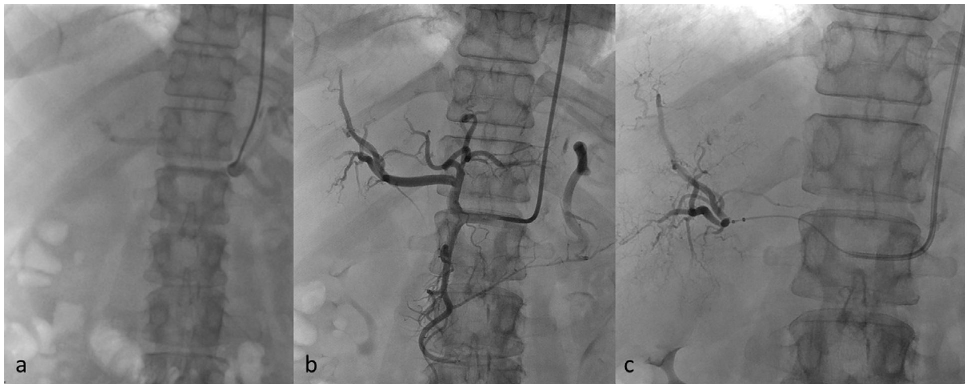

Figure 11 (a) Initial access with a 5Fr Ultimate-1 catheter, (b) subsequently exchanged out for a 6.5Fr Eucath sheathless guide catheter to (c) facilitate placement of a Surefire Infusion System 025 M catheter for Y-90 administration.

over an exchange length wire such as a Rosen wire for the sheathless guide catheter. Noting how much of the initial access catheter remained outside of the radial sheath after initial target vessel selection can help the operator estimate the appropriate length of sheathless guide to use. During exchange, the initially placed radial sheath must also be removed. After the sheathless guide is in stable position, the Y-90 delivery platform may be advanced to its intended site for administration (Fig. 11). Note that this approach does require a catheter exchange, which can slightly increase the risk of inciting radial artery spasm. If any device larger than 5Fr is used for a procedure, 5000 IU heparin is recommended (as opposed to the standard 2000 IU used during conventional access).

Approach 2: Guide Catheter

Following radial artery access and sheath placement as described in the "Basic" section, a 100-cm guide catheter is preloaded with a 125-cm simple angled tip catheter that is 1Fr size smaller than the guide catheter (eg, a 4Fr angiographic catheter would be paired with a 5Fr guide catheter), into which is preloaded a 0.035″ atraumatic tip guidewire, such as a Bentson guidewire. This combination of a standard catheter within a guide catheter is referred to as the "mother-child" technique. The smaller diagnostic catheter placed through the guide catheter minimizes the potential of dissection and allows for a smooth transition without a bare catheter tip. Note that the Ultimate-1 shape aids immensely in navigating the sometimes challenging anatomy between the subclavian artery to descending aorta; commercially available longer length guide catheters do not have an optimal tip configuration for this technique and are not recommended for the "mother-child" technique with TRY-90). The "mother-child" catheter combination is subsequently advanced through the radial artery to the descending aorta. The target visceral artery is selected, first with the 4Fr catheter, then with the guide catheter by way of advancing the guide catheter over the angiographic catheter. Once the guide catheter position is secure, the 4Fr catheter is removed and the delivery platform may be introduced.

Of note, in instances where the 100-cm length guide catheter cannot reach the intended visceral artery, an exchange wire is first placed to maintain access. The 4Fr catheter is subsequently removed and a guide extender may be used to elongate the working guide system length. Through this extended guide system, the delivery system can be advanced to its intended site for Y-90 administration (Fig. 12).

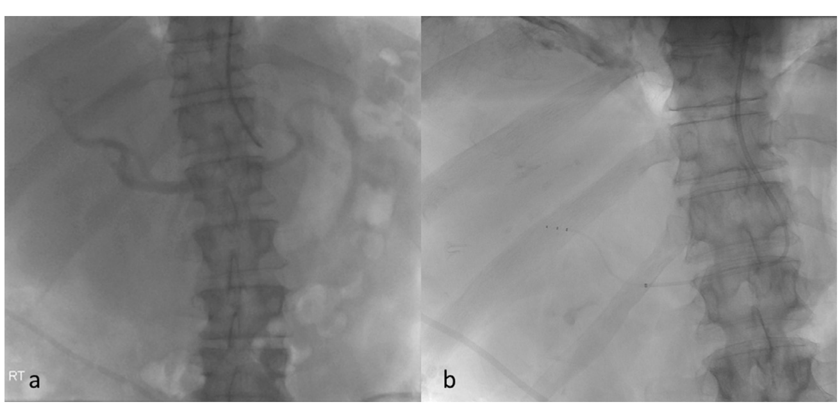

Figure 12 (a) The "mother-child" technique is used to first place a 6Fr guide catheter at the celiac trunk, followed by (b) extension of the guide system with a 25-cm long 5.5Fr GuideLiner that allows placement of a Surefire Infusion System 025 M catheter for Y-90 administration.

Pearls

- Perform preprocedural radial artery assessment in the clinic setting, including the Barbeau test and patient height measurement, to ensure patients are appropriate for TRY-90. Preprocedural US of the upper arm may also aid in identifying hostile radial anatomy.
- Thin collimation CT angiography is helpful to identify hepatic vascular anatomy and determine if TRA is an appropriate approach or not, based on the type of vessels involved in the disease process (OCTAVE Protocol).
- Ensure that the appropriate radial length catheters, microcatheters, guide catheters, and sheathless guide catheters are available and in stock before attempting TRY-90.
- Use the smaller swivel arm board for TRY-90 mapping to allow ease of transition to cone-beam CT acquisition.
- Use the larger, fixed arm board for TRY-90 administration to optimize stability and size of the radial working space.

Pitfalls

- If variant anatomy such as a radial loop or high origin of the radial artery is not detected beforehand, radial artery spasm can occur during initial catheter advancement, sometimes to the degree where conversion to TFA is necessary.
- The use of larger diameter guide catheters or sheaths may result in radial artery spasm and "lockdown" of the radial artery. Use of proper vasodilation and anticoagulation is required. In cases of severe spasm, patience, calcium channel blockers and perivascular injection of high concentration tumescent vasodilators (ie, 1-mg nitroglycerin in 10-mL 1% lidocaine) may relieve spasm.
- Failure to identify vascular anatomy that may be difficult to cannulate or reach by TRA until well into the procedure can necessitate conversion to TFA.
- Mal-deployment of a coil during embolization for protection or redistribution may necessitate conversion to or concomitant TFA access as current snare devices may not be sufficiently long to use from TRA. An in-depth knowledge of inventory is essential prior to embarking on a case.
- If standardized patent hemostasis protocols are not established and enforced, there will likely be higher rates of radial artery occlusion following the initial mapping procedure, thereby precluding repeat radial access on the day of Y-90 administration. Patent hemostasis is mandatory and use of the PROTEA hemostasis protocol is highly recommended.

Conclusion

TRY-90 is a safe, feasible, first-line approach to hepatic SIRT. A methodical, step-by-step approach—while anticipating deviations in routine techniques through proper preprocedural workup, knowledge of equipment compatibility, and recognition of complications—will optimize the success of TRY-90 for operators and patients alike.

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