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Transradial access chemoembolization for patients with hepatocellular carcinoma

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TITLE:

Transradial Access Chemoembolization for Hepatocellular Carcinoma Patients

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KEYWORDS:

hepatocellular carcinoma (HCC), radial artery (RA), chemoembolization, femoral artery (FA), bleeding, transradial access

SUMMARY:

Transarterial chemoembolization (TACE) is the standard therapy for patients in the intermediate stage of hepatocellular carcinoma and is typically performed through femoral artery access. Compared with transfemoral access, transradial access (TRA) can decrease the rate of bleeding complications and improve patient tolerance. A method is presented here to perform transarterial chemoembolization via radial artery access.

ABSTRACT:

Transarterial chemoembolization (TACE) is the most common modality for treatment of hepatocellular carcinoma (HCC) at the intermediate stage. TACE is typically performed via transfemoral access (TFA). However, transradial access (TRA) is preferred in coronary artery interventions due to decreased complications and mortality. Whether the advantages of TRA can be applied to TACE required investigation.

Patients receiving TRA TACE at a single center were retrospectively enrolled for study. Procedural details, technical success, radial artery occlusion (RAO) rate, and access site-

related bleeding complications were evaluated. From October 2017 to October 2018, 112 patients underwent 160 TRA TACE procedures. The overall technical success rate was 95.0% (152/160). The rate of crossover from TRA to TFA was 1.9%. No access site-related bleeding complications were found in any cases. Asymptomatic RA occlusion occurred in three patients (2.7%). Compared with TFA, TRA can increase safety and patient satisfaction while decreasing access site-related bleeding complications. Moreover, TRA interventions can benefit patients with advanced age, obesity, or a high risk of bleeding complications.

INTRODUCTION:

Hepatocellular carcinoma (HCC) is a very common malignancy, with the sixth highest incidence rate worldwide. It is also the second leading cause of cancer mortality around the world[1]. Because only 5%–20% of patients can receive curative therapy, transarterial chemoembolization (TACE) is the most popular palliative treatment for patients with unresectable HCC[2]. TACE has been recognized as the most commonly used and effective treatment approach for HCC patients at the intermediate stage[10]. Transfemoral access (TFA) chemoembolization is the most common approach for TACE[3]. However, there are risks associated with TFA intervention, including bleeding at the access site and major vascular complications[4]. These complications lead to prolonged hospitalization and increased costs. Moreover, TFA requires immobilization for at least 6 h, which increases discomfort and dissatisfaction for the patients.

Transradial access (TRA) is an alternative approach that has been used in percutaneous coronary intervention (PCI) for more than two decades[5,6]. TRA PCI has several advantages: increased procedure comfort, decreased access site-related bleeding, decreased major vascular complications, and decreased mortality[7,8]. The radial artery (RA) is easy to access and puncture because of its superficial location[7]. Hemostasis is easy to conduct after intervention and there is no strict immoblization[9]. Despite encouraging evidence for TRA intervention in cardiac catheterization, to date only a few studies used TRA in peripheral disease intervention. TRA interventions for malignant liver tumors are even rarer. Here, the clinical feasibility and safety of TRA hepatic embolization is analyzed. One institution's experience with the step-by-step TRA protocol provided is also described.

PROTOCOL:

This single-center retrospective study was approved by the local Institutional Review Board of Zhongshan Hospital, Fudan University.

1. Obtaining informed consent

1.1. Before the TRA interventions, have interventional radiologists (IRs) explain the benefits and potential complications of TRA to the patients.

2. Patient evaluation

2.1. After obtaining informed consent, evaluate the RA for the feasibility of puncture and cannulation.

2.2. Perform a comprehensive review of the patient's medical history. Confirm if patients had severe vascular tortuosity, severe peripheral vascular disease, a fistula for dialysis, or preparation for RA dialysis operation. These are relative contraindications for patients receiving TRA interventions.

2.3. Evaluate the visibility of the RA.

2.3.1. Perform a Barbeau test with the use of pulse oximetry to evaluate how visible the hand collateral arteries are before intervention[11]. The Barbeau D waveform is considered an absolute contraindication for RA cannulation.

2.3.2. For patients tested as Barbeau C waveform, apply a Doppler ultrasound examination to provide more reliable information about the amount of collateral circulation in the forearm and hand. An inner diameter smaller than 2 mm is considered a contraindication.

NOTE: After medical history evaluation and the RA evaluation, patients with contraindications should abstain from a puncture via the ipsilateral RA. The contralateral RA might serve as an ideal supply if it is found to be patent through Barbeau test evaluation. The left RA is initially chosen as a preferred access route. The right RA might serve as an alternative choice if the left RA was found unsuitable.

3. Radial artery access

3.1. Place the patient in a supine position on the angiography table. Then, place the left arm parallel to the patient’s body and close to the left waist, allowing easy placement of the catheter and wire and enabling operator positioning comparable to that with the TFA.

3.2. Mark the distal RA pulse by palpation. Clean the skin surface with 10% povidone-iodine surgical scrub solution and allow the solution to air dry. Cover the left arm with a surgical drape.

3.2.1. In case of potential left RA puncture failure, prepare an alternative access route by sterilizing and draping the right arm or right inguinal region.

3.3. Apply local anesthesia (i.e., 1 mL of lidocaine 2%) proximal to the styloid process along the axis of the most powerful pulsation of the left RA.

3.4. Extend the wrist, and puncture the RA with a 20 G needle using the modified Seldinger technique. When pulsatile arterial blood return isobserved , introduce a 0.025 inch hydrophilic guidewire.

3.4.1. Retract the guidewire and readjust the needle if resistance is encountered. Do not force the insertion of the guidewire. With the assistance of of digital subtraction angiography (DSA), inject about 1 to 2 mL of contrast to highlight the RA and help insert the hydrophilic guidewire.

3.5. Once access is obtained, remove the needle and introduce a 4-French hydrophilic sheath with the guidewire. After sheath insertion, gently pump back a small amount of arterial blood with a syringe to confirm that the sheath tip is within the vessel.

4. Anticoagulation and vascular dilation

4.1. Prepare 10 mL of a vasodilation cocktail solution (3,000 IU of unfractionated heparin, 0.1 mg of nitroglycerin, and 20 mg of lidocaine).

4.2. Administer 8 mL of the vasodilation cocktail solution through the sheath at a speed of 0.5 mL/s (**Figure 1**).

NOTE: Reduce or stop the dose of heparin for patients with moderate or high bleeding risk.

5. Catheter selection

5.1. Use a 4-French, 125 cm common catheter and a standard 0.035 inch x 180 cm hydrophilic wire to traverse the subclavian artery and engage the descending aorta. Use DSA fluoroscopy to visualize the proximal axillary artery during navigation within the arm to avoid potential lesions to an artery loop or vascular tortuosity.

NOTE: The subclavian artery has many arterial branches. Angiographic guidance prevents guidewire catheters from entering collateral vessels during retrograde catheterization. A few cases have an artery loop in the radial artery. If the standard wire cannot pass the loop, use of a microcatheter and angled 0.016 inch or 0.018 inch microwire is recommended.

5.2. Use the 4-French, 125 cm common catheter in combination with a standard 0.035-inch wire to negotiate the transverse arch to direct the guidewire toward the descending aorta.

NOTE: If the angle between the aorta and left subclavian artery is very acute, a Cobra 2–shaped catheter (e.g., Simmons I or Simmons II catheter) is recommended to accomplish this turn.

5.3. After catheterization of the descending aorta, replace the common catheter via a coaxial technique. Once the common catheter is inserted into the descending aorta, steer the catheter tip ventrally for catheterization of the celiac trunk under the guidance of DSA fluoroscopy. In most cases, it is easy to catheterize and perform angiography of the celiac trunk, the hepatic artery, and superior mesenteric artery.

NOTE: If the angle between the celiac artery and the descending aorta is very acute, use a

Cobra catheter to complete the procedure.

5.4. For hepatic embolization procedures, perform super-selective catheterization and chemoembolization using a coaxial technique and place a 2.8-French 150 cm microcatheter into the targeted branch of the hepatic artery feeding the tumors (**Figure 2**). Perform TACE according to the burden of disease and patient preference.

6. Radial artery hemostasis

NOTE: Nonocclusive hemostasis is performed using a special tourniquet to maintain RA patency (**Figure 3**).

6.1. Perform an angiogram through the common catheter using a high-pressure injector to confirm adequate embolization. The catheter tip is usually located in the common hepatic artery. Inject 9–12 mL of the contrast agent at a rate of 3–4 mL per s, with a fluoroscopy time of ~15 s. Then, remove the catheter over a guidewire to avoid damage to the RA.

6.2. Administer the remaining 2 mL of vasodilation cocktail solutions (section 4) through the RA sheath. Immediately after, retrieve the sheath about 5 cm.

6.3. Place a tourniquet over the radial access site on the left wrist, and adequately inflate the tourniquet air bag of with air using the accompanying syringe. Then completely remove the sheath, and slowly deflate the air bag. When leaking is observed at the access site, add 1 mL of air back to the cuff. Typically, 10–15 mL of air is added to the air bag to keep hemostasis.

6.4. Confirm that there is no bleeding or leaking. At the same time, ensure that the distal radial artery pulse is palpable during hemostasis. Use the pulse oximeter waveform to confirm the arterial waveform on the left thumb.

6.5. Slowly inflate the air sac at ~2 mL every 2 h for no longer than 6 h. Reconfirm that hemostasis is accomplished once the tourniquet is removed 6 h after operation.

NOTE: If bleeding or leaking from the puncture site is observed during deflation, air is added back to the air sac for 30 min and the process is repeated.

6.6. Before discharge, conduct Barbeau test to confirm the patency of the RA and record patients with radial artery occlusion and closely follow up.

7. Follow up

7.1. About 1 month after intervention, give TRA patients a thorough physical examination, including inspection of the left wrist and pulse examination. For patients with potentially occluded RAs, perform subsequent evaluations of hand blood supply using forearm Doppler ultrasound or pulse oximetry.

7.2. Closely follow up all patients after TACE. If new tumor nodules were evident on CT scans and the initial lesions seemed to revascularize, perform another TACE treatment.

REPRESENTATIVE RESULTS:

From October 2017 to October 2018, 112 patients underwent 160 TRA TACE procedures, and the overall technical success rate was 95.0% (152/160). Eight cases were met with technical failure. Of these, five cases were caused by left RA puncture failure and subsequently underwent successful TACE with right RA access. The other three cases were caused by cannulation failure, and underwent subsequent successful intervention by crossover to right FA access. The crossover rate of RA access to FA access was only 1.9%. No access site-related bleeding complications were found in any of the cases.

The baseline clinical data of cases with technical success or technical failure were compared (**Table 1**). Compared with patients that previously received TACE, patients undergoing first-time TACE via RA access were more likely to suffer technical failure ($P = 0.016$). Also, an increased number of catheters was required for patients suffering RA access technical failure. No significant correlations were found between technical success or failure and patient characteristics, including age, sex, or combined medical comorbidities. Three patients suffered asymptomatic RA occlusion.

The numbers of TRA TACE procedures were compared (**Table 2**). Owing to the low frequency of radial artery occlusion (RAO), no significant correlation was found between the increased rate of RAO and the number of TRA procedures. No cases required urethral catheterization for postoperative dysuria. Also, no neurologic complications or contrast medium-induced nephropathy were found in any cases during follow-up.

FIGURE LEGENDS:

Figure 1: Vasodilation cocktail solution. (**A, B**) 8 mL of vasodilation solution was given through the sheath immediately after access was obtained to prevent RA spasm and blood thrombosis. (**C**) Transradial artery insertion of a 4-Fr 125 cm common catheter. (**D**) The location of the left hand near the right inguinal region offered greater accessibility for intervention procedure.

Figure 2: A patient receiving a third TRA-TACE. (**A**) The common hepatic arteriogram pictured shows that a tumor stain remains. (**B**) Superselective angiography with a microcatheter shows the tumor's feeding artery. (**C, D**) The tumor stain disappeared after embolization with epirubicin-lipiodol emulsion.

Figure 3: Hemostasis after intervention. (**A**) The tourniquet used for radial artery hemostasis in the department. (**B**) The remaining 2 mL of vasodilation solution was given through the sheath. (**C**) Before the sheath was removed, the air bag was inflated with 10 to 15 mL of air. (**D**) The pulse oximeter waveform was used to confirm the arterial waveform on the left thumb.

Table 1: Demographic and clinical differences between cases with technical success and technical failure. No significant difference was found between patient characteristics, including age, sex, or height, and successful TRA TACE or failure of RA access. TRA intervention failure may increase the number of catheters used.

Table 2: The number of TRA TACE procedures patients underwent during the study. About 8% of patients had three or more TRA TACE procedures, no obvious increase of patients with post operational RAO.

DISCUSSION:

TRA interventional therapy has grown significantly worldwide in recent years, especially in diagnostic and Interventional cardiology procedures[12]. Moreover, there has been increasing attention to peripheral vascular disease intervention. Without compromising procedural success rates, TRA to cardiac intervention can effectively reduce the rates of bleeding and vascular complications compared with TFA[13,14]. Compared with TFA, TRA is superior in several capacities, including monitoring time after the procedure, time of ambulation, and greater overall patient satisfaction[15-17].

Despite these advantages recognized in coronary intervention, TRA is rarely applied by IRs. The apparent reluctance of IRs to utilize TRA may be explained by TRA's longer procedural time and a steep learning curve[18]. Potentially increased total fluoroscopic time and radiation dose also limit TRA to interventional procedures below the diaphragm, such as hepatic embolization and uterine artery embolization. At our institution, TRA intervention was introduced about 3 years ago and rapidly adopted as a preferred approach. As expected, expertise and institution-wide adoption are required before the benefits and efficiencies of TRA become clear[19]. Moreover, it is possible for IRs to increasingly learn more about TRA and improve their ability to use the method, which can rapidly increase adequate proficiency in TRA[18].

This protocol usually uses the same standard technique with dedicated radial devices, such as a slender vascular introducer sheath (typically 4-Fr) and a single-catheter technique with no need for catheter exchange. It is obvious that TRA procedure failure was associated with an increased number of catheter utility ($P < 0.001$). The rate of single catheter use in all cases is 85.6% and would further increase by the accumulated experience of the IRs and decreased rate of technical failure, which may somewhat decrease the cost during hospitalization. Due to the rarity of RAO, no significant correlation was found between the increased rate of RAO and a number of TRA procedures. A previous study demonstrated that the diameter of the RA decreased following TRA procedures[20] because it is an important parameter to consider, which may preclude its future use as a conduit or develop to RAO. Even 8.0% of patients in this study received more than 3x TACE procedures via RA access without the occurrence of RAO; the total rate of RAO was only 2.7%. It is apparent that, with a low rate of RAO, repeated TRA for hepatic embolization is clinically feasible.

TRA has several obvious advantages when compared with TFA. First, RA is more superficial than FA, and there are no surrounding critical structures that are susceptible to injury during artery access. Hence, it is easy to compress and achieve hemostasis after intervention, which significantly decreases the incidence of postprocedural bleeding complications compared with TFA[9]. Furthermore, the potential difficulty in locating the common femoral artery and the difficulty in detecting and controlling postprocedural hemorrhage in obese patients makes TRA an ideal treatment option[21]. Due to the superficial location and easy hemostasis of RA, TRA may be advantageous for patients who are deemed high risk for bleeding complications, such as those with thrombocytopenia, coagulation disorders, or liver dysfunction, those receiving anticoagulation, and elderly patients[22,23]. Second, TRA can enable patients to ambulate immediately after intervention, which is of paramount important to improve patient satisfaction. Previous studies demonstrated a strong patient preference and procedure satisfaction for TRA over TFA during hepatic embolization[3,24]. Because patients are susceptible to postprocedural nausea, vomiting, or potential dysuria, immediate ambulation is important for them to keep a comfortable position and relieve the adverse reaction. TRA is especially significant for elderly patients and those with back pain. Third, compared with TFA, it is possible for TRA to decrease the cost of hospitalization and to decrease the time of hospitalization[17,25].

Of course, complications for TRA also exist. Periprocedural stroke is a rare but serious complication associated with high mortality and impaired quality of life[26]. The potential reason for TRA's association with the risk of periprocedural stroke is that the guiding catheter is introduced through the subclavian artery, which is adjacent to the common carotid artery and vertebral artery, both of which directly supply the brain[27]. To date, no TRA-related stroke was reported, except a case of seizure recorded in a case series report[28], which was hypothetically contributed to the intraarterial administration of verapamil. RAO is a common complication for repeated TRA intervention, which is often asymptomatic. Few patients have experienced symptomatic complication of RAO, such as pain, numbness, or discoloration of the arm[6], making TRA an ideal alternative to TFA intervention. Typically, postprocedural mild pain at the access site is a common complication in the tested center's practice, which is often self-limited or treated with nonsteroidal anti-inflammatory drugs if necessary. Also, failure of TRA-related crossover to FA access, an unsatisfactory result for both patients and IRs, potential increases operation time, radiation exposure, or the time of hospitalization[29]. Furthermore, elderly patients are technically more challenging due to anatomical issues such as vascular tortuosity and atherosclerosis. All in all, the advantages of TRA must be balanced against these shortcomings. In general, a successful TRA entails a comprehensive evaluation of the access route for each patient before each therapy.

Critical steps of the protocol are given here. First, considering the convenience in operation and risk for cerebrovascular complications, the left RA could be the default choice for the procedure. Second, the Barbeau test must be performed for patients considered for TRA interventions. Third, ultrasound guidance is key to help RA puncture, especially for a new care provider. At last, use of a hydrophilic sheath, vasodilation cocktail solution, and nonocclusive hemostasis of the RA are essential precautions to reduce the occurrence of RAO.

In conclusion, this study demonstrates the safety and applicability of TRA hepatic embolization. Importantly, TRA can reduce postprocedural access site-related bleeding complications. TRA interventions can provide more convenience and comfort for HCC patients. TRA interventions can especially benefit patients with advanced age, obesity, or high risk for bleeding complications.

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DISCLOUSURES:

Study concept and design by WZ and ZPY; acquisition of data by ND, ZHZ and MJY; obtained funding by ZPY. The authors have no relevant financial disclosures.

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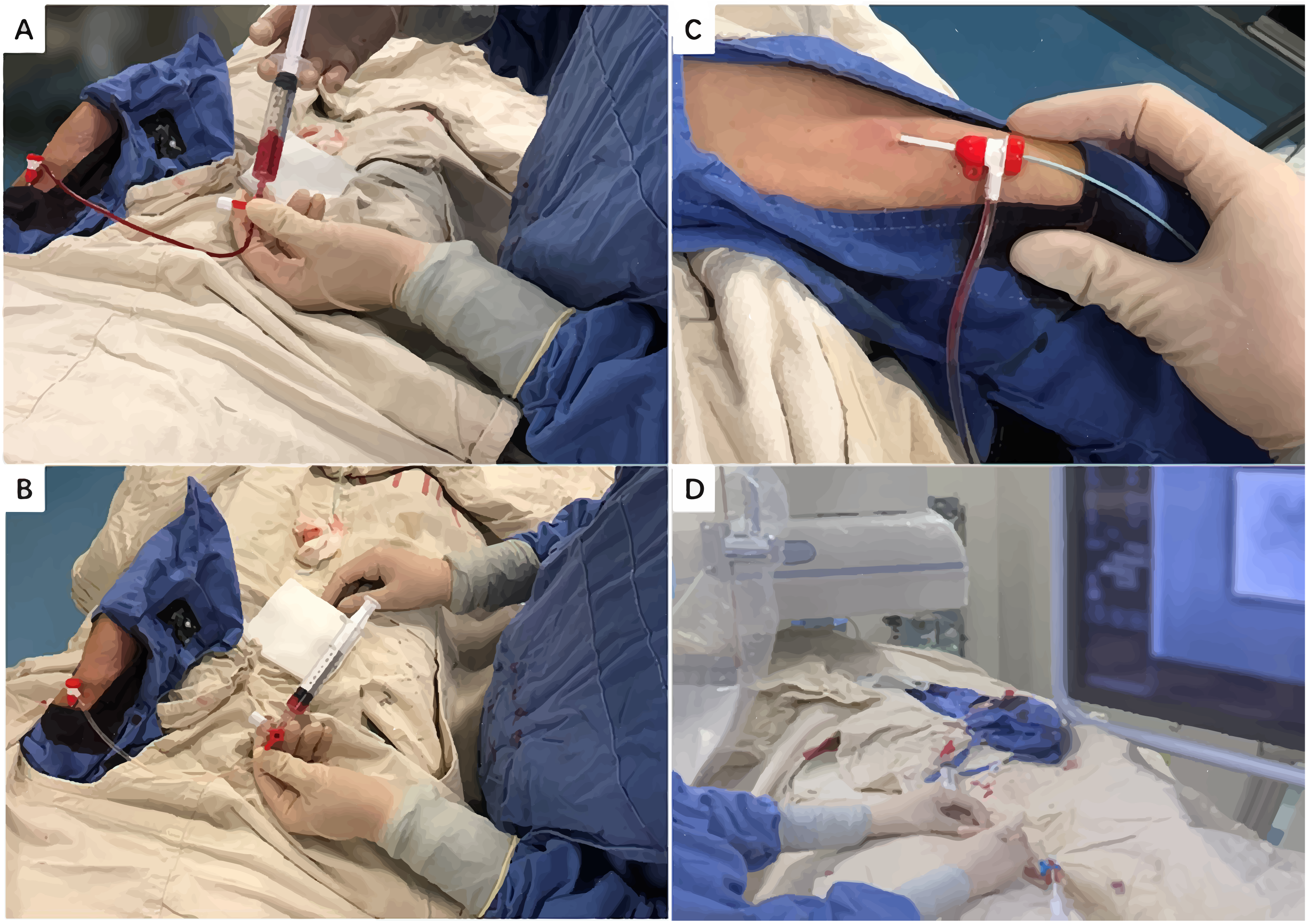
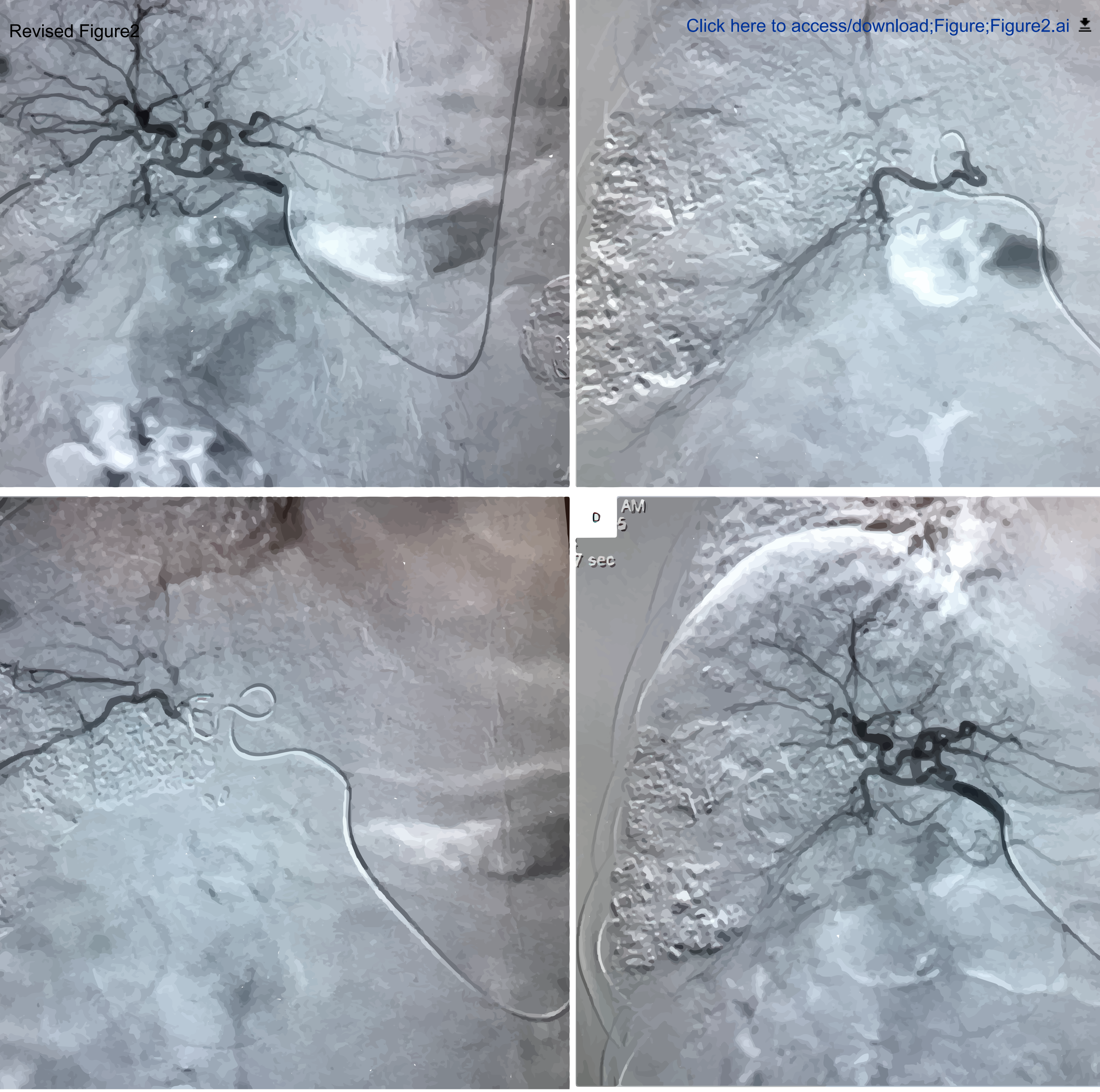
Revised Figure1



Revised Figure2



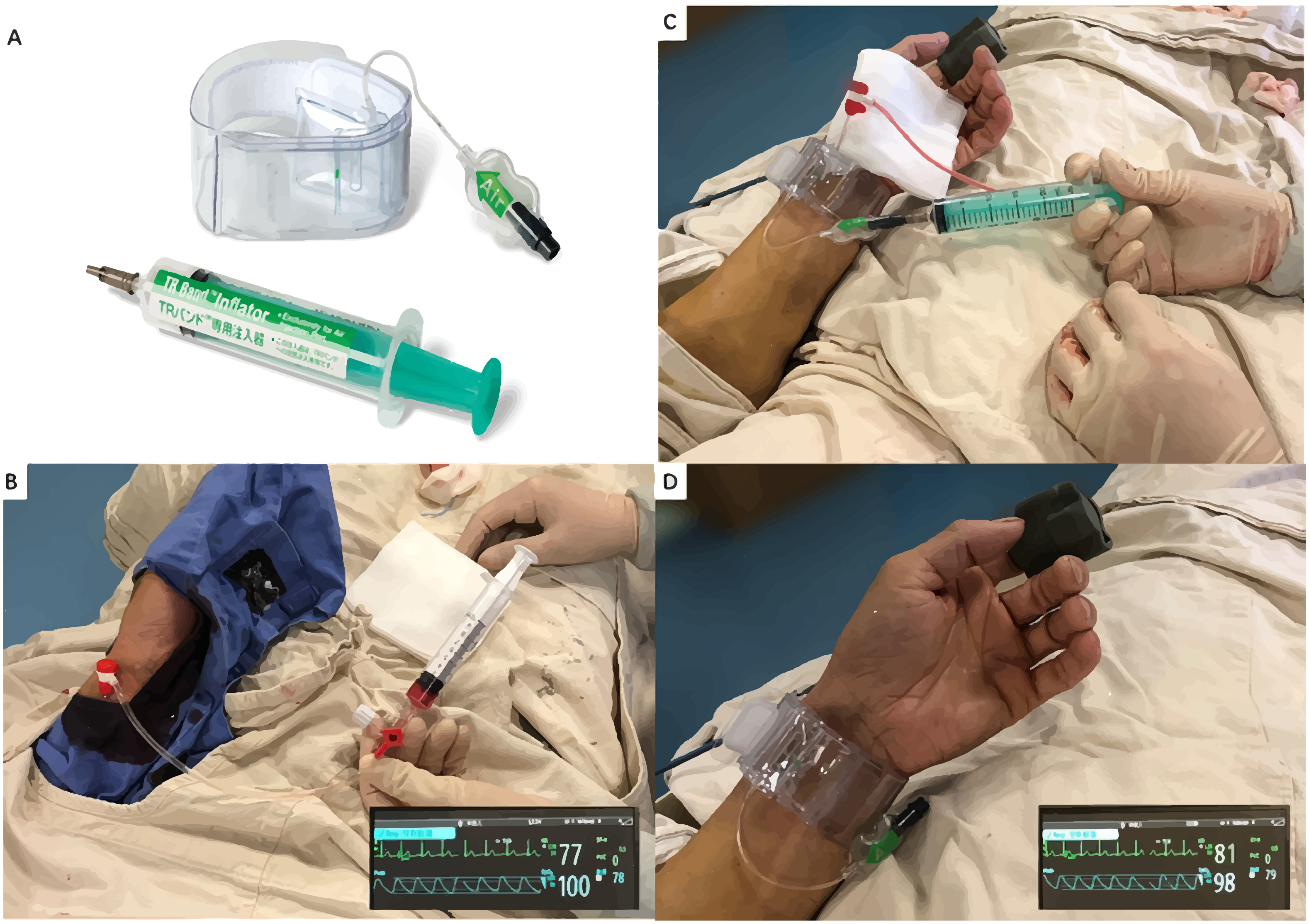

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Table 1. Demographic and clinical difference between cases with technical success and those

Case Characteristics	Overall (n=160)	Successful case (n=152)	Failure case (n=8)	P Value
Age, years	58.7±12.1	58.6±11.9	60.0±16.1	0.754
Sex, n (%)				0.893
Male	127(79.4)	120(78.9)	7(87.5)	
Female	33(20.6)	32(21.1)	1(12.5)	
Height, meter	1.68±0.06	1.68±0.07	1.70±0.06	0.389
BMI, kg/m^2	22.41±2.72	22.37±2.75	22.32±2.12	0.338
Hypertension, n (%)				1
Yes	53(33.1)	50(32.9)	3(37.5)	
No	107(66.9)	103(67.1)	5(62.5)	
Diabetes mellitus, n (%)				0.543
Yes	36(22.5)	33(21.7)	3(37.5)	
No	124(77.5)	119(78.3)	5(62.5)	
Previously TACE, n (%)				0.016*
Naïve	45(28.1)	43(28.3)	6(75.0)	
Yes	115(71.9)	109(71.7)	2(25.0)	
HBV infection				1
Yes	103(64.4)	98(64.5)	5(62.5)	
No	57(35.6)	54(35.5)	3(37.5)	
Catheter number (n)				<0.001*
1	137(85.6)	137(90.1)	0(0)	
≥2	23(14.4)	15(9.9)	8(100.0)	

TACE: transarterial chemoembolization; BMI: body mass index. *$P<0.05$

with technical failure.

Table 2. The numbers of TRA TACE procedures of patients underwent during the study.

Cases/patients	None RAO (n=109)	RAO (n=3)	Total (n=112)
Numbers			
1	76(67.9)	1(0.9)	77(68.8)
2	24(21.4)	1(0.9)	25(22.3)
≥3	9(8.0)	1(0.9)	10(8.9)

RAO: radial artery occlusion; TACE: transarterial chemoemboliz ation.

Name of Material/Equipment	Company	Catalog Number	Comments/Description
Reagents			
Embosphere	Merit	20173776165	
Gelfoam	Alicon	20143771056	
Heparin	Hepatunn	H51021209	
Injection syringe	KDL	20163150518	
Iodinated oil	Yantai Luyin Pharmaceutical Co.Ltd	H37022398	
Lidocaine	Shandong Hualu Pharmaceutical Co.Ltd	H37022147	
Lobaplatin	Hainan Changan International Pharmaceutical Co.Ltd	H20050308	
Nitroglycerin	Brijing Yimin Pharmaceutical Co.Ltd	H11020289	
Normal saline	Anhui Shuanghe Pharmaceutical Co.Ltd	H34023609	
Pharmorubicin	Pfizer	H20000496	
Ultravist 370	Bayer	H20171333	
Material			
Hydrophilic Guide Wire	Merit	LWSTDA38180	
Injection syringe	KDL	20163150518	
Maestro Microcatheter	Merit	28MC24150SN	
MPA1 (I) catheter	Cordis	451-406P0	
Sheath Introducer	Merit	PSI-4F-11-035	
Steerable Guidewire	Merit	TNR2411	
TR Band	Terumo	XX*RF06	
Equipment			
DSA	Toshiba	INFX-9000V	
Ultrasonic machine	SonoScape	20172231180	

Dear editor,

Thank you very much for your letter and advice on our manuscript JoVE61109R1. We are grateful to the editors for their positive and constructive comments, which substantially improved our present manuscript. We have resubmitted new version of manuscript accordance with recommendations of the technical editor. We have addressed the comments raised by the reviewers and amendments are highlighted in green in the revised manuscript. We hope that the revision is acceptable and look forward to hearing from you soon. Once again thanks for the editors' and reviewers' very valuable advice and warm help.

Best regards,

Zhi-Ping Yan

Department of Interventional Radiology, Zhongshan Hospital, Fudan University, Shanghai 200032, China.

Response to editors' comments for JoVE61109

In HCC patients at the intermediate stage, TACE has been recognized as the most commonly used and effective treatment approach. **This claim needs a citation.**

Revised in Introduction:

In HCC patients at the intermediate stage, TACE has been recognized as the most commonly used and effective treatment approach[10].

Revised in reference:

10 Galyfos, G., Sigala, F. & Filis, K. Transradial versus Transfemoral access in patients undergoing peripheral artery angioplasty/stenting: A meta-analysis. Cardiovascular Revascularization Medicine. 19 (4), 457-465, doi:10.1016/j.carrev.2017.09.015, (2018).

After medical history evaluation and the RA evaluation, patients with absolute contraindications are not recommended for a puncture via the ipsilateral RA. For patients with relative contraindication, contralateral RA might serve as an ideal supply, if it is patent through Barbeau test evaluation. **Please revise for clarity.**

Revised in Protocol:

After medical history evaluation and the RA evaluation, patients with absolute/relative contraindications are not recommended for a puncture via the ipsilateral RA. Contralateral RA might serve as an ideal supply, if it is patent through Barbeau test evaluation. The left RA is initially chosen as a preferred access rout. The right RA might serve as an alternative choice if the left RA failed the tests.

Commented [A1]: Please revise for clarity.

Sterilize and drape the right arm or right inguinal region to spare for preventing potential RA puncture failure. **What does this mean? This is unclear. Please revise.**

Response: Thanks a lot for your meticulous review of our manuscripts. In our department, TRA intervention are typically conducted via the left radial artery. At the time of left arm sterilizing, the right inguinal region was also sterilized.

Revised in Protocol:

Drape the left arm with a surgical drape. As an alternative access route preventing potential left RA puncture failure, the right arm or right inguinal region need to be sterilized and draped.

Extend the wrist, and puncture the RA with a 20 G needle via single- or double-wall puncture technique. **please describe this technique so that others may replicate it. How is the puncture technique done?**

Revised in Protocol:

Extend the wrist, and puncture the RA with a 20 G needle using the modified Seldinger technique. When pulsatile arterial blood return is witnessed, a 0.025-inch hydrophilic guidewire is introduced.

Keeping the catheter tip toward the front of the patients' body, when catheterization to the celiac trunk. **Is this the coaxial technique? Please be more clear.**

Revised in Protocol:

Once the common catheter exchanged into the descending aorta, steer the catheter tip ventrally to catheterize to the celiac trunk under the guidance of fluoroscopy of DSA.

After embolization, conduct an angiogram through the common catheter to confirm adequate embolization. **How is this done?**

Revised in Protocol:

After embolization, conduct an angiogram to confirm adequate embolization. An angiogram is performed through the common catheter using a high-pressure injector. The catheter tip is usually locating in the common hepatic artery. The contrast agent is injected at a rate of 3– 4 ml per second for a total amount of 9-12ml, and the fluoroscopy time is approximately 15 seconds.

Please note that some of the figure panels can be removed as they would be redundant with the video.

Response: As required, we removed the old Figure one from the revised manuscript.

“Patent” hemostasis after intervention. **Patent or patient?**

Response: We are sorry for making such ambiguity for the editor. The word “Patent” we used here is intended to express that the radial artery should remain unabstracted after hemostasis. To make reader have a well understanding of the process, we have deleted the words from the revised manuscript.

Figure 4. A patient receiving a third TRA-TACE. **Please include scale bars for each microscope image.**

Response: I am sorry to tell you that no scale bar was set during the microscope image storage. At the same time, we reviewed a number of papers related to interventional studies, and no scale bars were added for the angiographic image.

Although there are still many comments that we have not listed, we have made a careful and exhaustive modification of the manuscript to make it meet the publishing requirements of you.

Thanks for the expert editor and the peer reviewers’ suggestions. If you have any question, please do not hesitate to contact the E-mail address:

yan.zhiping@zs-hospital.sh.cn or zhang.wen2@zs-hospital.sh.cn

Best regards,

Wen Zhang and Zhi-Ping Yan

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