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Transradial Approach to Swine Endovascular Experiments: A Preclinical Report

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PRECLINICAL REPORT

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ABSTRACT
Transradial access (TRA) is the preferred site of access by interventional cardiologists, offering lower complication rates, shorter hospital stays, and higher patient satisfaction than transfemoral access. These features inspired neuro-interventionalists to adopt this approach. However, TRA has not yet gained widespread adoption in neuro-interventional procedures, potentially due to technical challenges. Swine, with their vascular system resembling that of humans, present an ideal model for conducting endovascular studies. Here, we share our experience with TRA in swine that could serve to train neuro-interventionalists and test transradial catheters and devices before application in human subjects. Standard clinical practices, similar to those used for humans, were adopted during the procedures. In our experiments, the ultrasound-guided TRA was obtained successfully in three swine, and distal carotid vasculatures were accessed without complications.

KEYWORDS
transradial, angiography, catheter, swine

INTRODUCTION
Interventional cardiologists widely favor transradial access (TRA) due to its safer profile, quicker recovery time, and higher patient satisfaction.[1] These clinical advantages have also influenced neuro-interventionalists to adopt TRA over transfemoral access (TFA). A meta-analysis encompassing a broad spectrum of diagnostic and therapeutic neuroendovascular interventions revealed lower access site complications with TRA than with TFA.[2] However, most neuro-interventionalists prefer TFA despite the advantages of TRA.[3] The reluctance to transition to TRA may be attributed to a lack of experience with this approach, the specialized catheters designed for its use, and inexperience in managing access challenges and complications.

Swine possess a vascular system that closely resembles that of humans from radial to common carotids. However, it is essential to note several differences in vascular branching in swine. The aortic arch of swine has two branches: the brachiocephalic trunk and the left subclavian artery. The brachiocephalic trunk further divides into the right subclavian artery and the bicarotid trunk, originating the right and left common carotid arteries (CCAs). The CCAs in swine branch into the external carotid and ascending pharyngeal arteries, giving the unique structure of the rete mirabilis.

CASE PRESENTATION
The study received approval from the Institutional Animal Care and Use Committee. The animals presented were originally used for a different endovascular testing study conducted using TRA. The experiments were considered successful when the TRA was obtained, vasculatures distal to CCA were accessed, and any complications that arose were managed using standard clinical procedures.

TRAs were obtained in three domestic pigs of varying weights (Pig 1: 33 kg; Pig 2: 96 kg; and Pig 3: 60 kg). Anesthesia was induced with intramuscular Xylazine (2 mg/kg) and Telazol (5 mg/kg) and maintained by 2%–3% isoflurane inhalation. Fentanyl was administered for analgesia preoperatively (2 μg/kg) and intraoperatively (2–5 μg/kg/hour). The swine's right forelimb was extended laterally using table restrainers to decrease the tortuous bends and facilitate catheterization before being draped in a sterile fashion. A micropuncture needle was inserted into the right radial artery under ultrasound guidance, and a wire was placed (Figure 1). A 10 cm 5-Fr sheath was inserted and then exchanged with a 7-Fr sheath (Glidesheath Slender, Terumo Medical Corporation, Somerset, NJ). A dose of 2.5 mg of verapamil was flushed into the radial artery sheath to prevent vasospasm, and 5 000 units of intravenous heparin were administered.

A radial access catheter (Rist radial access system, Medtronic, Minneapolis, MN) loaded with a 5-Fr Simmons angiographic catheter was then inserted under fluoroscopic guidance. The radial access catheter guided the angiographic catheter to the brachiocephalic trunk. The angiographic catheter was advanced to reconstitute a Simmons structure

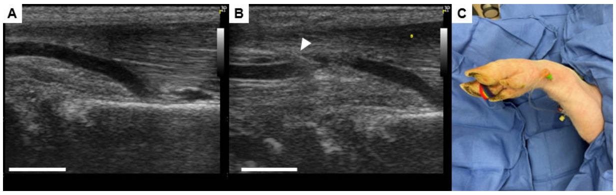

FIGURE 1. Obtaining the radial access. (A) Longitudinal view of radial artery; the radial artery is approximately 2.6 mm in this case (scale bar = 10 mm). (B) Needle entry into the radial artery (scale bar = 10 mm). (C) The 7-Fr sheath was inserted into the radial artery (a picture was taken after the experiment).

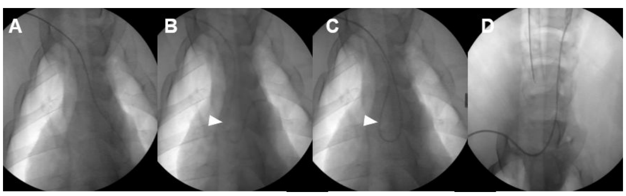

FIGURE 2. Catheterization of the aortic arch and forming the Simmons structure. (A) Catheterization of the descending aorta. (B) Reconstitution of the Simmons structure in the ascending aorta. (C) Simmons structure in the ascending aorta. (D) Left common carotid artery catheterization.

The white arrowheads point to the Simmons structure.

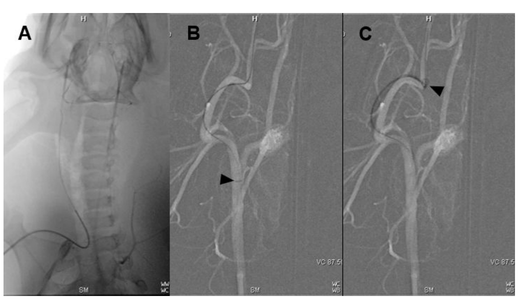

FIGURE 3. Catheterization of the right common carotid artery (CCA) and distal vasculature. (A) Catheterization of the right CCA. (B) Catheterization of the right external carotid artery. (C) Catheterization of the right infraorbital artery.

Black arrowhead points to the tip of the catheter.

in the aortic arch, then positioned upward in the brachiocephalic artery, and contrast material was injected to determine the course of the right and left CCAs. Then, the left (Figure 2) and right (Figure 3) CCAs were accessed with 0.035″ guide wires. Subsequently, the external carotid and distal vasculatures were successfully catheterized in all pigs (Figure 3). We have successfully demonstrated the feasibility of using TRA in three swine, and there were no complications during the procedures.

DISCUSSION

TRA emerges as a strategic solution to circumvent specific challenges posed by TFA, such as aortic and iliac artery tortuosity and calcification, and also offers a more stable route of catheterization, as the catheters are confined within smaller-diameter vessels, unlike TFA in the aorta.[4] TRA was associated with a lower risk of hemorrhagic transformation and demonstrated comparable outcomes in procedural success, first-pass reperfusion, and puncture-to-reperfusion time when compared with TFA in patients with stroke.[5] Moreover, the efficiency of TRA in neuro-intervention is underscored by shorter recovery time and discharge.[6]

While TRA requires a learning curve, our case report provides valuable guidance for training neuro-interventionalists and testing transradial catheters and devices before their use in human subjects.

The diameter of the radial artery in swine (~2.5 mm) closely resembles that of humans, which enabled us to insert a 7-Fr sheath in all animals. Similarly, the brachial artery in swine (4–6 mm) is comparable with that of humans.[7,8] The diameter of axillary arteries in swine closely aligns with human axillary arteries (6–7 mm). Although the CCA in swine (approximately 4–5.8 mm) is slightly smaller than the human CCA (approximately 6–7 mm), it still provides a practical model for testing devices intended for use in the human internal carotid artery (4–5 mm).[9,10]

Some limitations should be considered with this model. The sizes of the vasculature may vary from those of humans, depending on the specific vessel and the weight of the animals. The forelimb's position affects the number of tortuous bends in swine. The forelimb can be extended laterally to ease the catheterization. Another limitation is the length of the vessels. Swine have shorter upper extremities compared with humans, which may affect catheter testing, as catheters are often designed to accommodate specific curves at particular distances. Vasospasm can be very challenging, especially after unsuccessful radial punctures. Therefore, we first attempt distal cannulation; if unsuccessful, proximal access is attempted.

Patient consent

Not applicable. All procedures were approved by Mayo Clinic's animal care and use committee (protocol number A00005766-21).

Contributors

EAB, JL, AAO, and CB conceived the study. RK, WB, and DFK supervised the study. EAB, JC, CB, YHD, and DFK performed the endovascular experiments. All authors contributed to editing and revising the final version of the manuscript.

Conflicts of interest

JC received educational grant from Medtronic, Phenox, Microvention, the Philippe Foundation, the French Society of Radiology (Bourse de Recherche Alain Rahmouni SFR-CERF) and the French Society of Neuroradiology (Bourse de Mobilité Anne Bertrand SFNR); and received honoraria for lectures from Balt. RK received research support from Cerenovus Inc, Medtronic, Endovascular Engineering, Frontier Bio, Sensome Inc, Endomimetics, Ancure LLC, Neurogami Medical, MIVI Biosciences, Monarch Biosciences, Stryker, Conway Medical, Piraeus Medical, and Bionaut Labs. He holds the following research grants: NIH (R01NS076491, R44NS107111, R43NS110114 and R21NS128199) and NSF (081215707). WB holds equity in Nested Knowledge, Superior Medical Editors, Piraeus Medical, Sonoris Medical, and MIVI Neurovascular. He receives royalties from Medtronic and Balloon Guide Catheter Technology. He receives consulting fees from Medtronic, Stryker, Imperative Care, Microvention, MIVI Neurovascular, Cerenovus, Asahi, and Balt. He serves in a leadership or fiduciary role for MIVI Neurovascular, Marblehead Medical LLC, Interventional Neuroradiology (Editor in Chief), Journal of Neurointerventional Case Reports (Editor in Chief), Piraeus Medical, and WFITN. DFK holds equity in Nested Knowledge, Superior Medical Editors, and Conway Medical, Marblehead Medical and Piraeus Medical. He receives grant support from MicroVention, Medtronic, Balt, and Insera Therapeutics; has served on the Data Safety Monitoring Board for Vesalio; and received royalties from Medtronic. The remaining authors report no conflicts of interest.

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REFERENCES

1. Kolkailah AA, Alreshq RS, Muhammed AM, et al. Transradial versus transfemoral approach for diagnostic coronary angiography and percutaneous coronary intervention in people with coronary artery disease. The Cochrane Database of Systematic Reviews. 18 Apr 2018; 4(4): CD012318 DOI: 10.1002/14651858.CD012318.pub2. https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD012318.pub2/full
2. Ghaith AK, El Naamani K, Mualem W, et al. Transradial versus transfemoral approaches in diagnostic and therapeutic neuroendovascular interventions: A meta-analysis of current literature. World Neurosurgery. Aug 2022; 164: e694–e705. DOI: 10.1016/j.wneu.2022.05.031.
3. Starke RM, Snelling B, Al-Mufti F, et al. Transarterial and transvenous access for neurointerventional surgery: Report of the SNIS Standards and Guidelines Committee. Journal of NeuroInterventional Surgery. Aug 2020; 12(8): 733–741. DOI: 10.1136/neurintsurg-2019-015573.
4. Zalocar LAD, Doroszuk G, Goland J. Transradial approach and its variations for neurointerventional procedures: Literature review. Surgical Neurology International. 2020; 11: 248 DOI: 10.25259/SNI_366_2020.
5. Shaban S, Rastogi A, Phuyal S, et al. The association of transradial access and transfemoral access with procedural outcomes in acute ischemic stroke patients receiving endovascular thrombectomy: A meta-analysis. Clinical Neurology and Neurosurgery. Apr 2022; 215: 107209 DOI: 10.1016/j.clineuro.2022.107209.
6. Monteiro A, Cappuzzo JM, Aguirre AO, et al. Transradial versus transfemoral approach for neuroendovascular procedures: A survey of patient preferences and perspectives. World Neurosurgery. Jul 2022; 163: e623–e627. DOI: 10.1016/j.wneu.2022.04.043.
7. Mathern N, Yousefian E, Ridwan H, Nikoubashman O, Wiesmann M. Comparison of porcine and human vascular diameters for the optimization of interventional stroke training and research. PLoS ONE. 2022; 17(5): e0268005 DOI: 10.1371/journal.pone.0268005.
8. Holewijn S, Heijer MD, Swinkels DW, Stalenhoef AFH, Graaf JD. Brachial artery diameter is related to cardiovascular risk factors and intima-media thickness. https://onlinelibrary.wiley.com/doi/10.1111/j.1365-2362.2009.02152.x (accessed 16 July 2024).
9. Georges G, Couture T, Voisine P. Assessment of large animal vascular dimensions for intra-aortic device research and development: A systematic review. Innovations (Philadelphia, Pa). 2023; 18(2): 144–151. DOI: 10.1177/15569845231164134.
10. Krejza J, Arkuszewski M, Kasner SE, et al. Carotid artery diameter in men and women and the relation to body and neck size. Stroke. Apr 2006; 37(4): 1103–1105. DOI: 10.1161/01.STR.0000206440.48756.f7.