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Laboratory Investigation

Morphological Assessment of Cadaveric Radial, Brachial and Subclavian Arteries : A Neurointerventional Approach

Ali Yilmaz, M.D.,[1] Ayca Ozkul, M.D.,[2] Dong Seong Shin, M.D.,[3] Soo-Bin Im, M.D.,[3] Seok-Mann Yoon, M.D.,[4] Bum-Tae Kim, M.D.[3]

Departments Neurosurgery,[1] Neurology,[2] Adnan Menderes University Faculty of Medicine, Aydin, Turkey
Department Neurosurgery,[3] Soonchunhyang University Bucheon Hospital, Bucheon, Korea
Department Neurosurgery,[4] Soonchunhyang University Chonan Hospital, Cheonan, Korea

Objective : The transradial catheterization (TRC) is becoming widespread, primarily for neurointerventions. Therefore, the evaluation of radial artery puncture in clinical practice and a better understanding of the anatomy are important to improve the safety of neuroendovascular surgery.

Methods : Ten formalin-fixed adult Korean cadavers were dissected to expose radial artery (RA), brachial artery (BrA) and subclvian artery (ScA), bilaterally. Vessel lengths and diameters were meaured using a caliper and distance between the specific point of vessels and the anatomical landmarks including the radial styloid process, the medial epicondyle of the humerus, the sternoclavicular joint, and the vertebral artery orifice were also measured.

Results : The average length between the radial (RAPS) and the BrA puncture sites (BrAPS) and between the vertebral artery orifice (VAO) and the BrA bifurcation (BrAB) did not differ between sides (p>0.05). The average length between the radial styloid process (RSP) and the RAPS was 13.41±2.19 mm, and the RSP was 26.85±2.47 mm from the median nerve (MN). The mean length between the medial epicondyle (ME) and the BrAPS as 44.23±5.47 mm, whereas the distance between the ME and the MN was 42.23±4.77 mm. The average VAO-ScA angle was 70.94±6.12°, and the length between the ScA junction (SCJ) and the VAO was 60.30±8.48 mm.

Conclusion : This study provides basic anatomical information about the radial artery and the brachial route and can help improving new techniques, selection of size and shape of catheters for TRC. This can help neurointerventionists who adopt a transradial neuroendovascular approach and offers comprehensive and safe care to their patients.

Key Words : Transradial · Neuroendovascular approach · Radial artery anatomy.

INTRODUCTION

The use of transradial (TR) access for coronary intevention has been associated with lower rates of vascular complications, including reduced bleeding[1,8,10,11)], reduced mortality[9,13,15)], earlier ambulation[5)], and improved patient satisfaction[6)] compared with transfemoral catheterization (TFC). In addition, early mobilization is another key advantage, especially in older patients[2)].

The diameter of the radial artery (RA) is significantly smaller than that of the femoral artery (FA), and transradial catherization (TRC) can be more challenging due to anatomical issues and tortuosities in the vasculature. This may limit the ability to adopt a radial approach in patients with severe systemic atherosclerosis or in those with concomitant femoral artery stenosis. Because there are limited data on the use of TRC in neurointerventional surgery, the aim of this study was to understand the anatomic characteristics of the RA, brachial (BrA), and subclavian arteries (ScA) and their branches to facilitate the safe use of a transradial neuroendovascular approach. As the use of this approach to evaluating and treating non-coronary vascular disorders is quite rare, our data may help to build a foundation for performing neurointerventional surgery. This will be especially beneficial for a vertebral approach using radial and brachial routes, because there are no other direct pathways to the vertebral artery.

MATERIALS AND METHODS

The study was performed with 10 formalin-fixed Korean

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• Address for reprints : Bum-Tae Kim, M.D.
Department Neurosurgery, Soonchunhyang University Bucheon Hospital, 170 Jomaru-ro, Wonmi-gu, Bucheon, Seoul 14584, Korea
Tel : +82-32-621-5289, Fax : +82-32-621-5107, E-mail : bumtkim@gmail.com

adult cadavers, nine male and one female, with a mean age of 67.3 years (range : 28–87 years). The specimens, which were obtained from the anatomical department of our university, were placed in a supine position, the upper limbs were abducted to 90°, and their elbow and wrist joints were extended to straighten the arteries.

Both of the upper limbs of each cadaver were dissected from the axillary region down to the hand including the arm, cubital fossa, forearm, wrist, and palmar areas. The skin and fasciae of the dissected regions were incised and reflected to expose the deep structures. Both the pectoralis major and minor muscles were dissected to expose the axillary vessels and branches of the brachial plexus. The biceps muscle was also retracted laterally to follow the course and branching pattern of the axillary and brachial arteries and their surrounding nerves. The brachioradialis muscle was also displaced laterally to observe the RA in the forearm. The course and the branches of the RA in the forearm and palm were carefully dissected, and their morphology and variations were recorded. In addition, any variant in course, distribution, or branching patterns was measured.

Vascular lengths were measured using a caliper. The landmarks used for measurement were anatomical points on the radial styloid process (RSP), the medial epicondyle of the humerus (ME) (Fig. 1A, B), the sternoclavicular joint (SCJ), and the vertebral artery orifice (VAO) (Fig. 1C, D). Vascular diameters were also studied in radial artery puncture site (RAPS), the BrA puncture site (BrAPS), the axillary artery at the humerus head (AA), the subclavian artery (ScA) at the VA bifurcation, and the VAO.

The distances from the RSP to the RAPS and median nerve (MN) and from the ME to the MN and BrAPS were measured (Fig. 1A, B). The same measurements were made between the SCJ and the VAO at the shoulder level. In addition, the average angle between the VAO and the ScA was measured (Fig. 1C, D). Morphological assesments of the palmar arch and the thyrocervical trunk were also made.

RESULTS

Examination of the radial artery and its associaton with anatomical structures

There were no bilateral length differences between the RAPS and the BrAB (206.97±19.84 mm vs. 209.36±11.76 mm, $p>0.05$) and VAO (566.50±42.61 mm vs. 564.89±55.73 mm, $p>0.05$). The mean distance between the RAPS and the BrAB was 208.71±15.81 mm. The length of the RA between the RAPS and the VAO was also studied (565.69±48.13 mm), and no bilateral differences were found. The average length between the radial styloid process (RSP) and the RAPS was 13.41±2.19 mm, and the RSP was 26.85±2.47 mm from the MN.

The mean length between the medial epicondyle (ME) and the BrA puncture site (BrAPS) was 44.23±5.47 mm. The mean distance between the ME and the MN was 42.23±4.77 mm, and the

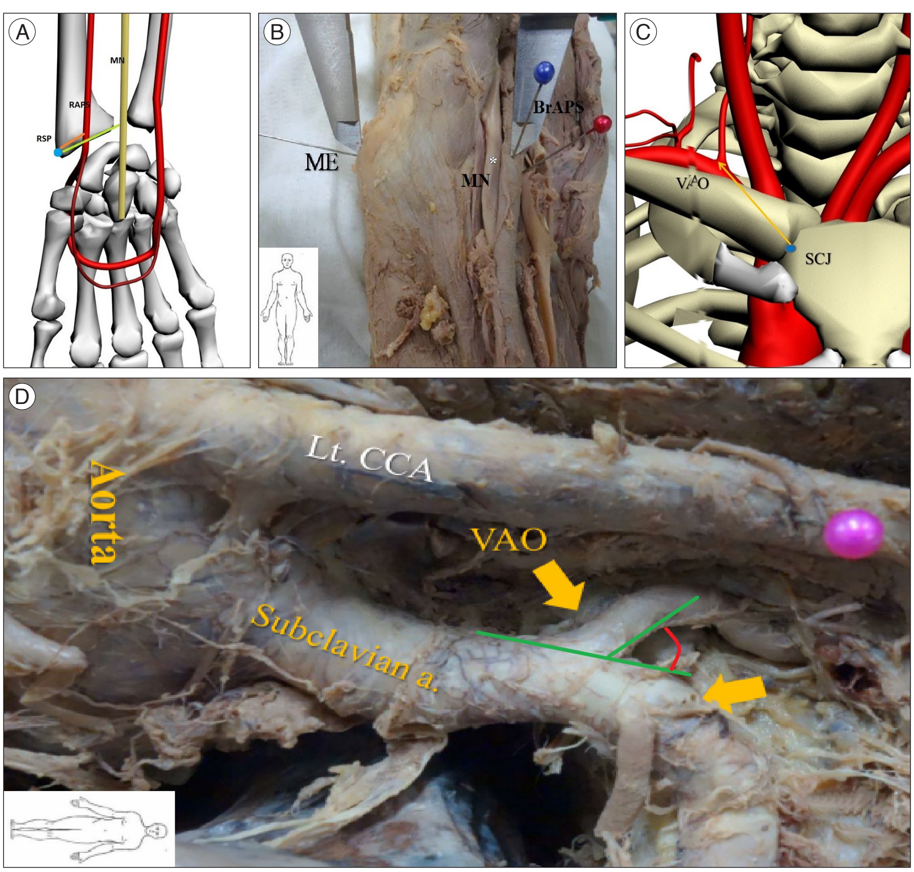

Fig. 1. Distances from RSP to RAPS and MN at the wrist level (A) and from ME to MN and BrAPS at the elbow (B) were measured. The same measurements, along with the VAO-ScA angle, were made between the SCJ and the VAO (C and D). RSP : radial styloid process, RAPS : radial artery puncture site, ME : medial epicondyle, MN (*) : median nerve, BrAPS (blue pin) : brachial artery puncture site, Lt CCA : left common carotid artery, SCJ : sternoclavicular joint, ScA : subclavian artery, VAO : vertebral artery orifice.

MN was located about 2 mm to the medial of the BrAPS (Table 1).

Examination of the BrA and its associaton with anatomical structures

The mean length between the BrAPS and the BrAB was 33.25±7.38 mm, whereas the mean length between the BrAPS and VAO was 327.97±40.14 mm. These values were similiar on both sides (p>0.05). The mean length between the BrAPS and the BrAB was 33.25±7.38 mm, whiereas the mean length from the BrAPS to the VAO was 327.97±40.14 mm.

Measurement of vascular diameters

The mean diameters of the RA (1.77±0.48 mm), BrA (3.19±0.75 mm), AA (4.79±0.97 mm), ScA (6.44±1.53 mm), and VAO (2.93±1.02 mm) were also measured. The diameters of the RA, BrA, AA, ScA, and VAO didn't significantly differ between sides (p>0.005).

Examination of anatomical structures

No palmar arch (78% vs. 78%, p<0.05) or thyrocervical trunk (with an average number of 2.50±0.61) anatomical differences were found between right and left sides (2.22±0.44 vs. 2.78±0.66, p>0.05). The average VAO-to-ScA angle (70.94±6.12°), and the median length between the SCJ and the VAO (60.30±8.48 mm) were also calculated and they were also similar on both sides (p<0.05).

DISCUSSION

This study investigated the anatomical basis of the RA, BRA, and ScA in the Korean population to determine an optimal direction and configuration and to reduce complications when a transradial approach to neurointerventional surgery is adopted.

The major branch of the axillary artery becomes the BrA at the distal border of the teres major tendon. The BrA ends close to the distal elbow joint at the neck of the radius by dividing into the radial and ulnar arteries[4]. The BrA frequently divides more proximally and may also trifurcate into radial, ulnar, and common interosseous arteries. Such variations are related to the termination of a short segment the BrA, which may occasionally divide into two trunks in the proximal segment, which may then reunite[4].

These variations can be explained by variations in embryogenic development. Ectodermal-mesenchymal interactions and extracellular matrix components within the developing limb bud interact with inductive factors in the mesenchyme[3]. In anatomical-based studies, high RA origin was the most common arterial variation in the upper limb, and its incidence varied from 4.17% to 15.6% in cadavers and embryos[12]. This incidence ranged from 8% to 24.4% in angiographic studies[14,16]. However, there were differences between races : an axillary RA origin was seen in 5% of Africans but in only 2.7% of Caucasians[7]. The incidence of high-origin RA varied from 5.9% to 12.1% among Caucasians, but it was lower in Korean cadavers, at only 2.3%[17]. However, in Singaporean Chinese cadavers, high-origin RA was found in even fewer patients, with only a 0.33% prevalence[18]. Although the differences in the RA origin among races have no clear explanation, racial differences are of great importance in clinical practice.

Although it involved a small number of cadavers, this study did not detect high-origin RA. Although the incidence of high-

Table 1. Distances between anatomical structures of the upper extremity

Structure	Average (mm)	Right (mm)	Left (mm)	p-value
RAPS VAO	565.69±48.13	566.50±42.61	564.89±55.73	>0.05
RAPS BrAB	208.71±15.81	206.97±19.84	209.36±11.76	>0.05
BrAB-BrAPS	33.25±7.38	33.85±8.37	32.65±6.76	>0.05
BrAPS-VAO	327.97±40.14	326.36±33.88	329.59±47.65	>0.05
RSP-RAPS	13.41±2.19	12.83±1.8	13.99±2.4	>0.05
RSP-MN	26.85±2.47	26.68±3.12	27.01±1.79	>0.05
ME-BrAPS	44.23±5.47	44.54±5.05	44.06±6.2	>0.05
ME-MN	42.23±4.77	42.20±4.61	42.26±5.20	>0.05
SCJ-VAO	60.30±8.48	58.89±8.7	61.7±8.5	>0.05

RAPS : radial artery puncture site, VAO : vertebral artery orifice, BrAB: brachial artery bifurcation, BrAPS : brachial artery puncture site, RSP : radial styloid process, RAPS : radial artery puncture site, MN : median nerve, ME : medial epicondyle of humerus, SCJ : sternoclavicular joint

Table 2. Artery diameters

Artery	Average diameter (mm)	Right (mm)	Left (mm)	p-value
RA	1.77±0.48	1.83±0.47	1.71±0.50	>0.05
BrA	3.19±0.75	3.39±0.72	2.01±0.76	>0.05
AA	4.79±0.97	4.79±0.92	4.80±1.07	>0.05
ScA	6.44±1.53	6.99±1.80	5.89±1.01	>0.05
VAO	2.93±1.02	2.72±1.01	3.14±1.06	>0.05

RA : radial artery, BrA : brachial artery, AA : axillary artery, ScA : subclavian artery, VAO : veretebral artery orifice origin RA is relatively low in Koreans, such anatomic variations may cause transradial cathetherization failure. Therefore, this should be considered during any interventional, cardiac, or vascular manipulations.

In this study, all subjects were adult cadavers with a mean age of 63.7 years; however, our subjects were mainly male (90%), and height and weight could not be measured. However, the lengths, angles, and vascular diameters did not differ between the sides of the 10 cadavers. The number of thyrocervical trunks on the right (2−3) seemed to be lower than that on the left (2−4), but this may be due to the formalin fixation process performed on these cadavers.

The results of this study show that the mean RAPS-to-VAO length was 565.69±48.13 mm. The distance between the BrAPS and the VAO was found to be 327.97±40.14 mm. The average VAO-to-ScA angle was 70.94±6.12°, and the median length between the SCJ and the VAO was 60.30±8.48 mm. Therefore, the optimal catheter for a transradial approach to neurointerventional surgery should be chosen according to these lengths and angles.

Today TRC is mainly prefered in patients with vascular anatomical diffuculties and in neuroendovascular practice several guiding catheters are used depending on the anatomy, including a 5 Fr Simmons type II and type I catheter (Cook, Bloomington, IN, USA), H1 (Cook Medical, Bloomington, IN, USA), or a Berenstein (Boston Scientific Corporation, Natick, MA, USA) with a 0.035 inch Glidewire (Terumo Interventional Systems). Our data of VAO-to-ScA angles suggest that Simmons type II and type I catheter can be more safely used in the selection of VAO. Learning and implementing TRC with novel techniques will cause widespread adoption and encourages neurointerventionists to perform this route more common. Therefore understanding the anatomic characteristics of these vessels is important.

When performing TRC, the location of the puncture site is also important for preventing nerve and tissue damage. In practice, TRC is performed primarily via the right radial artery for the right internal carotid system and for brachiocephalic, right vertebral, and basilar therapeutic procedures and via the left radial artery for left subclavian and left vertebral V1−4 segment preocedures. However, data about the route and specifity of the catheters have been limited. In this study, the distance between the RSP and the RAPS was 13.41±2.19 mm, and the RAPS was 26.85±2.47 mm from the MN. The same measurements were also made for the BrAPS. The distance from the ME to the BRAPS was 44.23±5.47 mm, whereas the distance between the ME and the MN was 42.23±4.77 mm. Therefore, a transbrachial approach to catheterization may cause median nerve injury because the BrAPS is close to the MN. The transradial approach has become more popular than the transfemoral or transbrachial approach because the RA has a superficially safe course for better haemostasis, is not surrounded by major veins or nerves, and has good collaterals[1].

We also studied vessel diameters. As expected, the diameter of the RA (1.77±0.48 mm) was smaller than that of the BrA (3.19±0.75 mm). Knowledge of RA diameter may help clinicians to cannulate various sheath sizes during transradial interventions.

Our data suggested that 5 Fr (1.65 mm) sheath can be more safely used for TRC. But 6 Fr (1.98 mm) and 7 Fr (2.31 mm) sheath can be inserted on the BrAPS.

Complications due to TRC include radial artery intimal dissection or perforation, gross hematoma, pseudoaneurysm, arteriovenous fistula formation, and thrombosis. To prevent such complications, it is important to select a favorable catheter size, angle, and length. Although the data in this study reflect the anatomical aspects of endovascular surgery, the results are limited due to the small sample and the formalin fixation process. So, we recommend that the selction of approaches, length and shape of catheters should be decided upon the angiographic characteristics during endovascular procedures compared with our cadaveric study datas.

CONCLUSION

In conclusion we believe that the basic RA and BrA anatomical information found in this study can help neurointerventionists adopt a transradial neuroendovascular approach. Our data can help improving new techniques, selection of size and shape of catheters for TRC. Further understanding of the three-dimensional aspects of the blood vessel structures in the upper extermity increases the safety of TRC in endovascular surgery.

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