The Radial Artery is Larger than the Ulnar

Heikki V. Riekkinen, MD, PhD, Kari O. Karkola, MD, PhD, and Annaliisa Kankainen, PhD

Department of Thoracic and Vascular Surgery, Jyväskylä Central Hospital, Jyväskylä, Department of Pathology and Forensic Medicine, University of Kuopio, Kuopio, and Department of Mathematics and Statistics, University of Jyväskylä, Jyväskylä, Finland

Background. **The radial artery is presently widely used as a bypass graft for coronary artery reconstruction. However, the traditional opinion that the ulnar artery is the larger forearm artery has been questioned.**

Methods. **The internal diameters of the radial and ulnar arteries were measured at the wrist in postmortem angiograms of 24 cadavers. Differences in mean values of variables between ulnar and radial arteries were analyzed using the Wilcoxon test.**

Results. **The mean diameter of the radial artery was 28% larger than that of the ulnar artery in the right arm ($p < 0.001$) and 26% larger in the left arm ($p < 0.001$). In the right arm the radial artery was dominant in 20 of 24 cadavers (83%), the ulnar artery in 3 of 24 (13%), and the arteries were equal in 1 of 24 (4%). In the left arm the figures were 17 of 24 cadavers (71%), 3 of 24 (13%), and 4 of 24 (17%), respectively.**

Conclusions. **In view of the present investigation the radial artery should be considered the larger forearm artery of the hand in most patients.**

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The use of the radial artery as a bypass graft for coronary artery reconstruction was introduced by Carpentier and colleagues [1] in 1973. However, disappointing results were retrieved at control angiography, and the technique was abandoned until unexpected good long-term results were achieved in several patients, and the technique was revived by Acar and colleagues [2]. Excellent early graft patency rates were obtained, possibly as a result of the modified harvesting technique and the use of calcium antagonists. Since then good results have been published by other investigators also, and the technique has quickly become widely used [3–5].

On the basis of anatomical studies, the ulnar artery has been considered the bigger artery of the forearm and hand [2, 3, 6]. However, in several studies the radial artery has been shown to have greater blood flow than the ulnar artery [7–10], but no difference in anatomical dimensions have been found at the wrist [9, 11].

Because of conflicting findings in previous investigations, we designed the present study to evaluate the relative internal diameters of the radial and ulnar arteries at the wrist. Casts of forearm arteries in cadavers were used to measure the arteries.

Material and Methods

Postmortem angiography from the aortic arch was performed in connection with diagnostic angiography of intracranial or coronary arteries in 32 cadavers. A portable device for pressure adjustment with compressed air was used. The ascending or descending thoracic aorta was cannulated and contrast medium was infused at a pressure of 120 mm Hg for at least 30 minutes.

Silicone rubber vulcanizing at room temperature (Silicon Kautschuk RTV-Vergussmasse K [Wacker-Chemie GmbH, Munich, Germany]) with 20% lead oxide was used. Vulcanizing was initiated by adding 2% of the vulcanizer (Haerter T) to the medium before injection.

Anteroposterior projection radiographs were taken using a distance of 40 cm, and the roentgenogram machine was set to 60 kW and 0.60 mAs.

Radiographs of eight cadavers were excluded because of filling defects in the casts. In the remaining 24 cadavers the mean age at the time of death was 60.6 years (median, 61; range, 36 to 88 years). There were 17 males and 7 females. Other characteristics are listed in Table 1.

The diameters of the radial and ulnar arteries were measured in the same radiograph with a ruler at the level of the ulnar head at the wrist in both arms. Three measurements were made of every diameter and the mean was taken for the results.

The data were statistically analyzed using the SPSS software (Statistical Package of Social Sciences [SPSS Inc, Chicago, IL]). To test the normality of the distributions of the variables, the Kolmogorov- Smirnov test was used. Since the variables were not normally distributed and there were only 24 observations, nonparametric methods were used. Differences in the mean values of the variables between the ulnar and radial arteries were analyzed using the Wilcoxon test. The arteries in the left and right hand of the same cadaver were compared separately so that the observations were independent.

Results

The mean diameter of the radial artery was significantly ($p < 0.001$) larger than the mean diameter of the ulnar

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Address reprint requests to Dr Riekkinen, Department of Thoracic and Vascular Surgery, Savonlinna Central Hospital, Keskussairaalantie 6, 57120 Savonlinna, Finland; e-mail: heikki.riekkinen@isshp.fi.

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Table 1. Summary of Cadaver Characteristics (n = 24 Cadavers)

Characteristic	n	Percent
Category of Death		
Disease	13	54%
Accident	8	33%
Suicide	2	8%
Undetermined	1	4%
The most important diseases		
Cardiovascular	11	46%
Alcoholism	7	30%
Vascular	1	4%
Diabetes	1	4%
Other	1	4%
No disease	3	13%

artery in both arms (Table 2). In the right arm the radial artery was 28% and in the left arm 26% wider than the ulnar artery. A typical radiograph is shown in the Figure 1.

In the right arm the radial artery was bigger in 20 of 24 cadavers (83%), the ulnar artery in 3 of 24 (13%), and the arteries were equal in 1 of 24 (4%). In the left arm the figures were 17 of 24 (71%), 3 of 24 (13%) and 4 of 24 (17%), respectively.

Comment

According to Carpentier and colleagues [1] there was no risk of ischemia after removing the radial artery because of the many anastomoses from the ulnar artery. Acar and colleagues [2] and Dietl and Benoit [3] referred to the same anatomical study [6] after which the forearm and hand are mainly vascularized by the ulnar artery and its collateral branches. However, in 1946 Debakey and Simeone [12] had already reported a three time greater incidence of loss of the hand after the ligation of the radial artery compared with the ligation of the ulnar artery in battle injuries. Furthermore, in 1961 Keen [13] reported on the basis of cadaveric dissections that the ulnar artery was larger than the radial artery in the proximal forearm,

Table 2. The Relative Internal Diameters of the Radial and Ulnar Arteries at the Wrist

	Right Arm		Left Arm	
	Radial Artery	Ulnar Artery	Radial Artery	Ulnar Artery
Mean	3.2	2.5	3.0	2.4
Median	3.3	2.5	3.1	2.5
Standard deviation	0.5	0.5	0.5	0.5
Minimum	2.0	1.5	2.0	1.5
Maximum	4.0	3.5	3.7	3.3
Range	2.0	2.0	1.7	1.8

The mean diameter of the radial artery was significantly ($p < 0.001$) larger than the (mean) diameter of the ulnar artery in both arms. There was no statistically significant difference between the remainders of the diameters of the radial and ulnar arteries in the right and left arms.

Fig 1. A typical radiograph of a cast of forearm arteries.

but that the radial artery had a greater diameter at the wrist level.

In 1983, Doscher and colleagues [11] found a slightly but significantly greater flow in the ulnar than in the radial artery in Doppler ultrasound studies. However, a greater flow was later found in the radial artery in pulse volume plethysmographic [7, 10], isotopic [8], and digital pulse oscillographic [9] studies.

In the present study the diameter of the radial artery was 28% larger than the diameter of the ulnar artery at the wrist in the right arm and 26% in the left arm. This means a more than twofold flow in the radial artery compared with the ulnar artery according to Poiseuille's Law, which states the flow to be proportional to r^4. These findings are in accordance with those of Tonks and colleagues [8], who found a 2.2:1 ratio between the flow of the radial and the ulnar arteries. In the present study, we

found that in the right arm the radial artery was larger in 83% of the patients, and in the left arm the radial artery was larger in 71% of the patients. In the study of Kleinert and colleagues [7], 87% of thumbs and 70.5% of index fingers were mainly vascularized by the radial artery.

There are only a few reports on the internal diameters of the radial and the ulnar arteries. Doscher and colleagues [11] found no difference in the diameters in Doppler ultrasound studies. Unfortunately this method is sensitive to changes in the angle of the ultrasonic beam and is probably not reliable. Tonks and colleagues [8] dissected the radial and ulnar arteries at the wrist of 11 cadavers and found no difference in the diameters. However, according to the experience of the present authors, it is difficult to estimate the real internal diameter of an empty and opened artery. In our opinion, the cast method, which we have used for many years in postmortem examinations and also in experimental investigations [14], has been more reliable for this purpose.

The discrepancy between the findings of different flows despite the same internal diameter in the radial and ulnar arteries at the wrist has been explained by different peripheral resistance [11]. However, we believe that the inability to demonstrate differences in arterial diameters depends on the methodologies. It has been shown that chronic increase in arterial blood flow induces an increase in the arterial diameter [15].

Our results indicate that the radial artery is the bigger forearm artery at the wrist, and not the ulnar artery. This finding does not mean that the radial artery cannot be used as a bypass graft. In fact, only minor complications have been published after harvesting the radial artery [2–4, 16, 17]. One explanation for this could be that the ulnar artery possibly increases in size over time after the radial is removed. However, 5 years after operation a significantly lower transcutaneous (PO2) have been found in the operated arm than in the control during exercise [18].

Recently, a forearm flap based on the ulnar artery has been recommended [9]. Also the use of the ulnar artery as a coronary bypass graft has been presented [19, 20].

In conclusion, in cast studies in cadavers the mean internal diameter of the radial artery was significantly greater ($p < 0.001$) than the diameter of the ulnar artery at the wrist. In view of the present investigation, the radial artery should be considered the bigger forearm artery of the hand in most cases. Because of the excellent patency rates of the radial artery graft and the low incidence of ischemic complications in the hand, the radial artery is a good choice for a bypass graft in most patients. However, if there is any indication of hand ischemia during the compression of the radial artery, the use of the ulnar artery can be considered.

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