

Prevalence of The Arterial Hand Dominance Using the Modified Allen Test and Pulse Oximetry among Plastic Surgery Patients

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Background: The ulnar and radial arteries are the major source of blood supply in the hand, as they form the superficial and deep palmar arches. Arterial hand circulation is one of the most complicated arterial trees and connections in the body, with tremendous variations in its structure. This study aimed to evaluate whether the ulnar artery or radial artery is the dominant artery in hand circulation among plastic surgery patients at King Khalid University Hospital and to correlate the arterial hand dominance with handedness and gender.

Methods: This is an analytical cross-sectional study conducted at King Khalid University Hospital in Riyadh, Saudi Arabia, on plastic surgery patients. The sampling method is purposive sampling. The calculated sample size is 28; however, 100 participants have been enlisted in the study. The data have been collected using the modified Allen test with a pulse oximeter.

Results: The collective prevalence of dual arterial dominance in our study was 69% compared with 56% and 30% for Little et al ($P = 0.013$) and Fuhrman et al ($P < 0.001$), respectively. With regard to gender, women were more likely to have a dual arterial blood supply than men, with the frequency values of 85% and 58.3% for women and men, respectively ($P = 0.017$).

Conclusions: Our study found that dual arterial supply is predominant among our participants, with 69% of our participants possessing a dual arterial supply, while 18% and 13% constitute the prevalence of radial and ulnar dominance, respectively. This contrasts with what has been reported previously in the literature. (*Plast Reconstr Surg Glob Open* 2024; 12:e5603; doi: [10.1097/GOX.0000000000005603](https://doi.org/10.1097/GOX.0000000000005603); Published online 19 February 2024.)

INTRODUCTION

Studies on human cadavers show that arterial hand circulation in humans has a wide range of variations, some of which are still unidentified. The ulnar and radial arteries, together, make up the major arteries that supply the hand. Occasionally, other arteries contribute to the hand arterial blood supply, such as the anterior interosseous artery, posterior interosseous artery, and median artery. The ulnar and radial arteries

compete with one another for arterial dominance. A study published in 1978 examining the arterial dominance in the hand in 100 healthy subjects (age: 13–43 years) before and after compression of the radial or ulnar artery found that 110 hands (55.0%) had radial arterial dominance, 24 hands (12.0%) had ulnar arterial dominance, and 66 hands (33.0%) had neither vessel as the dominant one (dual supply). Another study published in 1973 studied the circulatory patterns in 100 apparently normal hands clinically by use of the Allen test and ultrasonically with a Doppler flowmeter, which concluded that the ulnar artery is the dominant artery for digital blood supply, as demonstrated by the cessation of the interdigital pulses on compression of the ulnar artery in 75 of the 300 clefts examined, compared with the 57 interdigital arteries when the radial artery was compressed. Additionally, a study published in 1992 evaluating the collateral circulation to the hand using digital blood pressure, plethysmography, and the modified Allen test on 70 hands of healthy volunteers

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reported that plethysmography indicated that 49 of 70 (70%) hands had a dominant artery, the ulnar artery was dominant in 28 of 49 (57%), and the radial artery in 21 (43%).¹⁻³

The Allen test is used to assess collateral blood flow within the hands, specifically testing for the presence of a complete palmar arch. Typically, this is done before performing a procedure that can affect the radial or ulnar artery's blood flow. These procedures include free flapping, arterial cannulation, arterial sampling, and radial artery grafting for coronary artery bypass grafting. The Allen test was first introduced into the medical field in 1929 by Dr. Edgar Van Nuys Allen, upon examination of three patients with thromboangiitis obliterans, as Dr. Allen was interested in and known for his research in peripheral vascular diseases. Dr. Allen described that the test is performed by simultaneously occluding one artery in each hand, and asking the patient to clench both fists and wait for 1 minute. This version of the test can only detect complete occlusion, and therefore, the test has been modified to assess the collateral circulation of the hand, hence the modified Allen test. The modification was done by Dr. Irving S. Wright, and in this test, the examiner occludes the ulnar and radial arteries of one hand, asks the patient to clench their fist and wait for 30 seconds, and then asks the patient to extend their fingers. After that, the examiner releases the ulnar artery while continuing to occlude the radial artery. If the color of the hand returns to the normal color, it is considered that adequate collateral circulation is present.⁴⁻⁷

METHODS

Study Design and Sampling

This is an analytical cross-sectional study that has been conducted at King Khalid University Hospital in Riyadh, Saudi Arabia. The participants were purposively sampled from the plastic surgery clinics at King Khalid University Hospital in Riyadh, Saudi Arabia. Patients were assessed based on our predefined selection criteria, which include all patients attending the plastic surgery clinics and in accordance with a preestablished minimum projected sample size. Subjects in whom our exclusion criteria exist were thus excluded from the study, and the remainder were included, which ultimately totaled 100 subjects. Arterial hand dominance was determined by the modified Allen test and pulse oximeter of the dominant hand of our participants as subjectively defined individually by our cohort. None of our subjects were ambidextrous; in such situations, a measurement of both hands would be considered.

The results of the aforementioned tests were incorporated into data sheets in addition to demographic information and the presence of chronic vasculopathogenic conditions, which, for the purpose of this study, were limited to having either diabetes mellitus, hypertension, or dyslipidemia. Patients with known peripheral arterial disease, documented vascular injuries, and recent

Takeaways

Question: Among plastic surgery patients at King Khalid University Hospital, What is the arterial hand dominance?

Findings: Prevalence of dual arterial dominance in our study was 69% ($P = 0.013$; $P < 0.001$). With regard to gender, women were more likely to have a dual arterial blood supply than men, with frequency values of 85% and 58.3%, respectively ($P = 0.017$).

Meaning: Our study finds that dual arterial supply is predominant (69%) among our participants. This contrasts with that reported previously in the literature.

arterial cannulation within 21 days preceding the test were excluded from this study.

Performance of the Modified Allen Test Using Pulse Oximetry

Arterial dominance was determined by the performance of the modified Allen test, which has a sensitivity of 77% and a specificity of 93%,⁸ in addition to pulse oximetry. The radial and ulnar arteries are first located by the examiner and are henceforth occluded with the middle three digits of the examining clinician. The subject is then asked to clench his or her fist to facilitate the emptying of retained circulation. The subject is then asked to unclench his or her fist, and the color of the open palm is noted. The observation of a blanched palmar surface gives a clinical confirmation of the adequacy of arterial occlusion. The pulse oximeter probe would confirm the clinical observation, as can be ascertained by the loss of the pulse oximeter reading or waveform. The ulnar artery will then be released, and the capillary refill time is measured. Then the process will be repeated but with releasing the radial artery instead. The pulse oximeter would then determine the adequacy of the released artery to supply the hand based on the waveform readings. Showing either no change or initial drop with full recovery in the pulse oximeter waveform indicates that the released artery is capable of supplying the hand. Other observations of the waveform, such as partial recovery or flattening of the pulse oximeter waveform, indicate inadequacy of the released artery to supply the hand on its own. Patients were then classified as having dual, ulnar, or radial arterial dominance based on the observed results.^{8,9}

Statistical Analysis

Data were analyzed using SPSS, version 26.0. Descriptive statistics (mean, SD, frequencies, and percentages) were used to describe the quantitative and categorical variables. The chi square goodness-of-fit test was used to assess the null hypothesis of this study. Also, the Fisher exact test was used where appropriate. A P value of less than 0.05 was considered statistically significant.

Ethical Consideration

The study was approved by the institutional review board, College of Medicine, King Saud University, Riyadh,

Table 1. Demographic Variables

Variable	Frequency (%)
Sex	Males: 60% Females: 40%
Medical conditions	Vasculopathogenic conditions: 18% Others: 82%
Age	Mean (SD): 37.54 (13.9) Range: 15–75

Saudi Arabia. Informed consent was obtained from all participants.

RESULTS

The demographic variables of our participants are listed in Table 1. Sixty percent of our cohort consisted of men and 40% were women. The majority of our participants were without diagnosed vasculopathogenic conditions. The mean age of our participants at the time of data collection was 37.54 (Table 1).

With regard to gender, women were more likely to have a dual arterial blood supply than men, with values of 85% and 58.3% for women and men, respectively ($P = 0.017$). Having a vasculopathogenic condition was not significantly associated with the presence of a dual arterial supply, as values totaled 61.1% and 70.7% for patients with and without vasculopathogenic condition, respectively ($P = 0.615$). The majority of our participants were right-handed with a percentage of 92%, whereas those who expressed being left-handed constituted 8% of our cohort, none of our participants were known to be ambidextrous ($P = 0.260$; Table 2).

The comparison of our results to historical estimations of arterial dominance is listed in Table 3. The collective prevalence of dual arterial dominance in our study was 69% compared with 56% and 30% for

Little et al and Fuhrman et al, respectively ($P = 0.013$; $P < 0.001$; Table 3).

DISCUSSION

Determination of arterial dominance is vital before the conduction of procedures that involve manipulations of the arterial tree supplying the hand. Knowing the arterial dominance of the hand is of pivotal importance to the modern plastic surgeon, as the implications involve presurgical planning of procedures that involve flapping, reimplantation, and overall tissue viability of hand structures. Such procedures are highly vulnerable to ischemic events in the immediate postoperative period or delayed wound healing due to malperfusion of the involved structures. As such, surgical risk may be anticipated in advance in those with threatened arterial perfusion and may be aborted altogether, if the potential risks outweigh the benefits. Even simple nonsurgical procedures such as radial artery cannulation are not without risk of complications. There is increasing evidence suggesting that the disruption of the radial artery flow may not be as benign as previously thought, with the most frequent being arterial thrombosis. Although the proportion of individuals who are at risk for significant ischemia may be minor, tissue loss in these situations is a significant casualty.^{9–12}

The accepted dogma of ulnar predominance is evidently based on historical findings that have yet to be reassessed in modern clinical practice despite its critical implications. Having a misguided preconception of such epidemiological data may influence the subsequent interpretation of the determination of arterial dominance. Many methods exist to ascertain the patency of the hand collateral circulation, the most famous of which is the Allen test, conceived by Dr. Edgar Van Nuys Allen and subsequently modified by Dr. Irving S. Wright,

Table 2. Association between Arterial Dominance and Demographic Characteristics

		Dual Arterial Supply (%)	Radial Artery (%)	Ulnar Artery (%)	Total	Asymptotic Significance (Two-sided)
Sex						
Female	Count	34 (85)	4 (10)	2 (5)	40	0.017
Male	Count	35 (58.3)	14 (23.3)	11 (18.3)	60	
Medical Condition						
Vasculopathogenic	Count	11 (61.1)	4 (22.2)	3 (16.7)	18	0.615*
Others	Count	58 (70.7)	14 (17.1)	10 (12.2)	82	
Dominant Hand						
Right-handed	Count	65 (70.7)	15 (16.3)	12 (13)	92	0.260*
Left-handed	Count	4 (50)	3 (37.5)	1 (12.5)	8	

*Fischer exact test.

Table 3. Comparison with Previous Studies

	n = 100	Little et al	P	Fuhrman et al	P
Arterial Dominance					
Dual	69%	56%	0.013	30%	<0.001
Ulnar	13%	25%		40%	
Radial	18%	19%		30%	
Age					
Mean (range)	37.54 (15–75)	32 (18–67)		NA	

Chi square goodness-of-fit test was applied to all data points.

which allowed the delineation of the dual arterial contribution to hand circulation. The hand arterial collateral flow is adequate only when there is a complete superficial or deep palmar arch. We have conducted this study to establish a reference for arterial hand dominance, which can drastically reduce the adverse effects of the medical procedures that manipulate the radial or ulnar arteries.^{4-7,13,14}

There were scarce reports of arterial dominance of hand circulation, a surprising observation given the vitality and commonality of operations that involve hand arterial manipulation. Our findings contrast with those reported by Fuhrman et al in a study conducted in 1992, in which ulnar dominance (40%) was reported in a cohort of 70 patients, whereby dual arterial dominance and radial each constituted 30% of the study participants. Our findings are more in line and amplify what has been reported by Little et al, in a 1973 study involving 100 healthy patients. Dual arterial dominance was found to be present in 56% of the participants; this more closely approximates the findings of our present study. It should be noted, however, that heterogeneity exists in methods of arterial dominance determination. Ultrasound Doppler and plethysmography were used by Little et al and Fuhrman et al, respectively. This study, however, uses pulse oximetry, which reliably combines the detection of the perturbation of arterial waves as well as the intravascular oxygen saturation, raising the degree of certainty in observed clinical findings. Our findings call for vigilance in the interpretation and dissemination of information about arterial dominance in academic textbooks and clinical teaching, as the corpus of literature is deficient in its reports of arterial hand dominance. We hereby recommend the replication of these findings using more precise measures, and the most recent technological advancements that have been applied in the field of plastic surgery and beyond in the determination of arterial dominance, ideally in a larger cohort with robust statistical techniques to allow generalizable findings to be generated about the interconnections of the hand vascular tree. Technology has played a major role in the medical revolution we have witnessed in recent years, as many software, applications, and artificial-intelligence-based models have been implemented in medicine to aid physicians in their clinical encounters daily.¹⁵⁻¹⁸

We recognize the limitations of our study, namely that it is a single-center study with a relatively small number of participants. Furthermore, more accurate methods for the determination of arterial hand dominance exist, and this will likely improve with the advent of technology (eg, computer-assisted imaging), which should ideally form the epidemiological basis of such findings.

CONCLUSIONS

Our study finds that dual arterial supply is predominant among our participants, with 69% of our participants possessing a dual arterial supply, and 18% and 13% constitute the prevalence of radial and ulnar dominance,

respectively. This contrasts with what has been reported previously in the literature and calls for more robust studies in assessing the dominance of hand arterial circulation.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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ETHICAL APPROVAL

The study was approved by the institutional review board, College of Medicine, King Saud University, Riyadh, Saudi Arabia (Approval no.: E-23-7624 with Ref. No. 23/0293/IRB).

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