

## **A study of the superficial palmar arteries using the Doppler Ultrasonic Flowmeter**

**M. AL-TURK AND W. K. METCALF**

*Department of Anatomy, University of Nebraska Medical Center,  
42nd and Dewey Avenue, Omaha, Nebraska 68105, U.S.A.*

*(Accepted 28 April 1983)*

### **INTRODUCTION**

An excellent review of previous studies of its arterial supply is presented as an introduction to their own detailed investigation of 650 dissections of the hand by Coleman & Anson in 1961. They provide the current dogma on the normal anatomy and classify the variations they have observed.

The introduction of the continuous-wave ultrasonic Doppler technique provides, for the first time, a non-invasive method of assessment of the arterial pattern in the living human subject.

The application of ultrasound in medicine is recent. In 1960 Satomura & Kaneko, using an ultrasound blood-rheograph based on the principle of the Doppler effect, first described this non-invasive method of studying instantaneous changes in blood flow in human peripheral arteries. Later, Strandness, McCutcheon & Rushmer (1966) popularised transcutaneous flow detection for studying peripheral vascular problems. Since then, the transcutaneous Doppler ultrasound flow detection technique has emerged as a simple and useful diagnostic tool in various fields of medicine.

The purpose of this study has been: (1) to investigate the use of the Doppler Flowmeter in localising superficial arteries in the hand, (2) to determine whether results are consistent from day to day, (3) to compare right and left hand arterial patterns, and (4) to classify the arterial patterns observed and determine their concordance with studies on cadaveric material.

### **MATERIALS AND METHODS**

Twenty five white Caucasian subjects of 20–30 years of age were studied. All subjects were healthy and without evidence of cardiovascular disease. The investigation was performed under the same environmental conditions: at rest and at room temperature (20–21 °C). The Doppler Ultrasonic Flowmeter (Parks Electronics Lab, Beaverton, Oregon, U.S.A. 97005) was used to localise the *arcus palmaris superficialis*, the *arteriae digitales palmares communes*, and the *arteriae digitales palmares propriae*. The course of these arteries on the palmar surface of the hand was mapped on the skin after being localised by the Doppler probe. The ultrasound detection of blood flow is based on the Doppler effect. This is the change in frequency that occurs when sound waves are reflected from moving objects. The application of this principle to transcutaneous detection of blood flow is dependent on measuring the difference between the emitted and detected frequencies of ultrasound as determined by crystals situated in the Doppler probe. The Doppler probe was placed transcutaneously over the expected anatomical position of the artery and aligned with it at an angle of 45°.

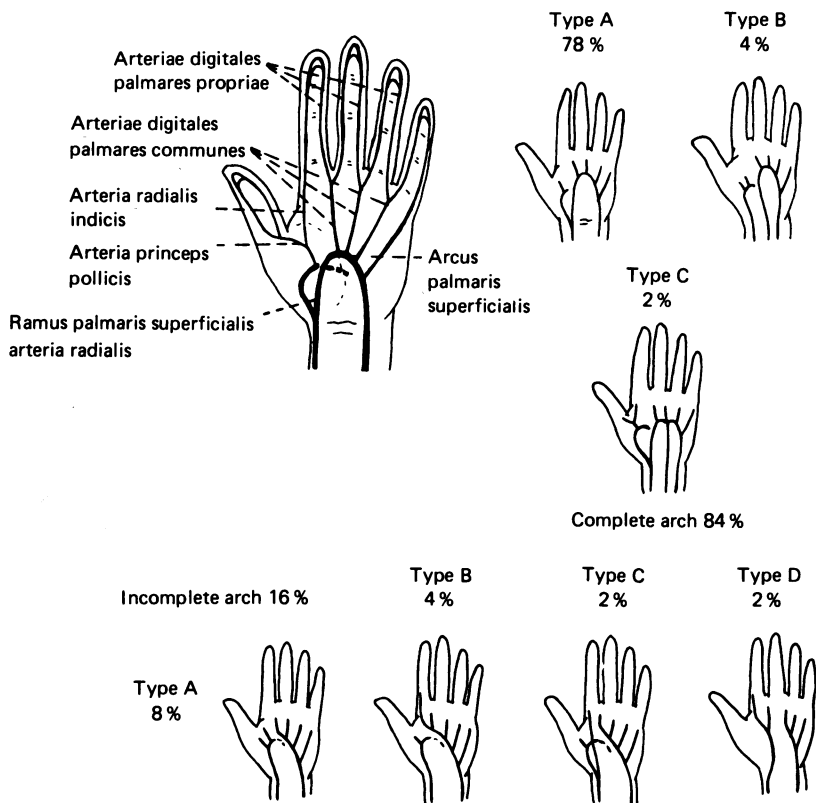


Fig. 1. Types of arcus palmaris superficialis encountered in 50 records of the hands. Shown schematically, with the percentage of occurrence of each of the seven types.

By moving the probe from side to side across the vessel, the centre of the artery could be located readily by the characteristic noise at the frequency of the pulse rate. This procedure was applied repetitively to follow the course of the vessel beneath the palmar surface of the hand. A record of the palmar surface of the hand was taken using an IBM Copier II. Both right and left hand maps were drawn independently for each volunteer.

The procedure was repeated four times on 4 of the 25 subjects on different days under the same environmental conditions and without referral to preceding records.

## RESULTS

### *Arcus palmaris superficialis*

Jaschtschinski (1892) grouped the variations into two categories on the basis of derivation from a complete or an incomplete arch. This serviceable classification was adopted with slight modification in the following description.

#### *Group I: a complete arch*

The ramus carpeus palmaris arteria ulnaris was considered to form a complete arch when it anastomosed with the ramus palmaris superficialis arteria radialis or the persistent arteria mediana.

Of the 50 hands in this study, there were 42 examples (84%) which possessed a complete arch. These were subdivided into three types.

*Type A.* The classical radio-ulnar arch was formed by the ramus palmaris superficialis arteria radialis and the ramus carpeus palmaris arteria ulnaris. This is the configuration regularly described (Fig. 1). It was found in 78 % of all hands.

*Type B.* The mediano-ulnar arch was composed of the ramus carpeus palmaris arteria ulnaris and a persistent arteria mediana (Fig. 1). This type of arch occurred in 4 % of the hands.

*Type C.* The radiomediano-ulnar arch was formed by the ramus palmaris superficialis arteria radialis, the ramus carpeus palmaris arteria ulnaris and the arteria mediana (Fig. 1). Only 2 % of the hands fell into this category.

In no case did a branch from the ramus carpeus palmaris arteria radialis take part in the formation of the arcus palmaris superficialis and no example of complete absence of the arch was found.

### *Group II: incomplete arch*

When the ramus carpeus palmaris arteria ulnaris did not anastomose with either the ramus palmaris superficialis arteria radialis or the arteria mediana or both, the arch was considered incomplete. A total of eight hands (16 %) fell into this category. They were subdivided into four main types.

*Type A.* The ramus carpeus palmaris arteria ulnaris gave origin to the three arteriae digitalis palmaris communes and the arteria digitalis palmaris propriae ulnaris to the little finger. The ramus palmaris superficialis arteria radialis and arteria mediana were absent (Fig. 1). This pattern was found in 8 % of the hands.

*Type B.* The ramus carpeus palmaris arteria ulnaris, in addition to the three arteriae digitalis palmaris communes and the arteria digitalis palmaris propriae ulnaris to the little finger, gave origin to the arteria radialis indicis. The ramus palmaris superficialis arteria radialis and arteria mediana were absent (Fig. 1); 4 % belonged to this type.

*Type C.* The ramus palmaris superficialis arteria radialis gave origin to the arteria radialis indicis, the ramus carpeus palmaris arteria ulnaris gave origin to the three arteriae digitales palmares communes and the arteria digitalis palmaris propriae ulnaris to the little finger (Fig. 1). Only 2 % showed this pattern.

*Type D.* The ramus carpeus palmaris arteria ulnaris gave origin to the arteriae digitales palmares communis secundus and tertius and the arteria digitalis palmaris propriae ulnaris to the little finger. The arteria radialis indicis and digitalis palmaris communis primus took origin from the ramus carpeus palmaris arteria radialis (Fig. 1). Only 2 % of the present series fell into this category.

### *Branches of the arcus palmaris superficialis*

It is customarily stated that three arteriae digitales palmares communes arise from the convexity of the arch, and that these vessels pass to the interdigital webs of the corresponding second, third, and fourth interosseous spaces.

### *Classification*

In 50 hands, five different patterns of the branches of the arcus palmaris superficialis were observed.

*Type I.* This type contained four arteriae digitales palmares communes (Fig. 2). In all these cases, a vessel that supplied the ulnar side of the thumb and the radial side of the index finger corresponded to the arteria digitalis palmaris communis primus described by Tandler (1897). Also in all these cases, this artery took origin from the

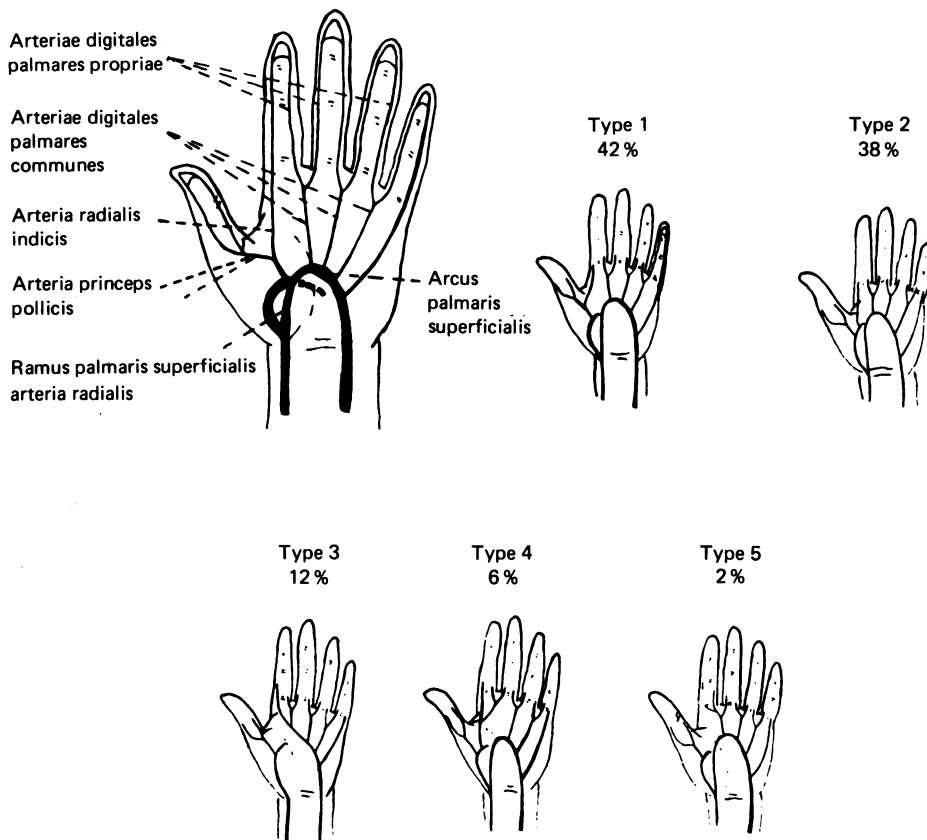


Fig. 2. Variations in pattern of the arteriae digitales palmares communes, radialis indicis, and principis pollicis encountered in the examination of 50 hands. Shown schematically with the percentage occurrence of each of the five types.

ramus carpeus palmaris arteria radialis. The other three arteriae digitales palmares communes took origin from the arcus palmaris superficialis and passed to the webs of the second, third, and fourth interspaces; 42 % of cases showed this pattern.

*Type II.* This type had three arteriae digitales palmares communes that passed to the interdigital webs of the second, third, and fourth interspaces (Fig. 2). All of these arteries arose from the arcus palmaris superficialis. The arteriae radialis indicis and princeps pollicis arose separately from the ramus carpeus palmaris arteria radialis. This is the configuration usually described; in the present series it occurred in 38 % of hands.

*Type III.* In addition to three arteriae digitales palmares communes as described under Type II, an artery passed to the radial side of the index finger and replaced the arteria radialis indicis (Fig. 2). This artery arose from the arcus palmaris superficialis, while the arteria princeps pollicis took origin from the ramus carpeus palmaris arteria radialis. Of the total of 50 hands, 12 % showed this pattern.

*Type IV.* This type had two arteriae digitales palmares communes arising from the arcus palmaris superficialis which passed to the third and fourth interspaces (Fig. 2). The arteria digitales palmaris communis which passed to the web of the second interspace arose from the arteria radialis indicis as it passed to the radial side of the index

finger. The arteriae princeps pollicis and radialis indicis arose from the ramus carpeus palmaris arteria radialis. This was a rare pattern found in only 6% of hands.

*Type V.* This type had three arteriae digitales palmares communes, as in Type II, and a branch to the radial side of the index finger which arose from the arteria digitales palmaris proprius ulnaris of the index finger (Fig. 2). This also was unusual. It was found in only one hand or 2% of the cases.

#### DISCUSSION

The incidence of complete arcus palmaris superficialis in this study is in accordance with that found in previous studies by Coleman & Anson (1961). There have been no other reports of the incidence of macroscopic arcus palmaris superficialis continuity.

Kamienski & Barnes (1976) reported that their functional test of the integrity of the palmar arch does not correlate with the incidence of arcus palmaris continuity studied in cadavers by Coleman & Anson (1961). The present study also does not correlate with Kamienski & Barnes' (1976) definition of complete and incomplete arcus, but is in agreement with them on the presence of functional continuity between the superficial and deep circulations in almost all hands.

Little, Zylstra, West & May (1973) state that circulatory dynamics in the hand follow a very variable pattern and that ischaemia following occlusion of either arteriae radialis or ulnaris may occur in any finger. It has also been reported by Mozersky *et al.* (1973) that the arcus palmaris superficialis is supplied predominantly by the arteria ulnaris, occurring in 88% of 140 hands investigated. The present study supports the observations of both Little *et al.* (1973) and Mozersky *et al.* (1973).

Tandler (1897) was aware of divergence of opinion regarding the connections of the arcus palmaris superficialis in the first interspace. In a study of 130 specimens, he found that the final termination of the ramus carpeus palmaris arteria ulnaris in the palm is usually an artery which supplies both the radial side of the index finger and ulnar side of the thumb. He named this vessel the arteria digitalis palmaris communis primus. Coleman & Anson's (1961) study supports Tandler's (1897) observations. In the present study, it is found that the artery which supplies both the radial side of the index finger and ulnar side of the thumb arises from the ramus carpeus palmaris arteria radialis and it is considered to be the arteria digitalis palmaris communis primus for classification purposes.

In the present study, in agreement with Coleman & Anson (1961), the most frequent type is that with four arteriae digitales palmares communes.

This study does not reveal any case of absence of the arteria digitalis palmaris communis as reported by Coleman & Anson (1961).

#### SUMMARY

The pattern of the superficial arteries of the hand has been studied utilising the Doppler Flowmeter technique.

The superficial arteries of the hand formed several diversified patterns that permitted classification into well defined categories. The arcus palmaris superficialis was complete in 84% of the hands and incomplete in 16%. The arteria digitalis palmaris communis primus took origin from the arch in 94% and from the arteria radialis indicis in 6% of the hands.

The arteria princeps pollicis and radialis indicis were quite variable in their origin and frequently differed from the normal textbook description.

In 52 % of the subjects, the arterial patterns in the right and left hand were different with respect to one or more arteries, while they were identical in 48 % of the subjects.

It would be unwise to base anything more than tentative conclusions on the data so far accumulated, because of the small population used in this project and the absence of similar studies in the literature.

#### REFERENCES

- COLEMAN, S. S. & ANSON, B. J. (1961). Arterial patterns in the hand based upon a study of 650 specimens. *Surgery, Gynecology and Obstetrics* **113**, 409-424.
- JASCHTSCHINSKI, S. M. (1892). Morphologie und Topographie des Arcus volaris sublimis und profundus. *Anatomische Hefte* **7**, 163-188.
- KAMIENSKI, R. W. & BARNES, R. W. (1976). Critique of the Allen test for continuity of the palmar arch assessed by Doppler ultrasound. *Surgery, Gynecology and Obstetrics* **142**, 861-864.
- LITTLE, J. M., ZYLSTRA, P. L., WEST, J. & MAY, J. (1973). Circulatory patterns in the normal hand. *British Journal of Surgery* **60**, 652-655.
- MOZERSKY, D. J., BUCKLEY, C. J., HAGORD, C. O., JR, CAPPS, W. F., JR & DANNEMILLER, F. J., JR (1973). Ultrasonic evaluation of the palmar circulation: a useful adjunct to radial artery cannulation. *American Journal of Surgery* **126**, 810-812.
- SATOMURA, S. & KANEKO, Z. (1960). Ultrasonic blood rheograph. *Proceedings of the 3rd International Conference on Medical Electronics, London*, pp. 254-258.
- STRANDNESS, D. E., JR, MCCUTCHEON, E. P. & RUSHMER, R. F. (1966). Application of a transcutaneous Doppler flowmeter in evaluation of occlusive arterial disease. *Surgery, Gynecology and Obstetrics* **122**, 1039-1045.
- TANDLER, J. (1897). Anatomie der Arterien der Hand. *Anatomische Hefte* **7**, 263-282.