ARTERIAL DOMINANCE IN THE HAND

B. HUSUM AND T. PALM

SUMMARY

Arterial pressure was measured simultaneously in the thumb and in the contralateral arm using strain-gauge plethysmography in 100 healthy persons aged 13–43 yr, before and after compression of the radial or the ulnar artery. The radial and ulnar pulses were palpable in all instances. In 29 (14.5%) hands compression of either artery did not reduce the thumb pressure. In 152 (76%) occlusion of the radial artery caused a decrease of more than 10 mm Hg, but never to less than 40 mm Hg. In 91 (45.5%) occlusion of the ulnar artery reduced thumb pressure, on three occasions to less than 40 mm Hg. Radial dominance was shown in 110 hands (55.0%), 24 (12.0%) showed ulnar dominance and in 66 (33.0%) neither vessel dominated.

Cannulation of the radial artery is accepted widely for i.a. pressure monitoring or frequent blood sampling. However, the procedure is not free from complications, the most frequent being thrombosis of the artery. In prospective studies, Bedford and Wollmann (1973) and Palm (1977) found a frequency of thrombosis of the radial artery following cannulation of 40%.

Before cannulation of the radial artery the consequences of occlusion of the artery should be evaluated by ensuring the presence of a collateral flow through the ulnar artery (Allen, 1929). The ulnar collateral flow is adequate only when there is a complete superficial or complete deep palmar arch (Coleman and Anson, 1961). Friedman (1970) found that in 3.4% of 290 healthy young subjects the ulnar pulse was absent.

Using a modified Allen test, Ryan and others (1973) found that six of 13 subjects had ulnar arterial dominance, three demonstrated radial dominance and in four neither vessel was dominant. The modified Allen tests correlated with pulse volume recordings in determining the dominance of arterial supply in 12 of 13 hands. In view of the high frequency of complications, cannulation of the non-dominant vessel was suggested.

We have evaluated the arterial contributions to the maintenance of the distal arterial pressure in the thumb as part of a wider study of cannulation of the radial artery.

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SUBJECTS AND METHODS

One hundred healthy volunteers (57 females) were examined. The age range was 13–43 yr (median 29.6 yr); the age distribution was the same for both sexes.

Arterial pressure in the thumb was measured using a method based on the conventional cuff principle (Gundersen, 1972; Palm, 1977). A 22-mm wide cuff was placed around the proximal phalanx of the thumb. The plethysmograph comprised a mercury-in-rubber strain-gauge (Parks Electronics, Oregon) placed around the distal phalanx of the thumb. After inflation of the cuff to about 30 mm Hg greater than systolic arterial pressure, the pressure in the cuff was released slowly until an increase in the intravascular volume of the thumb was observed on the strain-gauge plethysmograph. At this point the cuff pressure reflected the perfusion pressure of the thumb. A 12-cm wide cuff around the upper arm was used for determining the systemic arterial pressure in the arm by strain-gauge plethysmography.

The subjects were in the supine position in a room at a constant temperature of 22 °C. Using a two-channel strain-gauge the systemic arterial pressure was determined simultaneously in both arms. Arterial pressure was then determined simultaneously in the right thumb and left arm and vice versa. Measurements of arterial pressure in the thumb were made after successive compression of the radial artery and the ulnar artery with simultaneous measurements of the systemic arterial pressure in the contralateral arm. A decrease in systolic pressure greater than 10 mm Hg (2.5 times greater than the standard deviation of duplicate measurements; Gundersen, 1972) was
taken as evidence that arterial occlusion was followed by a significant reduction in perfusion pressure in the thumb.

Corrections were made for differences in arterial pressure between the arms or for changes in systemic arterial pressure throughout the examination period. In the present study no attempt was made to compare this test with the Allen's test.

As the variables cannot be assumed to follow a normal distribution, they have been described by the medians and range.

RESULTS

Both the radial and the ulnar artery were palpable in all of the 200 hands.

In 17 subjects, the simultaneous determination of the systemic arterial pressure in the two arms revealed differences ranging from 12 to 27 mm Hg, the median being 14.5 mm Hg.

In 29 hands no decrease in arterial pressure in the thumb occurred after compression of either the radial or the ulnar arteries. In the remaining 171 hands compression of one or both of the arteries successively was followed by a decrease of arterial pressure in the thumb, that is, perfusion pressure through collaterals was inadequate to compensate fully for the decrease in flow produced by arterial occlusion (table I).

In 80 hands the arterial pressure in the thumb was reduced after compression of the radial artery but not after compression of the ulnar artery. In 19 hands the opposite was the case and in the remaining 72 hands compression of each of the arteries reduced the thumb arterial pressure. In 30 of these 72 hands the largest decrease in thumb arterial pressure was observed following compression of the radial artery, in five after compression of the ulnar artery and in 37 the magnitude of decrease was the same following compression of both arteries.

Thus 110 hands (55.0%) had radial arterial dominance, and 24 (12.0%) had ulnar arterial dominance, while in 66 hands (33.0%) neither of the vessels was dominant.

In 152 hands (76.0%) compression of the radial artery reduced the arterial pressure in the thumb from 8% to 48% of the pressure before compression. The median pressure reduction was 18.8% (95% confidence limits 16.6–22.0%); in no instance did the pressure decrease to less than 40 mm Hg. In 91 hands (45.5%) compression of the ulnar artery reduced the arterial pressure from 6% to 87% of the pressure before compression. The median pressure reduction was 12.8% (95% confidence limits 12.0–15.5%); in three hands the pressure decreased to less than 40 mm Hg.

DISCUSSION

In a study of 290 subjects aged 6–21 yr Friedman (1970) found that radial pulses were always present. Ulnar pulses were absent in 3.4%, always bilaterally. In the detailed anatomical study of Coleman and Anson (1961) there was no mention of missing radial or ulnar vessels. In the present study the radial and ulnar pulses were palpable in all 200 hands (confidence limits 98.2–100.0% of cases).

There are three major anastomoses between the radial and ulnar arteries in the hand. The deep palmar arch and the dorsal arch are formed primarily by the radial artery. The superficial palmar arch is formed primarily by the continuation of the ulnar artery into

<table>
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<tr>
<th>Artery compressed</th>
<th>Hands with decreased pressure</th>
<th>Magnitude of decrease in pressure (%)</th>
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<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Radial artery only</td>
<td>80</td>
<td>40.0</td>
</tr>
<tr>
<td>Ulnar artery only</td>
<td>19</td>
<td>9.5</td>
</tr>
<tr>
<td>Both arteries successively</td>
<td>72</td>
<td>36.0</td>
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<tr>
<td></td>
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<tr>
<td>Both after compr. radial artery</td>
<td>152</td>
<td>76.0</td>
</tr>
<tr>
<td>Both after compr. ulnar artery</td>
<td>91</td>
<td>45.5</td>
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the palm. In their study of 650 specimens Coleman and Anson (1961) found that a complete superficial palmar arch was present in about 80% while the deep palmar arch was complete in 97% of subjects. Usually the calibre of the deep palmar arch varied inversely with that of the superficial palmar arch. Mozersky and others (1973), using a directional Doppler ultrasonic velocity detector in a study of the palmar circulation in 70 young subjects, found an incomplete superficial palmar arch in 34%. The superficial palmar arch was found to be supplied predominantly by the ulnar artery in 88% and by the radial artery in 12% of the subjects. With the exception of this and the study of Ryan and others (1973) using a modified Allen test, information on the dominance of arterial supply to the hand is scarce.

We measured arterial pressure in the thumb to quantitate changes following arterial compression. By strain-gauge plethysmography combined with a pneumatic cuff technique, systolic pressures of 300–10 mm Hg may be found. The reproducibility of the strain-gauge method for measuring arterial pressure has a standard deviation on double determinations of 4 mm Hg when the systemic pressure is unchanged and when the cuff and strain-gauge are not disturbed between determinations (Gundersen, 1972; Nielsen, Bell and Lassen, 1972; Lassen et al., 1975). In the present study we regarded pressure changes exceeding 10 mm Hg to be significant.

Our results show that when the arterial pressure in the thumb was used as an indicator of the “overall perfusion” through the various anastomoses between the radial and ulnar arteries, radial arterial dominance was significantly more frequent than ulnar dominance (110 v. 24). In 66 hands neither of the vessels was dominant. Because of differences in technique, our data are not comparable with those of Mozersky and others (1973) and Ryan and others (1973).

In 76.0% of hands compression of the radial artery reduced the arterial pressure in the thumb, indicating a significant radial arterial contribution to the blood supply of the thumb. The reduction in arterial pressure never exceeded 48% of the pressure before compression. In no case was the pressure less than 40 mm Hg in any hand, the level associated with clinical symptoms of inadequate blood supply (Lassen et al., 1975). In 45.5% of hands compression of the ulnar artery reduced the pressure in the thumb to a maximum of 87% of the pressure before compression. In three hands (in two subjects) the pressure in the thumb was reduced to less than 40 mm Hg. Thus, clinically important pressure reductions following occlusion of the ulnar artery were observed in 1.5% of subjects (confidence limits 0.3–4.3%).

In cannulation of the radial artery the consequences of thrombosis within the vessel would seem to be not serious since the thumb pressure would not be less than 40 mm Hg.

We conclude that in younger, healthy subjects it is safe to use the radial artery for routine arterial cannulation. The existence of adequate collateral arterial supply should be determined before cannulation.

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REFERENCES


DOMINANCE ARTERIELLE DANS LA MAIN

RESUME
On a mesuré simultanément la tension artérielle dans le pouce et dans le bras contra-lateral en effectuant une plethysmographie à l’aide d’un appareil de mesure de la surcharge sur 100 personnes en bonne santé, âgées de 13 à 43 ans, avant et après compression de l’artère radiale ou de l’artère ulnaire. Les pulsus radial et ulnaire ont été palpables dans chaque cas. Dans 29 cas (14,5%), la compression de l’une ou de l’autre artère n’a pas diminué la pression du sang dans le pouce. Dans 152 cas (76%), l’occlusion de l’artère radiale a provoqué une diminution de plus de 10 mm Hg, mais jamais à moins de 40 mm Hg. Dans 91 cas (45,5%), l’occlusion de l’artère ulnaire a réduit la pression du sang dans le pouce, et à trois reprises à moins de 40 mm Hg. On a constaté une dominance radiale dans 110 cas (55%), dans 24 cas (12%) on a trouvé une dominance ulnaire et dans 66 cas (33%) aucun vaisseau n’a accusé de dominance.

DOMINIERENDE ARTERIEN IN DER HAND

ZUSAMMENFASSUNG
In 200 gesunden Personen im Alter von 13 bis 43 Jahren wurde vor und nach dem Abdriicken der Speichen- und Ellenarterie der Arteriendruck gleichzeitig im Daumen und im kontralateralen Arm gemessen, wobei eine Plethysmographie mit Anspannungsmessuhr benutzt wurde. Der Puls der Ellen- und Speichenarterie konnte in allen Fällen gefühlt werden. In 29 (14,5%) aller Hände reduzierte die Abdückung der Speichen- und Ellenarterie den Puls im Daumen nicht. In 152 (76%) Händen verursachte ein Abdrücken der Speichenarterie eine Verringerung von mehr als 10 mm Hg aber nie weniger als 40 mm Hg. In 91 (45,5%) Händen verringerte ein Abdrücken der Ellenarterie den Blutdruck im Daumen in drei Fällen auf weniger als 40 mm Hg. In 110 (55,0%) Händen herrschte die Speichenarterie vor, in 24 (12%) Händen die Ellenarterie und in 66 (33%) Händen herrschte keine der beiden vor.

DOMINACION ARTERIAL EN LA MANO

SUMARIO
La presión arterial fue medida simultáneamente en el pulgar y en el brazo contralateral, valiéndose de pletismografía por galga de esfuerzo en 100 personas saludables cuyos fluctuaban entre 13 y 43 años, antes y después de comprimirse la arteria radial o cubital. Los pulsos radial y cubital fueron palpables en todos los casos. En 29 (14,5%) manos, la compresión de una u otra arteria no redujo la presión en el pulgar. En 152 (76%), la oclusión de la arteria radial produjo una disminución que superó los 10 mm Hg, sin caer bajo los 40 mm Hg. En 91 (45,5%), la oclusión de la arteria cubital redujo la presión en el pulgar, en tres ocasiones a menos de 40 mm Hg. Se demostró una dominación radial en 110 manos (55,0%), dominación cubital en 24 (12,0%) y en 66 (33,0%) no predominó ninguno de los dos vasos.