Upsala J Med Sci 101: 113–120, 1996

A Modified Technique of Ultrasonic Triplex Scanning of the Lower Extremity Arteries

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ABSTRACT

This study was undertaken to evaluate the utility of a modified technique of triplex scanning of the lower extremity arteries in 20 subjects without any clinical signs of arterial disease. The distal aorta and iliac arteries were examined with the subject in supine position and lying slightly on the opposite side. By moderate compression of the probe towards the psoas muscle and directing it over the iliac arteries with slight medial retraction of the abdomen, satisfactory visualization of the common and external arteries with 7.5 MHz high resolution imaging and a 5.6 MHz doppler probe were obtained in 56 of 80 segments (70 %). In obese individuals it was necessary to use 5 MHz probe for satisfactory scanning of the aortic bifurcation and common iliac arteries. The distal superficial femoral, popliteal and tibioperoneal trunk segments were examined with the patient prone and the knee slightly flexed. Peak systolic, early diastolic reverse and late diastolic forward flow velocities were studied together with measurement of the arterial diemeters, which demonstrated wide variations.

This study suggests that satisfactory scanning of the iliac and femoropopliteal arteries with the described technique

can be achieved in the majority of subjects with a superficial high resolution probe. The combination of 7.5 MHz two-dimensional imaging with a 5.6 MHz pulsed wave Doppler probe offers optimal information of these arteries in nonobese individuals.

INTRODUCTION

Duplex ultrasound scanning, which combines the attributes of both real-time B-mode ultrasonography and range-gated pulsed-wave Doppler flow signal analysis, allows acquisition of velocity information from a specific location along the visualized artery. The addition of a real-time color coded flow image in duplex scanners (triplex) enables the examiner to determine the presence of arterial stenosis and occlusion by observing the changes or absence of the color patterns. Duplex scanning and color flow imaging have substantially enhanced the diagnostic accuracy in the evaluation of the superficially located vessels of the extracranial carotid artery system and replaced all previous direct and indirect noninvasive methods.

The applications of duplex or triplex scanning of the deeper arteries in the abdomen and pelvis have been less frequently studied, mainly due to the technical difficulties obtaining accurate Doppler information. Technical refinements in probe technology and deep duplex imaging have led to a widespread interest of these methods in the assessment of the lower extremity arteries. The aim of the present study was to

evaluate the value of a modified examination technique of triplex scanning of the lower extremity arteries with a high resolution superficial probe and to study the velocity patterns and diameters of the iliac and femoropopliteal arteries in healthy subjects.

MATERIAL AND METHODS

The lower extremity arteries of 20 healthy volunteers (6 men and 14 females) were studied by triplex scanning, using a Hewlett-Packard Sonos 1000 model version M fitted with a 7.5 MHz linear phased array transducer (7.5 MHz high resolution imaging probe combined with a 5.6 MHz Doppler) and a 5 MHz sector imaging probe with 3.7 MHz Doppler frequency (Hewlett-Packard Company, Massachusetts,USA). The age, weight and the abdominal circumference of the subjects are summarized in Table 1. All subjects were without symptoms of peripheral arterial disease and had normal ankle-brachial pressure index (<0.9).

Table 1. Subject characteristics

	Mean	Range
Age	43	21-71
Weight(kg)	64	50-81
Abdominal circumference(cm)	79	61-97
Length (cm)	169	156-185

The volunteers did not fast prior to the examination. The distal aorta and the iliac arteries were examined with the subject in supine position and lying slightly on the opposite side. The scanning of the aortic bifurcation and common iliac arteries were performed by moderate compression of the probe towards the psoas muscle and directing it medially over the arteries with slight retraction of the abdomen. The probe was then moved distally to the inguinal ligament, following the course of the external iliac artery. Slight deep compression of the probe together with retraction of the abdomen medially which reduced the distance between the probe and the artery was also applied for scanning of the external iliac arteries. Examination of the common, superficial and deep femoral arteries were performed by following the course of the arteries to the level of knee with the leg in slight external rotation and abduction and the knee moderately flexed. The popliteal artery and tibioperoneal trunk were studied with the subject prone and the knee slightly flexed by placing a cushion at the ankle level. No effort was made to visualise the crural arteries distal to the trifurcation level.

In each individual bilateral examinations were performed at 8 different segments (distal aorta, common iliac, external iliac, common femoral, deep femoral, superficial femoral, poplitea and tibioperoneal trunk). At each segment the diameter of the artery, peak systolic, early diastolic reverse and late diastolic forward flow velocities were registered.

RESULTS

A complete bilateral examination from the distal aorta to the tibioperoneal trunk took average 50 min (range 40 to 90 min). It was possible to obtain satisfactory visualisation of the common and external iliac arteries with the superficial 7.5 MHz linear probe in 56 of 80 segments (70 %). In the remaining, usually obese individuals it was necessary to use the 5 MHz probe for satisfactory scanning and Doppler evaluation of the aortoiliac segments. Scanning of the arterial segments below the inguinal ligament was achieved with 7.5 MHz probe in all individuals. The distal part of the superficial femoral artery just above the knee level and the tibioperoneal trunk were the most difficult segments to examine.

The results of the diameter and the flow velocity measurements are presented in Table 2. Similar measurements were obtained on both sides in the same individual. Peak systolic velocity measurements demonstrated wide variations in the studied individuals. Diastolic velocity measurements did not show similar wide variations. Relatively higher peak systolic velocity values were obtained in the iliac segments compared to proximal or distal segments. Peak systolic velocity values never exceed 185 cm/sec in the iliac and 160 cm/sec in the femoropopliteal segments.

Table 2. Diameter and velocity measurements in various arterial segments

Segment	Diameter (mean + SE)	PSV (mean+ SE)	DRV (mean+SE)	DFV (mean+SE)
Aorta	1.2 ± 0.1	97.6 ± 9.8	23 ± 4	11 ± 0.8
Common iliac	0.8 ± 0.1	113 ± 5	31 ± 1.9	31 ± 1.9
External iliac	0.7 ± 0.1	120 ± 5	31 ± 2	16 ± 0.9
Common femoral	0.7 ± 0.1	98.4 ± 4	28 ± 1.4	14 ± 0.7
Deep femoral	0.5 ± 0.1	71 ± 4	15 ± 1.2	10 ± 0.7
Superficial femoral	0.6 ± 0.1	96 ± 3	29 ± 1.6	13 ± 0.9
Poplitea	0.5 ± 0.1	71 ± 4	15 ± 1.2	10 ± 0.7
Tibioperoneal trunk	0.3 ± 0.1	60 ± 4	14 ± 1.1	11 ± 1.7

PSV: Peak systolic velocity (cm/sec)

DRV: Diastolic reversed velocity (cm/sec)

DFV: Diastolic forward velocity (cm/sec)

DISCUSSION

The recent development of phased array scanning in a linear format established the potential for obtaining high quality color flow doppler imaging of the arteries (4). High frequency transducers are preferred to examine the superficially located arteries like the femoral or carotid as improved scanning resolution is achieved at higher frequencies. When depth penetration is important as in the aortoiliac segments, lower frequencies are needed (3.5 or 5 MHz). The same transducer has to be used for pulse-echo imaging and for Doppler applications. The optimal ultrasonic frequency for Doppler studies at a given penetration is generally lower than that for scanning. Therefore it is

desirable to combine a high frequency imaging probe with a lower frequency of Doppler transducer.

The present study was undertaken to evaluate the utility of triplex scanning of the lower extremity arteries with a 7.5 MHz linear phased array scanning probe with a 5.6 MHz Doppler unit. In order to scan and obtain accurate Doppler information from the aortoiliac arteries with that superficial probe, a modified examination technique was used. Moderate compression of the probe towards the psoas muscle and then directing it over to the proximal iliac arteries with slight retraction of the abdomen medially decreased the distance between the probe and the arteries. By this technique it was possible to obtain satisfactory visualisation of the aortoiliac segment in 70 % of the normal subjects with a 7.5 MHz and in the remaining with a 5 MHz probe. It was not necessary to use 3.5 MHz probe for satisfactory visualization of the aortoiliac segment as reported in other studies (1-3). The femoropopliteal segments were analysed with a similar reported technique and demonstrated satisfactory scanning with 7.5 MHz probe in all individuals (2). The distal part of the superficial femoral artery above the knee joint and the tibioperoneal trunk were the most time consuming segments.

The application of color imaging with duplex ultrasound allows rapid detection of the areas of maximal stenosis by demonstrating an abnormal color flow pattern. As the flow information in a color Doppler image is semi-qualitative, the

accurate diagnosis and grading of stenosis depends on quantitative peak systolic velocity measurement from the spectral analysis. However, velocity related diagnostic criteria for duplex or triplex scanning of the lower extremity arteries are not yet clearly defined. The peak systolic velocity measurements of various arterial segments in healthy individuals in the present study demonstrated wide variations.

CONCLUSION

In conclusion, this study suggests that satisfactory scanning of the iliac and femoropopliteal arteries with the described technique can be achieved by using a high frequency high resolution linear phased array probe in the majority of subjects. With the future developments in probe technology triplex scanning has the potential to offer much better scanning and Doppler information of the deep arteries.

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