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STUDY OF DIFFERENT BLOOD VESSELS IN THE HEAD AND NECK REGION USING COLOR DOPPLER ULTRASONOGRAPHY AND ITS COMPARISON WITH WESTERN DATA

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ABSTRACT

Measurement of blood vessel diameter using Color Doppler Ultrasonography images is a potential methodology in diagnosis, physiological study and is more relevant to the free-vascular tissue transfer surgery. In this study, standard methods of blood vessel diameter of different blood vessels measurement which are relevant to the free tissue reconstructive surgery of face and allied area were adopted. A total of 20 numbers of subjects were selected from the staff members of KPC medical college and Hospital and data of different blood vessels diameter were collected from individual papers published in different journals for comparative study. Finally we develop a chart of mean diameter of different blood vessels, which will be a good reference of the reconstructive surgeon and the industry for the development of microvascular anastomotic devices.

KEY WORDS : Anastomotic device, blood vessel, reconstructive surgery, ultrasound, Color Doppler

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INTRODUCTION

When diameter of any blood vessel is required, referring to textbooks and literature usually reveals different values [1-3]. There could be several reasons to explain this in-consistency, such as age and sex of the subjects, external and internal factors influencing arterial diameter, viability of the subject (cadaver or living person), and finally measurement methods, which could be invasive or non invasive [4,5]. Radiology & Imageology plays the most important role in defining vessel diameter almost in all sections [6]. The use of Colour Doppler Ultrasonography in the assessment of vascular details is a well established fact in the present day modern diagnostic era [6]. Of all parameters, which can be available with colour doppler ultrasonography, assessment of vessels diameter is the most challenging job, when microvascular reconstructive surgery is considered, particularly in Head and Neck region [7]. Multivessel diameter study with colour Doppler ultrasonography is not widely available in literature. But for microvascular reconstructive surgery, for assessing vessels diameter, this modality is of immense value [8,9]. It is easy to perform, less time consuming, less costly with least maneuvers, no side-effect as no radiation is used and provide maximum information. Especially when comparative study is done in western VS Indian population, it provides ready references for reconstructive surgeons and the manufacturer of microvascular anastomotic devices. This study was undertaken in the department of Radio-Diagnosis, KPC Medical College & Hospital, Jadavpur, Kolkata India. The use of Color Doppler Ultrasound in the assessment of vessels diameter is well established and is required for the micro vascular reconstructive surgery. In the literature single vessel diameter studies are available, but no comprehensive data are available for the common vessels which are required to the micro vascular anastomosis purposes and are more relevant for the purposes of vascular anstomotic device design and making. At this same time there is no study for the Indian population, is available. We want to asses the different vessels diameter in a comprehensive manner and want to provide the ready references for the reconstructive surgeons and the manufacturer of micro vascular anastomotic devices in future.

MATERIALS AND METHODS

MEASUREMENT OF VESSELS DIAMETER: Anatomical landmark of blood vessels are important parameters for the measurement of diameters of vessels. A list of such land marks are given below:

1. Common carotid artery – At the level of thyroid gland.
2. External carotid artery & internal carotid artery – At the level of bifurcation of CCA.
3. Facial artery – Near the angle of mandible.
4. Radial & Ulnar artery - At the level of wrist.
5. Brachial artery – At the level of Elbow.
6. Axillary artery – At the level of Axillary Region.
7. Common Femoral artery – At the level of just below the inguinal region.
8. Superficial Femoral artery – At the level of mid thigh.
9. Popliteal artery – At the level of popliteal fossa.
10. Anterior Tibial artery – Above the ankle along the anterolateral aspect of leg.
11. Posterior Tibial artery – Just behind the medial malliolus.
12. Dorsalis Pedis artery – At the level of Ankle.
13. Internal Jugular Vain – At the level of thyroid gland.
14. Axillary Vein - At the level of Axillary Region.
15. Brachial Vein - At the level of Elbow.
16. Superficial Femoral Vein - At the level of mid thigh.

17. Popliteal Vein - At the level of popliteal fossa.
18. Common Femoral Vein - At the level of just below the inguinal region

A total 20 healthy, nonsmoker, nondiabetic (controlled), without any vascular disease (atherosclerosis), nonobese subject of different age group male and female were selected from the KPC medical college and Hospital employees, who volunteered for this study. These groups were selected because of their availability at the time of experimentation.

Figure 1
Colour Doppler Imaging (CDI) machine. Patient's external carotid artery measurement in the department

Specification of the machine:
In brief, the instrument used was an ultrasound Doppler (model VIVID S5) Ge company, equipped with an annular phased array transducer (APAT, Vingmed Sound) probe (11.5-mm diameter) operating at an imaging frequency of 7.5 MHz. The principal components of the ultrasound instrument are depicted in the following schematic drawing Fig- 2.

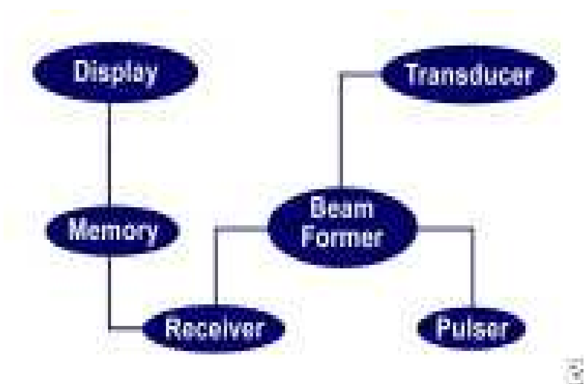

Figure 2
Components of a duplex machine.

Pulser:
The pulser generates short electrical pulses, which are converted to ultrasonic waves in the transducer. To image deeper structures, the PRF (Pulser Receiver Former) is set lower to allow the transducer more "listening" time. Axial resolution is equal to half of the SPL.

Beam former

The beam former controls the shape and direction of beam, known as focusing and steering. The beam former can be mechanical or electronic. Mechanical beam formers operate via an oscillatory mechanism. Electronic beam formers may be linear-switched arrays or linear-phased arrays. Focusing the beam narrows the pulse, which improves lateral resolution. Lateral resolution is equal to pulse width.

Transducer

The transducer contains, piezoelectric crystal (converts electric energy to ultrasonic waves) the damping element and the matching layer. The damping element is behind the crystal. It acts to reduce the pulse length and to improve lateral resolution. The matching layer is in front of the crystal. It reduces reflection of ultrasound at the transducer surface, improving ultrasonic transmission. Gel is applied on to patient's body surface to improve ultrasonic transmission. Even a very thin layer of air on the surface can reflect virtually the ultrasound, affecting the proper image formation.

Receiver

The receiver amplifies (ie, magnify small signals), compensates (i.e, equalizes signals that are at different distances from the transducer), compresses (i.e, reduces the brightness scale to that it is visible to the eye), demodulates (i.e, changes bidirectional signals and smoothens), and rejects (i.e, gets rid of ambient noise).

Memory

Memory often is coded in binary.

Display

The display comprises a series of lines representing adjacent scan lines. The varieties of scanning formats are unlimited. The most commonly used methods are linear (ie, rectangular) and sector (ie, pie shaped). Deeper scanning theoretically requires that fewer scan lines be made available in order to maintain a real-time display. Alternatively, the number of scan lines can be preserved at the cost of a slower real-time display.

Procedure

During Doppler ultrasonography, a handheld instrument (transducer) is pressed lightly over the skin on a superficial blood vessel. The transducer sends and receives ultrasound waves that are amplified through a microphone. The waves bounce off solid objects, including blood cells. The movement of blood cells causes a change in pitch of the reflected sound waves (called the Doppler Effect). If there is no blood flow, the pitch does not change. Information from the reflected sound waves can be processed by a computer to provide graphs or pictures that represent the flow of blood through the blood vessels. These graphs or pictures can be saved by the computer for future review or evaluation. CDI was performed with a Sonoline Elegra Advanced System (Ge Company,Germany) using a phased array transducer type 7.5L40. (Ge Company,Germany), as described previously. Ultrasound frequency was 7.5 MHz in the pulsed Doppler mode. The transducer was carefully set on the skin without exerting pressure on the bulb. Acoustic coupling between transducer and skin was optimized by a carbomeric gel (Vidisic®, Dr Mann Pharma, Germany). After identification of the artery as per the mentioned landmark, the required vessels were identified in the color Doppler mode. Flow velocity in the artery was measured along its course. Pulsed Doppler mode was used to measure flow velocities. A real time image was recorded.

The diameters of different artery and vein were measured from longitudinal two-dimensional images stored in the ultrasound Doppler image buffer and on optical disks. The diameters were determined along the central axis of the ultrasound beam, where the best spatial resolution is achieved. The two dimensional images of various artery were stored and the outer and inner diameters were measured from the image with the help of a digital caliper. The entire artery which is to be measured was enlisted and measured in a fixed reference point (anatomical landmark) for different subjects and different vessels. An ultrasound examination may be performed in many ways. Recommended techniques include the following: Enter the patient's name and examiner's name into the computer, take a focused history, measure bilateral brachial artery blood pressure, ask the patient to lie supine, and choose a conventional starting site (right or left - mostly use right). Have the patient's head turned contra lateral to the side being tested, place a towel on clothing for protection, apply gel liberally to the transducer or neck, and start the scan transversely from the proximal common carotid artery (CCA) moving distally and continue the process for all the artery. Switch to the sagittal view; by convention, and images at the top of the screen are closest to the transducer; color may be used at this point to identify flow within the artery and potential areas of high velocity. The on-screen probe is placed in the artery parallel to vessel walls; make sure to correct for excessive angles. The "gate" is the width of the listening window; the larger the gate, the more likely that signal will be detected. However, the trade-off is increased noise. Perform spectral analysis and find the highest velocity or frequency.

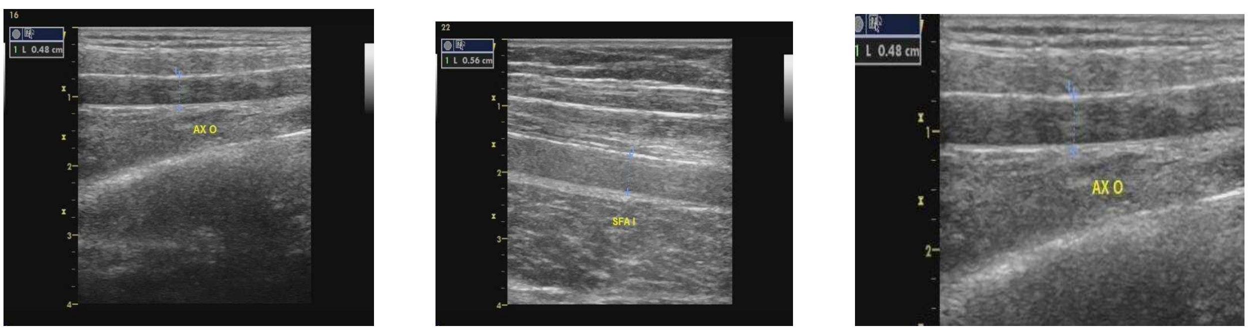

Figure 3
The diameters of axial & superficial femoral artery were measured from longitudinal two-dimensional images, as depicted in the screen.

The procedure is followed for all the vessels which are to be measured; at least 2 to 3 spectral analyses of each vessel should be obtained. Color imaging and power Doppler may be used but may not necessarily provide additional information. Velocity measurements may also be obtained.

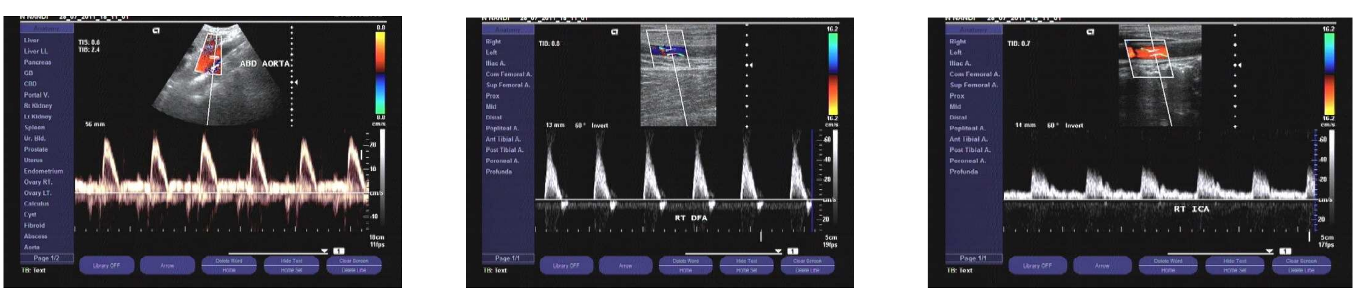

Figure 4
Measurement of the diameter of various arteries in the changes of blood flow velocities.

Measurement of the diameter of various arteries in the changes of blood flow velocities over the course of a cardiac cycle were recorded continuously. Peak systolic velocity and end diastolic velocity (EDV) can be determined directly, and time average mean velocity (TAMn), pulsatility index and resistive index are calculated automatically by the CDI software. In addition to the basic CDI protocol, for vCDI measurements the diameter (d) of the artery was assessed in the colour Doppler mode (C-mode) at the same position where shortly before the velocity had been measured. Calculation of blood flow (volume per time; dV/dt) was performed by the formula $dV/dt = TAMn \times (0.5 \times d)\ 2 \times \pi$. Dimension of dV/dt was adjusted to µl/min.

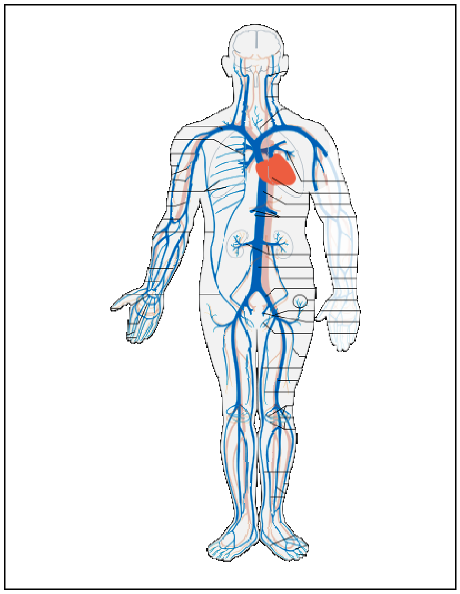

Figure 5
Humanvascularsystem

RESULTS AND DISCUSSION

The data obtained from different subject is presented in tabular form and mean diameter were determined for each vessel of all subjects.

Table-1
Vessels diameter in Head &Neck Region for Indian population

Subject →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Mean
CCA	7.5	8.3	6.1	6.3	7.1	6.7	6.7	6.5	6.7	6.3	7.2	6.6	7.1	8.4	7.5	8.4	6.8	6.3	6.5	7.5	7.03
ECA	9.5	5.2	7.0	5.2	5.7	6.4	5.7	4.4	5.0	5.7	5.2	5.6	5.4	5.2	4.5	4.6	5.3	5.8	5.3	4.9	5.58
ICA	4.9	5.4	5.2	5.3	4.4	5.6	5.6	5.4	5.6	5.4	5.8	5.5	5.9	7.6	6.2	7.5	5.6	5.4	5.6	5.8	5.69
FACIAL A	2.8	2.5	2.3	1.9	2.3	2.1	2.8	2.0	3.1	2.3	3.5	2.5	2.6	3.1	4.0	2.9	2.8	2.7	3.0	3.2	2.72
RADIAL A	3.5	3.3	3.5	2.7	3.6	3.1	3.2	2.3	2.1	2.9	2.3	2.8	2.3	3.3	2.4	2.9	2.9	2.5	2.6	2.6	2.84
ULNAR A	3.1	3.5	2.9	3.9	3.8	3.5	3.1	2.9	2.6	2.7	2.7	2.7	2.8	3.5	2.7	2.7	2.6	2.8	2.9	2.7	3.01
BRACHIAL A	5.2	5.4	5.4	4.3	5.0	5.3	5.4	5.0	4.7	4.7	4.9	4.8	4.7	5.6	4.9	4.2	4.7	4.8	5.1	5.2	4.97
AXILLARY A	4.9	6.7	5.2	5.2	5.9	5.8	4.8	5.2	4.6	4.9	4.8	5.0	5.2	5.1	4.9	3.7	5.2	5.2	5.3	5.0	5.13
CFA	8.0	7.0	8.4	8.3	8.6	8.9	8.3	7.1	7.8	7.7	7.1	7.0	7.2	7.3	8.0	9.4	7.2	7.2	7.0	7.8	7.77
SFA	6.5	8.6	6.7	6.3	7.4	6.5	6.0	7.0	6.3	6.1	6.4	6.4	6.3	6.2	6.5	5.8	6.2	6.5	6.2	6.0	6.50
POPLITEAL A	6.8	8.3	6.3	6.3	7.2	7.0	6.6	5.6	6.9	7.0	6.9	6.8	6.7	6.9	6.9	6.5	6.7	6.7	6.8	6.7	6.78
ATA	4.1	4.2	3.6	3.6	3.6	3.3	3.2	2.9	3.1	3.0	3.3	3.2	3.1	3.2	3.5	3.5	3.0	3.1	3.2	3.3	3.35
PTA	4.2	2.7	2.6	2.7	3.7	2.1	2.6	2.1	2.6	2.6	2.7	2.8	2.9	2.7	2.7	2.1	3.1	2.7	2.9	3.8	2.82
DPA	2.8	2.7	3.6	2.7	3.1	2.7	3.2	2.5	2.8	2.7	2.7	2.6	2.6	3.0	2.7	2.7	2.5	2.8	2.7	2.6	2.79
IJV	9.2	8.8	9.4	8.1	6.9	9.5	9.2	7.7	10.1	10.0	11.0	10.0	9.8	9.3	10.5	9.5	10.4	10.4	9.8	9.2	9.44
AXILLARY V	6.2	6.5	5.1	5.0	5.2	4.2	6.3	2.5	5.4	5.3	7.1	7.0	7.2	6.3	7.2	5.8	7.2	7.2	7.4	6.1	6.01
CFV	7.2	4.0	3.1	3.3	3.1	2.9	6.4	5.6	5.0	5.8	8.2	8.0	8.2	6.4	7.0	7.4	7.8	7.8	7.6	8.0	6.14
BRACHIAL V	4.2	7.9	6.3	6.3	9.6	5.2	4.1	6.0	5.9	5.3	2.9	2.9	3.2	5.4	2.7	4.9	2.8	3.4	3.9	4.2	4.86
POPLITEAL V	7.2	8.9	7.5	5.4	6.5	10	9.0	7.2	6.8	6.7	6.4	6.5	6.4	7.0	6.3	9.0	6.8	6.8	7.0	6.8	7.21

All the data of vessel diameters of western population were collected from literatures and a comparative chart is prepared to compare the difference of vessel diameter.

Table 2
Comparative data of different vessels diameter in Head &Neck Region – Western Vs Indian population

Name of the Vessels	Western population		Indian population	
	Range (mm)	Mean diameter (mm)	Range (mm)	Mean diameter (mm)
Common Carotid Artery	6.1 - 8.0	7.2	6.1 - 8.4	7.03
External Carotids Artery	5.11- 8.7	6.2	4.4 - 9.5	5.58
Internal Carotid Artery	4.66 - 7.8	5.5	4.4 - 7.6	5.69
Facial Artery	1.7 - 3.6	2.6	1.9 - 3.5	2.72
Radial Artery	2.58 - 3.8	3.0	2.1 - 3.6	2.84
Ulnar Artery	1.5 - 3.3	2.4	2.6 - 3.9	3.01
Brachial Artery	4.03 - 6.11	4.3	4.2 - 5.6	4.97
Axillary Artery	4.56 - 6.13	5.2	3.7 - 5.9	5.13
Common Femoral Artery	8.2 -12.7	10.6	7.0 - 9.4	7.77
Superficial Femoral Artery	5.9 - 8.2	6.7	5.8 - 8.6	6.50
Popliteal Artery	6.5 - 8.2	7.21	5.6 - 8.3	6.78
Anterior Tibial Artery	3.1- 4.8	3.95	2.9 - 4.2	3.35
Posterior Tibial Artery	2.7- 4.9	3.2	2.1 - 4.2	2.82
Dorsalis Pedis Artery	1.83 - 2.96	2.08	2.5 - 3.6	2.79
Internal jugular Vein	5.9 - 6.9	6.2	6.9 - 11.0	9.44
Axillary Vein	5.4 - 7.8	6.8	2.5 - 7.4	6.01
Brachial Vein	6.05 - 7.1	6.84	2.7 - 9.6	6.14
Popliteal Vein	5.8 - 8.1	6.2	5.4 - 9.0	5.86
Common Femoral Vein	7.3 - 9.6	8.2	6.9 - 8.2	7.21

STATISTICAL ANALYSIS

From the above charts a bar diagram is prepared depicting the mean diameter of Western and Indian subjects. According to the chart maximum vessel diameter of western population is a bit (0.5-1 mm) higher than Indian population. In case of common femoral artery the diameter is more than 2 mm greater for western population, but in case of internal jugular vein the diameter is 3 mm less for western population.

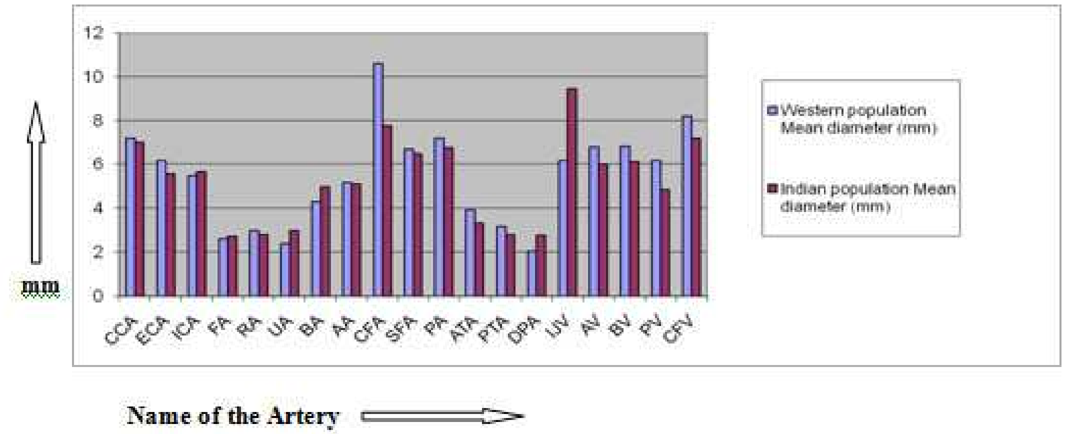

Figure 6
Comparative bar diagram of vessels diameter between Western & Indian population

CONCLUSION

The measurement of blood vessels diameter in twenty different healthy Indian subjects using ultrasonography were performed and compared with the Western data. From the data it was clear that the range and mean diameter for each vessel were quite similar for Indian and Western population. From the table and graph it was observed that the paired vessels (artery and vein) vary significantly in both populations. So a wide range of devices will be more appropriate for different ethnic group.

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