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A clinical cross-sectional study on the importance of carotid intima-medial thickness as a surrogate marker of atherosclerosis in hypertensive individuals: An imaging algorithm

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Abstract

Introduction: The carotid artery tends itself to study by high-resolution ultrasound devices because it is superficial in location, are relatively stationary and runs parallel to the surface of the neck, at least to the level of the carotid bifurcation. Employing B-mode ultrasound, the 'double echo' pattern represents the combined width of the carotid artery intima and media, can be readily and reproducibly visualized in nearly all subjects.

Color Doppler sonography became a mainstay in evaluation of the extra-cranial territory and its accuracy in comparison with angiography is well established. Carotid sonography has largely replaced angiography for suspected extra-cranial Carotid atherosclerosis.

Objectives of the study:

1. To assess Carotid Intima media thickness [IMT], Resistive index [RI], plaques & stenotic changes in hypertensive patients using High frequency B-scale ultrasound and Color Doppler.
2. To compare the findings in hypertensive subjects with normotensive subjects.

Methodology:

Type of study: Clinical Cross Sectional and Correlational Study.

Source of data: Data for our study was collected from the patients referred to Department of Radio diagnosis and modern imaging with clinically diagnosed essential hypertension. They were evaluated with B-scale and color doppler. The normotensive subjects were patient's relatives, hospital and clinical staff.

Study period: The study was performed for the period of two years from Sep. 2018 to aug.2020 excluding the period of data analysis and write-up.

Method of collection of data: A structured, pre-prepared case proforma (CP) was used to enter the clinical history, physical examination findings, and investigations-hematological, urinary and duplex sonography findings. Total number of subjects selected for the study was 100. We selected 50 hypertensive patients aged between 40-55 years and 50 normotensive subjects of same age group.

Results and Conclusion: Hypertension is a well-known major risk factor for atherosclerosis. Early atherosclerotic changes represent increase in intima media thickness (IMT) & resistive index (RI). Intima media thickness is considered a morphological parameter and resistive index [RI] as a hemodynamic parameter. These parameters can be assessed easily, accurately, noninvasively and in a cost-effective way by high frequency ultrasound and Doppler study. Study we performed revealed that intima media thickness [IMT] and resistive index [RI] of common carotid artery as assessed by high frequency ultrasound and Doppler study respectively, are significantly increased in all hypertensive patients compared with normotensives. This can help us to predict future cardiovascular and cerebrovascular pathologies.

Keywords: Imaging, ultrasound, atherosclerosis, vascular, carotid, hypertension

Introduction

The human carotid arteries, located on each side of the neck, have the key role of carrying blood to the head. They divide into an external branch supplying the neck, face and other external parts and an internal branch, supplying the brain, eye and other internal parts.

The carotid artery tends itself to study by high-resolution ultrasound devices because it is superficial in location, are relatively stationary and runs parallel to the surface of the neck, at least to the level of the carotid bifurcation.

Employing B-mode ultrasound, the 'double echo' pattern represents the combined width of the carotid artery intima and media, can be readily and reproducibly visualized in nearly all subjects.

Colour Doppler sonography became a mainstay in evaluation of the extra-cranial territory and its accuracy in comparison with angiography is well established. Carotid sonography has largely replaced angiography for suspected extra-cranial Carotid atherosclerosis.

The principal appealing points in favour of sonography are patient comfort, lack of risk and accuracy. In contrast the angiography is invasive and expensive. Moreover, contrast related adverse effects can also be avoided.

There are multiple risk factors that are associated with Stroke. They can be classified as modifiable and non-modifiable risk factors. The non-modifiable risk factors are age, sex, family history, race and ethnicity and the modifiable risk factors include hypertension, cardiac disease, diabetes mellitus, physical inactivity, hyperlipidemia, cigarette smoking, alcohol abuse, carotid stenosis, and transient ischemic attack.

Elevated blood pressure is an independent and important cause of serious cardiovascular diseases and premature mortality from such diseases ^[1]. Hypertension plays an important and critical role in atherosclerotic cardiovascular disease, but its effect is greatly increased by coexistent contributors, particularly abnormalities in blood lipid and glucose metabolism. Sequelae of atherosclerotic cardiovascular events including stroke, coronary disease and peripheral arterial disease, are two-three folds more common in hypertensives compared to normotensives of the same age. The incidence of every clinical manifestation of cerebrovascular and coronary heart disease is increased in hypertensive patients, and the risk is proportional to the severity of the antecedent hypertension ^[2].

Increased Intima-media thickness [IMT] of an artery has been used as a surrogate marker of the early atherosclerotic process ^[3]. The development of noninvasive techniques such as high-resolution ultrasound imaging allows the measurement of combined Intima and media thickness [IMT] ^[4]. Areas which are open to investigate with high resolution ultrasound technique are mainly carotid and femoral arteries. Many studies have shown that the atherosclerotic process start to develop in the carotids approximately at the same time as in aorta, actually preceding plaque occurrence in coronary arteries. It has also been shown that there is significant correlation between Carotid atherosclerosis and extent of coronary artery atherosclerosis suggesting that thickening of Intima media complex reflects the local morphological alterations in the carotid arteries as well as corresponds to generalized atherosclerosis ^[5].

The same applies to carotid artery distensibility, which diminishes with increasing severity of atherosclerosis. However, assessment of an arterial distensibility requires relatively arduous procedure and is subject to inter-observer and intra-observer variability. In contrast, the Resistive index [RI] according to Pourcelot is a hemodynamic parameter that is easily determined by Doppler sonography basically reflecting the vascular resistance, which in turn depends on distensibility of the vessel. So, Intima media thickness [IMT] and Resistive index [RI] are complementary to each other in assessing the atherosclerosis of vascular system ^[6].

To prevent death and morbidity from cerebrovascular disease, there is great interest in identifying asymptomatic patients at high risk who would be candidates for more intensive, evidence-based medical interventions that reduce cerebrovascular disease risk. Imaging of arteries to identify and quantify the presence of subclinical vascular disease has been suggested to further refine cerebrovascular disease risk assessment. As a screening test, imaging must be safe, sensitive, affordable and lead to interventions that can favorably alter the natural history of cerebrovascular disease. Measurement of carotid intima-media thickness (CIMT) with B-mode ultrasound is a non-invasive, sensitive and reproducible technique for identifying and quantifying atherosclerotic burden and CVD risk. It is a well-validated research tool that has been translated increasingly into clinical practice for predicting future risks.

Materials and Methods

Type of study

Clinical Cross Sectional and Correlational Study.

Source of data

Data for our study was collected from the patients referred to Department of Radio diagnosis and modern imaging with clinically diagnosed essential hypertension. They were evaluated with B-scale and color doppler. The normotensive subjects were patient's relatives, hospital and clinical staff.

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Method of collection of data

A structured, pre-prepared case proforma (CP) was used to enter the clinical history, physical examination findings, and investigations-hematological, urinary and duplex sonography findings.

Total number of subjects selected for the study was 100. We selected 50 hypertensive patients aged between 40-55 years and 50 normotensive subjects of same age group.

Inclusion criteria

Hypertensive group-All male and female patients suffering from primary hypertension without any symptoms and within the age group between 40-55.

Normotensive group-All male and female subjects without hypertension and within the age group between 40-55.

Exclusion criteria

All patients presenting with hypertension before 40 years of age and after 55 years of age. All hypertensive patients and normotensive subjects with history of secondary hypertension, diabetes mellitus, smoking, alcoholism and postmenopausal women.

Imaging Equipment: In the study we used Aloka alfa-6 ultrasound machine with 7.5-10MHZ linear array transducer.

Results

Our study was a clinical cross sectional and correlational study done on hypertensive and normotensive subjects to know the effect of hypertension on intima media thickness

[IMT] and resistive index [RI] of carotid arteries which can be effectively done using high frequency ultrasound and Color Doppler sonography. High frequency ultrasound transducers have made the better visualization of the various layers of arteries [intima, media and adventitia] particularly of superficial arteries like carotid arteries with good resolution. With this, the accurate measurement of Intima media thickness is possible. Advances in color Doppler like pulsed Doppler study has made possible to study the various hemodynamic parameters like various velocities and spectral indices like Resistive index and Pulsatility index. So, B mode, real time, gray scale high frequency ultrasound gives anatomical or morphological information of the vessel wall and the pulsed Doppler gives the physiological information within the vessel.

Clinical background and significance of the study

The strongest risk factor for atherosclerotic diseases is hypertension. The risk of cardiovascular diseases increases with isolated systolic hypertension and isolated borderline hypertension and these conditions are also associated with higher risk of subclinical atherosclerotic disease.³⁶ Hypertension predisposes to atherosclerosis by mechanisms which may include endothelial dysfunction, hyperinsulinemia, hemodynamic stress, and multiple metabolic alterations. The hypertensive patients with preceding overt atherosclerotic disease have impaired production of endothelium-derived relaxin factors and there is also seen increased activity of endothelium-derived contractile substances.

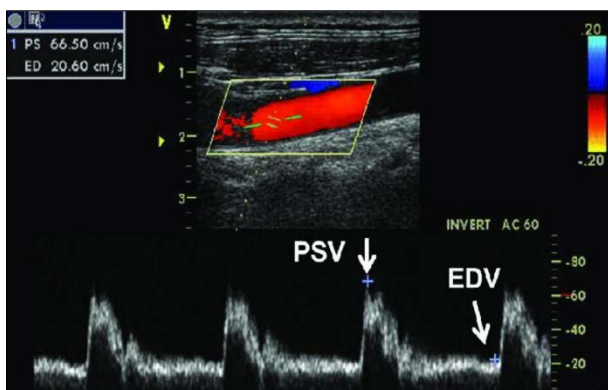


Fig 1: Showing: normal intima media thickness (imt) and resistive index (ri) in a normotensive subject



Fig 2: Showing raised intima media thickness of right cca in a hypertensive subject

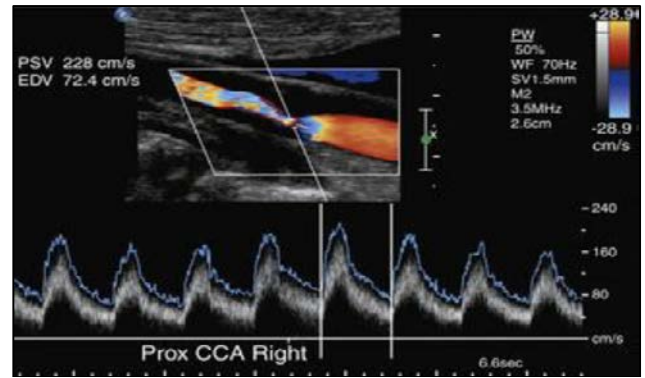


Fig 3: Showing: raised psv and edv in a hypertensive subject

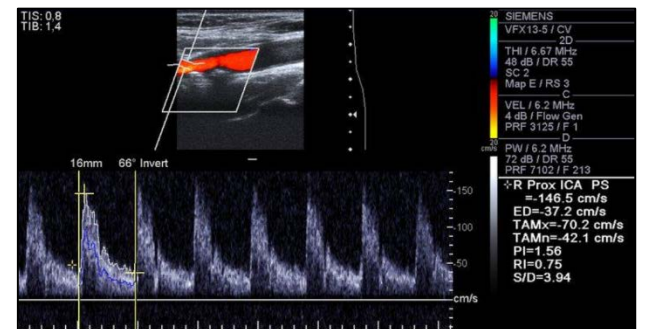


Fig 4: Showing raised psv and edv of cca in a hypertensive subject

Vascular system of human body is prone for atherosclerosis by various risk factors among which hypertension is an important and independent risk factor. It is one of the major killers throughout the world and Asians are more prone for atherosclerosis compared to western world. So, it is very essential to implement a comprehensive method for identification of initial atherosclerotic events in high-risk patients and also in general public so that more vigorous preventive measures can be taken. Various non-invasive markers of early arterial wall alteration are currently available. Of them, Intima-media thickness (IMT) and Resistive index (RI) of large artery walls, especially carotid are the important parameters that can be assessed by Duplex sonography in a relatively simple way and represents a safe, inexpensive, precise and reproducible measure. Intima-media thickness [IMT] as morphological value and Resistive index [RI] as a hemodynamic value reflects the atherosclerotic process in an indirect manner and these can be assessed as a surrogate marker of generalized atherosclerosis.

In our study these parameters were assessed in Common carotid arteries of hypertensives and normotensives, and the results were compared. Results showed statistically significant increase in Intima media thickness [IMT] and Resistive index [RI] values in hypertensives compared to normotensives as concluded by other previous Indian and foreign studies.

Conclusion

Hypertension is a well-known major risk factor for atherosclerosis. Early atherosclerotic changes represent increase in intima media thickness (IMT) & resistive index (RI). Intima media thickness is considered a morphological parameter and resistive index [RI] as a hemodynamic parameter. These parameters can be assessed easily, accurately, noninvasively and in an cost effective way by high frequency ultrasound and Doppler study. Study we

performed revealed that intima media thickness [IMT] and resistive index [RI] of common carotid artery as assessed by high frequency ultrasound and Doppler study respectively, are significantly increased in all hypertensive patients compared with normotensives. This can help us to predict future cardiovascular and cerebrovascular pathologies.

Ultrasonography is a easy, safe, quick, accurate, noninvasive and non-expensive method of investigation of vessel wall changes in atherosclerosis. High resolution sonography using high frequency transducers gives superb resolution of vessel wall layers so that all layers of the vessel wall namely, intima, media and adventitia can be clearly visualized. Increase in thickness of Intima media complex is said to be the earliest morphological changes that occurs in the vessel wall in atherosclerosis. These changes can be clearly visualized with high resolution sonography and Intima media thickness [IMT] can be accurately measured. Alteration in the vessel wall also causes alteration in hemodynamic of vascular system. Color Doppler gives accurate hemodynamic information within the blood vessels. Resistive index [RI] is the widely studied hemodynamic parameter that shows alteration in its value along with Intima media thickness [IMT] as the atherosclerosis progresses.

So, IMT gives morphological information and RI gives hemodynamic information in atherosclerosis of the blood vessels. Moreover when both parameters are studied together they are less prone for inter-observer and intra-observer variability and will be more accurate.

These parameters can be better studied in superficial arteries like carotid or femoral artery. We measured both Intima media thickness [IMT] and Resistive index [RI] of Common carotid artery in hypertensive and normotensive subjects. Our study showed that High frequency ultrasound and Color Doppler can be effectively used to study intima media thickness [IMT] and resistive index [RI] of common carotid artery and these parameters are significantly increased in hypertensive patients compared to normotensives. Our study results closely correlate with the results of previous studies. Hence carotid assessment by above mentioned parameters can serve as a screening tool to predict outcome of future cardiovascular and cerebrovascular accidents.

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