Original Article

DOI: 10.7860/IJARS/2018/35156:2374

Radiology Section

Cross-sectional Study of Abnormal Intima Medial Thickness of Common Carotid Artery in Acute Cerebral Infarct Patients

VISHWANATH T THIMMAIAH

ABSTRACT

Introduction: Intima Media Thickness (IMT) is abnormal in most cases of acute cerebral infarct and is routinely measured in clinical practice by Brightness (B)-Mode ultrasound. IMT represents structural change that occurs in common carotid artery in acute cerebral infarct much before the clinical symptom.

Aim: IMT is a valid independent indicator for risk assessment of acute cerebral infarct. Present study is aimed to know the association of IMT with acute cerebral infarct.

Materials and Methods: Total of 210 cases of acute cerebral infarct were included in the present study over a period of one year. IMT was measured in common carotid artery on the side of acute cerebral infarct by B-mode ultrasound. Cramer's V value ranging from 0.0 to 1.0 and p-value < 0.05 were considered statistically significant.

Results: Abnormal IMT was seen in 145 cases (69%) with 118 males and 27 females. Maximum cases (28.8%) were in the age groups of 51 to 60 years with right side infarct in 154 (73.3%) and left sided in 56 (26.7%) cases. Cramer's V value ranged from 0.019 to 0.032 in various age groups indicating good association and significant p-value of <0.001 was obtained.

Conclusion: Common carotid IMT is easy to measure by B-mode ultrasound, with IMT representing structural vessel wall property. B-mode derived measurements of Intima medial thickness is valid and associated well with acute cerebral infarct.

Keywords: B-mode, Indicator, Ultrasound

INTRODUCTION

Distensibility of artery is a reflection of mechanical stress affecting the arterial wall during each cardiac cycle. Decreased arterial distensibility or increased arterial wall stiffness is a common pathological mechanism for many factors associated with cerebro vascular and cardiovascular diseases [1]. Structural and functional changes of vessel wall do occur with aging resulting in reduced carotid distensibility and increased stiffness as the age progresses. Local distensibility of a vessel is important for protecting the arterial wall from damage that occurs during each cardiac cycle, particularly for common carotids that are more susceptible to vascular damage. Common carotid IMT is a strong predictor of future vascular events and acts as a surrogate marker for cerebrovascular disease. Although, carotid IMT assesses the structural properties of the carotid artery, it does not assess the functional properties of the vessel. DC represents the functional property of the vessel and changes in arterial distensibility occur much earlier than clinical symptoms or IMT changes alone. IMT and DC represent different vessel wall properties and acts as intermediate risk factors for many vascular changes that occur in acute cerebra infarct [2]. Increased IMT and reduced carotid DC can be used as an indicators for the risk of acute cerebral infarct when combine together than considered independently [3].

IMT and DC are independent risk factors for acute cerebral infarct. IMT and DC measurements can be measured clinically and the present study is undertaken to find the association of IMT and DC with acute cerebral infarct.

MATERIALS AND METHODS

This cross-sectional study was undertaken in the Department of Radiology, JSS Medical College Mysuru, India, over a period of one year from April 2012-April 2013. Total 210 cases diagnosed with acute cerebral infarct by Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) were included in the study. Pediatrics with acute cerebral infarct, acute or chronic thrombus involving carotid artery, neoplastic lesion involving carotid body, acute cerebral venous thrombosis and acute intracerebral hematomas were excluded from the study. The Study was approved by institutional ethical committee and required patient consent was obtained.

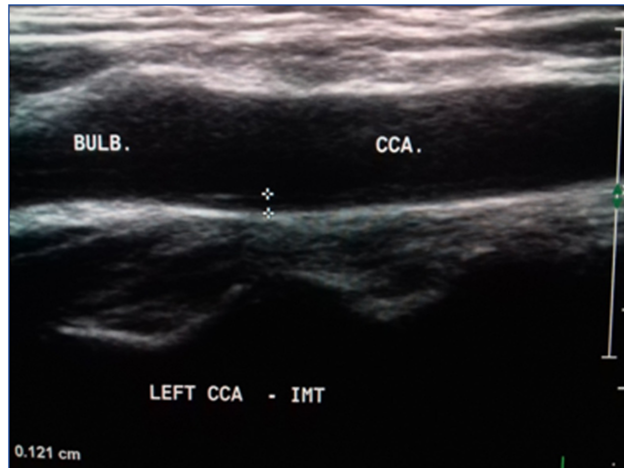
Data Collection

Patients diagnosed as acute cerebral infarct by cross-sectional imaging were referred for carotid Doppler examination was brachial artery blood pressure was measured non invasively and pulse pressure was calculated as the difference between maximal systolic and diastolic blood pressure. Patient was then placed in supine position with both shoulders over a soft pillow to provide adequate support. Neck was slightly hyper extended to make Doppler examination comfortable. High frequency probe (7-12 MHz) was placed on common carotid artery on the side of acute cerebral infarct with slight compression so as to obtain good longitudinal image of the artery.

[Table/Fig-1]: B-mode image showing IMT measurement in right common carotid artery.

IMT measurement after obtaining a suitable image with adequate magnification, IMT was measured on the far wall of transducer, about 1 cm proximal to the carotid bifurcation [Table/Fig-1]. Two plus shaped calipers were used so that the first caliper is placed on the thick echogenic line in the carotid wall and the other cursor over the thin echogenic line towards the luminal anechoic area. Maximum distance between the two calipers were measured and recorded for each patient.

DC measurement [Table/Fig-2] M-mode ultrasound was used to record the maximal change in the diameter of common carotid artery during systole and diastole phase of each cardiac cycle M-mode cursor was placed 2 cm proximal to common carotid bifurcation at plaque free site to obtain the movement of interfaces that involves serial measurements of the location of a carotid wall echo structurefrom periodic



[Table/Fig-2]: B-mode image showing IMT measurement in left common carotid artery.

pulsing in a single X-axis direction of the transducer. M-mode display the time traces of the depth of reflecting interfaces over a few cardiac cycles. Maximum and minimum differences between the traces of opposite walls are used as estimates of the systolic and diastolic diameters respectively on a single given image. DC was calculated from the formula-

(2xΔd/Dd)/ΔP (10-3/kPa)

Where: Δd is change in systolic and diastolic diameter; ΔP is pulse pressure and Dd is end diastolic diameter. DC of <24x10-3/kPa was taken as the cutoff between normal and abnormal values.

After obtaining the values of IMT and DC all patients were categorised in to four groups.

Group-1: Normal IMT and Normal DC

Group-2: Normal IMT and Abnormal DC

Group-3: Abnormal IMT and Normal DC

Group-4: Abnormal IMT and Abnormal DC.

STATISTICAL ANALYSIS

All the data was entered in Microsoft Excel sheet for analysis. Categorical variables were reported as proportions. Analysis was done using Microsoft Excel 2013 and SPSS 20.0 software. Cramer's V and p-values were calculated for each age group.

RESULTS

Total of 210 cases of acute infarct were included in across sectional study, with 154 (73.3%) cases showed right sided infarct and 56 (26.7%) showed left sided infarct [Table/Fig-3]. Mean age was 56.4 years for males and 54.7 years for females with a total of 174 and 36 cases respectively [Table/Fig-4]. The lowest age was 31 years in both males and females with highest age being 75 years and 78 years for male and female respectively. IMT was abnormal in 145 cases with 118 males and 27 females [Table/Fig-5]. After applying Cramer's V test, the value ranged from 0.19 to 0.32 with a significant p-value of <0.001 [Table/Fig-6]. Hence, abnormal IMT is associated well with acute cerebral infarct.

Acute Cerebral Infarcts			Total
Age (in years)	Right	Left	
31-40	16 (66.7%)	8 (33.3%)	24
41-50	24 (49.0%)	25 (51.0%)	49
51-60	32 (74.4%)	11 (25.6%)	43
61-70	68 (85.0%)	12 (15.0%)	80
71-80	14 (100.0%)	0 (0.0)	14
Total	154 (73.3%)	56 (26.7%)	210

[Table/Fig-3]: Age wise distribution of acute cerebral infarct.

Sex	Acute Cerebral Infarct		Total
	Right	Left	
Male	129 (74.1%)	45 (25.9%)	174
Female	25 (69.4%)	11 (30.6%)	36
Total	154 (73.3%)	56 (26.7%)	210

[Table/Fig-4]: Sex wise distribution of acute cerebral infarct.

IMT	Sex		Total
	Male	Female	
Normal	56 (32.2%)	9 (25.0%)	65 (31.0%)
Abnormal	118 (67.8%)	27 (75.0%)	145 (69.0%)
Total	174 (100.0%)	36 (100.0%)	210 (100.0%)

[Table/Fig-5]: Sex wise distribution of Intima medial thickness in acute cerebral infarct.

Age (in years)	IMT (>0.90 mm) Total (n=145)	Crammer's V value	p-value
31-40	08	0.19	<0.001
41-50	35	0.20	<0.001
51-60	42	0.21	<0.001
61-70	38	0.33	<0.001
71-80	22	0.32	<0.001

[Table/Fig-6]: Abnormal IMT values in various age groups.

DISCUSSION

Atherosclerosis is serious health epidemic with high prevalence in developing countries and forming a chief cause for morbidity and mortality worldwide [4]. Arterial distensibility is defined as the ability of the artery to expand and relax with each cardiac pulsation [5]. It represents local compliance of blood vessel and changes with arterial pressure changes [6]. Many risk factors are known for the development of cerebral infarct, but they do not precisely predict which individuals will develop infarct over a period of time. Increased arterial stiffness is a common pathologic mechanism and forms an intermediate risk factor in the pathway of development of cerebral infarct [7]. Distensibility represents functional property of an artery and its impairment can occur in the early stage of atherosclerotic process, much before the structural wall changes or clinical symptoms [8]. Measurements of arterial stiffness and IMT of common carotid artery helps to identify their individual roles in the pathogenesis of acute cerebral infarct, with early detection leading to the development of more effective preventive strategies. During each cardiac cycle there is mechanical stress on the carotid arterial wall that reduces local compliance and shear stress on the endothelial surface that causes increased carotid IMT [9]. Increased arterial stiffness occurs from damaging effect on the arterial wall over a period of time by many other associated cerebrovascular risk factors and is one of the earliest detectable manifestations [10]. Arterial distensibility depends mainly on the age and blood pressure of an individual [11]. Elastin is the basic component of these elastic fibers, with its gene located on chromosome seven in humans and forms the bulk of tunica media of large and medium sized arteries [12]. Aging causes loss of these elastic fibers in the arterial wall leading to an increase in arterial stiffness.

Distensibility coefficient, compliance coefficient, pressure strain elastic modulus, Young's modulus, and pulse wave velocity are among the several parameters used for arterial stiffness measurement. In most of these parameters, the relationships between distensibility of artery indicated by change in lumen diameters, pulse pressure, and carotid lumen diameter are included [13]. Measurements of these variations in carotid arterial diameters during the cardiac cycle are highly valid in the study of arterial pathophysiology and mechanical properties of the arterial wall [14]. DC is a valid indicator of these functional properties of carotid arteries and can be used as a predictor for initiation or progression of atherosclerosis and arterial hypertension, which forms major risk factors for development of acute cerebral infarct. Decreased DC and Increased IMT are associated with cerebrovascular disease and has higher risk for future development of cerebral infarction [15]. Reduced DC can be considered as an independent risk factor by itself for future development of cerebrovascular disease. Common carotid IMT and distensibility are considered clear markers of cerebrovascular disease in patients who already have risk factors and are also predictors for cerebral infarct. Increased IMT usually does not discriminates between the low and high risk patients alone. Decreased DC being common pathologic mechanism for many factors that lead to the occurrence and progression of vascular changes, occurring much earlier than increased IMT or clinical symptoms, the combination of DC with IMT allows for a better comprehensive analysis of the individual with risk factors and for future prediction of cerebral infarct. DC is a measure of the arterial distensibility with each cardiac pulsation. IMT and DC represent different vessel wall properties with IMT representing mechanical and DC representing functional property of a vessel [16]. The true relation between IMT and DC increasing the risk for the development of risk for stroke is unknown, but several hypothesis have been postulated for their association .Most important is the presence of atherosclerosis leading to both increased IMT and reduced stiffness, Increased stiffness leading to reduced elasticity and increased vessel damage, Both mechanisms applying each other for self perpetuating and reinforcing forces for stroke development or are independent mechanisms.

Arterial distensibility cannot be measured directly, but indirect measurement is possible with B and M-mode ultrasound [17]. Common carotid artery DC measurement along with IMT is reliable and easy to perform clinically with little additional time [18]. Both of these parameters can be easily obtained by B-mode and M-mode ultrasound. Mechanical properties of the common carotid arteries are easily accessed by calculating dynamic measurements using M-mode ultrasound. DC which is the most reliable parameter for stiffness assessment of carotid arteries, is calculated by considering maximum diameter change of lumen diameters during each cardiac cycle and blood pressure changes [19]. Small change in diameter in carotid arteries will have big changes in arterial distensibility and reproducibility of diameters measurement by M-Mode ultrasound [20]. Measurement of both parameters will further improve the characterisation of atherosclerosis in common carotid arteries and forms a more sensitive marker for progression or regression of atherosclerosis than IMT measurement alone. It also helps to select those patients who will require earlier and more aggressive anti atherogenic treatment [21]. Non invasive imaging methods to measure accurately arterial stiffness are available and are easy to perform clinically [22]. Ultrasound techniques are very safe reliable, repeatable and cost effective [23]. M-Mode is available with all ultrasound manufactures and can be repeated many times for averaging the values for age and sex matched ratios. Advantage with M-mode being both systolic and diastolic lumen diameters are displayed in a single image with which DC can be calculated in single sitting. Though, Ultrasound has limitations like observer dependency, two-dimensional image data and incomplete characterisation of atheromatous plaques, it can be used still used as an effective imaging modality for distensibility measurement. CT Carotid Angiogram (CTA) of common carotid can also be used to measure distensibility with added advantage that non circular cross sections can also be measured [24]. The disadvantages of CTA are radiation exposure, availability, repeatability and high cost. MRI with MR Angiogram is another non invasive imaging method available for distensibility measurement with carotid plaque characterisation. Two dimensional dark blood (2D) T2 weighted and three dimensional (3D) T1 CINE imaging protocols are used for distensibility measurement, but has limitations of high cost, availability, and complex technology. M-mode ultrasound measures both systolic and diastolic diameters of a cardiac cycle in one single image that can be captured by placing cursor over the carotid image obtained from B-mode. Similar image by B-mode would require sequential images to be captured and compared with each cardiac cycle, thus making its complex compared to M-mode [25]. By measuring these parameters by M-mode ultrasound, which can be easily performed in day today practice, future predictions of acute cerebral infarct can be done. All cerebral infarct patients referred for carotid evaluation, along with IMT, DC measurement should be implied in routine clinical practice. DC measurements are valid and can be used as an valid independent risk factor for acute cerebral infarct.

LIMITATION

IMT and DC was measured in common carotid artery on the side of acute cerebral infarct. However, similar changes can occur in contralateral common carotid or internal carotid artery which was not measured in our study. To focus and to measure IMT and distensibility of Internal carotid artery is difficult in many cases when compared to common carotid artery.

CONCLUSION

Common carotid IMT and distensibility are independent markers of acute cerebral infarct. Both increased IMT and reduced distensibility are associated with acute cerebralinfarct. IMT represents structural wall property and distensibility represents functional wall property with increased IMT and reduced distensibility as the age progresses. IMT and DC values are valid and both are associated well with acute cerebral infarct.

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AUTHOR(S):
1. Dr. Vishwanath T Thimmaiah

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Radiology, JSS Medical College and Hospital, Mysuru, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Vishwanath T Thimmaiah,
Associate Professor, Department of Radiology,
JSS Hospital, MG Road, Mysuru-570015,
Karnataka, India.
E-mail: vishurad@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Publishing: **Apr 01, 2018**