

DOPPLER ULTRASOUND SCREENING FOR SIGNIFICANT CAROTID ARTERY STENOSIS IN CARDIAC SURGERY PATIENTS, PRESENTING TO HAYATABAD MEDICAL COMPLEX, PESHAWAR, PAKISTAN

¹*Dr. Muhammad Aasim, ²Dr. Haroon Mustafa, ³Dr. Raheela Aziz, ⁴Dr Shahzada Hussain and ⁵Dr Muhammad Salman Khan

¹Incharge/Head Cardiac Surgery Unit, Department of Cardiology Medical Teaching Institute (MTI) Hayatabad Medical Complex (HMC), Phase- IV, Hayatabad Peshawar, Pakistan.

^{2,3,4}Medical Officer and Diagnostic Radiologist, Radiology Department, Medical Teaching Institute (MTI) Hayatabad Medical Complex (HMC), Phase-IV, Hayatabad Peshawar, Pakistan.

⁵Senior Medical Officer and Diagnostic Radiologist, Naseerullah Khan Memorial City Teaching Hospital Kohat Road Peshawar, Pakistan.

*Corresponding Author: Dr. Muhammad Aasim

Incharge/Head Cardiac Surgery Unit, Department of Cardiology Medical Teaching Institute (MTI) Hayatabad Medical Complex (HMC), Phase-IV, Hayatabad Peshawar, Pakistan.

Article Received on 10/05/2020

Article Revised on 01/06/2020

Article Accepted on 22/06/2020

ABSTRACT

Background: This study aimed to determine the frequency of significant carotid artery stenosis by Doppler Ultrasound screening in patients undergoing open heart surgery. **Method:** From January 2019 to April 2019, 125 consecutive patients who were booked for open heart surgery, in Hayatabad Medical Complex Peshawar Pakistan, were included in this study. Adult patients aging more than 18years were studied irrespective of the planned cardiac surgical procedure, while pediatric and adolescent patients below the age of 18years were excluded. Using Mindray® DC 70 Color Doppler Ultrasound Scanner, significant carotid artery stenosis was determined by a Radiologist as stenosis of more than 50 % luminal diameter of the carotid artery under study. **Results:** We studied 250 carotid arteries of 125 patients (87 males and 38 females with age range 19 to 80 years (mean 57.47 years). Significant stenosis was found in 13 patients (10.40 %) with slight male preponderance (7:6). **Conclusion:** Doppler ultrasound study is a good modality, free of radiation hazards for screening carotid arteries in patients undergoing open Heart surgery. Patients with significant carotid artery stenosis on Doppler ultrasound study may be objectively confirmed by subsequent CT carotid angiography. However, further studies are required to assess the efficiency of Doppler ultrasound study in carotid artery stenosis in comparison to CT carotid angiography. Routine Doppler ultrasound screening in adult cardiac surgical patients can identify significant carotid artery stenosis and can help in subsequently reducing the risk of operative stroke in patients undergoing open heart surgery.

KEYWORDS: Carotid artery stenosis, Doppler Ultrasound studies, Cardiac Surgery patients, Peshawar.

BACKGROUND

Stroke is a major public health problem and Carotid Artery Disease is highly associated with a risk of stroke. This risk increases with the severity of the carotid artery stenosis.^[1]

Neurological events represent major complication in patients with significant Carotid Artery Disease undergoing cardiac surgery, and the manifestations may range from transient symptoms to full blown stroke. Previous studies have determined around 2.1-5.2 % stroke incidence in such patients with reported mortality of 0-38 %.^[2]

Patients having Ischemic heart disease who are undergoing surgical bypass usually have significant carotid artery stenosis (CAS). Chen et al. observed CAS (>75% stenosis) in 13% of ischemic heart disease (IHD)

patients before CABG.^[3]

Asymptomatic Carotid Atherosclerosis Study (ACAS) demonstrated the benefit of performing carotid endarterectomy in selected asymptomatic patients with significant carotid artery stenosis (60% stenosis).^[4] It therefore becomes clinically important to identify the subgroups of patients who have a sufficiently high incidence of high-grade CAS to warrant routine carotid ultrasound screening.^[5]

Carotid ultrasonography (CUS) is a proven noninvasive, inexpensive and sensitive diagnostic tool to detect plaque and asymptomatic carotid artery stenosis, and has become the first choice for carotid scanning. It can evaluate carotid structural alterations, as well as the severity of arterial damage by atherosclerotic changes.^[6]

Early detection of CAS with screening CUS can decrease incidence of stroke in patients undergoing open heart surgery.

This study aimed to determine the presence and frequency of significant carotid artery stenosis in patients undergoing Open Heart Surgery.

METHODS

The study aimed to determine the presence and frequency of significant carotid artery stenosis in patients undergoing Open Heart Surgery. We conducted a single institution prospective study from January 2019 to April 2019, in Medical Teaching Institute Hayatabad Medical Complex (MTI-HMC), Peshawar. During this course, we included all adult patients more than 18 years old, who had consulted cardiac surgeon for any type of open heart surgery including CABG, valve replacement, congenital defects, or mixed/complex cardiac diseases. Pediatric and adolescent patients below the age of 18 years were excluded from the study.

The carotid Doppler ultrasound was performed by a Radiologist using Mindray ® DC 70 Color Doppler ultrasound scanner. Patients were put in supine position with the head tilted to the opposite side of the carotid artery being examined. Proper carotid preset was selected on the machine and Scan started with high resolution cross sectional gray scale view of the CCA from its origin to its bifurcation and continued up the ICA and ECA as far as their visible extent in the neck. This was then followed by longitudinal view of the same arteries. The vessels were examined for presence of any anatomical variations, increased IMT, wall calcification, plaque, stenosis or occlusion. Color Doppler technique was employed to assess flow status, luminal filling along with any flow void areas, direction of blood flow and

color aliasing. Spectral Doppler was used to measure peak systolic velocities, end diastolic velocities and ICA/CCA PSV Ratio. Percent stenosis was calculated by measuring the size of plaque and diameter of the remainder patent lumen along with presence of color aliasing at the stenotic site and measurement of peak systolic velocity, End Diastolic velocity and ICA to CCA PSV ratio. (Fig 1). The carotid Doppler scan also included examination of the vertebral arteries.



Figure 1: Plaque present at Right ICA causing 30% Stenosis by diameter.

Data was collected and stored in computer software from where it was retrieved upon completion of the study. A diagnosis of CAS made and its severity graded as per the Society of Radiologists in Ultrasound criteria according to which the patients were classified into the groups as shown in Table 1.^[7] The results were discussed with the referring cardiac surgeon.

Table 1: Classifications of Patients with Carotid Artery Stenosis.

	NORMAL	MILD	MODERATE	SEVERE	Near Occlusion	Total occlusion
Plaque Estimate(%)	No plaque No intimal thickening	Visible <50	Visible ≥50	Visible ≥50 Obvious luminal narrowing	Clearly visible Almost occupying whole lumen.	Clearly visible No detectable patent lumen
Stenosis(%)	No	<50	50-69	>70	>90	100
ICA PSV(cm/s)	<125	<125	125-230	>230	>>230	-----
ICA EDV(cm/s)	<40	<40	40-100	>100	>100	-----
ICA/CCA	<2	<2	2-4	>4	>4	-----

RESULTS

In the three months period, a total of 125 consecutive patients were included in the study, of which 87 were males (69.60 %) while 38 were female (30.40 %). The mean age was 57.47 years with minimum of 19 years and maximum of 80 years.

Significant CAS was found in 13 patients (10.40 %) amongst which 7 were male (53.85%) while 6 were

female (46.15 %). Percentage of males with significant CAS out of all patients was 5.6 % and that of female was 4.8 %. All patients, except one (40 year old having bilateral ICA stenosis of more than 50 %), were above 50 years of age. One of the patients had complete right ICA blockage; one had bilateral complete ICA occlusion, one patient having complete right ICA occlusion and more than 50 % luminal compromise of left ICA by calcified plaque. Similarly one patient was having 65 % stenosis

of his right ICA and complete occlusion of left ICA while one female patient had 82 % stenosis of her right ICA by a calcified plaque. Rest of the seven patients had stenosis of more than 50 % confined to single Internal Carotid Artery.

Insignificant CAS was found in 69 patients (55.20 %) out of which 50 were male (72.46%) while 19 were female (27.54 %). Percentage of male patients with non significant CAS amongst all patients was 40.0 % while that of female was 15.20 %. The findings included increased IMT, carotid arterial wall calcifications, plaque or stenosis less than 50 %, and isolated vertebral artery compromise including subclavian steal phenomenon, VA

thrombosis. Eight patients (6.4%) had isolated increased IMT, 40 patients (32 %) showed arterial wall calcifications or flat plaques, 16 patients (12.8 %) showed plaques causing CA luminal compromise of 35-50 %. VA abnormality was observed in 5 patients (4.0%).

Forty three patients (34.40 %) had normal carotid Doppler ultrasound. Males were 31 (72.09 %) while females were 12 (27.91 %). Percentage of males with negative Doppler scans out of all included patients was 24.80 % while that of females was 9.60 %. The results are summarized in Table 2.

Table 2: Gender Wise Distribution Of Cad According To Severity (N=125).

	Males	Females	Total
	87(69.60%)	38(30.40%)	125(100%)
Normal CUS	31(72.09%)	12(27.91%)	43(34.40%)
Insignificant Abnormality	50 (72.46%)	19(27.54%)	69(55.20%)
➤ Only Increased IMT	5(62.50%)	3(37.5%)	(6.4%)
➤ Wall calcifications, Flat plaques	30(75%)	10(25%)	40(32%)
➤ 35-50% stenosis	11(68.75%)	5(31.25%)	16(12.8%)
➤ Only Vertebral artery abnormalities	4(80%)	1(20%)	5(4.0%)
➤ Significant Disease Unilateral/bilateral>50% stenosis	7(53.85%)	6(46.15%)	13(10.40%)

All the patients were divided into four groups with age range of 19-30 years, 31-40 years, 41-60 years and above 60 years. We had only one patient out of 125 (0.8%) in the first group i.e age range 19-30 years, Five patients (4.0%) were in age range 31-40 years, 77 (61.60%) in age range 41-60 years and 42 (33.60%) were above 60 years of age. Out of 43 (34.40%) patients who had normal carotid Doppler study, only 1 (2.32%) patient was in group 1, 3 (6.97%) in group 2, 33 (76.74%) in group 3 and 6 (13.95%) in group 4. There was no

patient belonging to group 1 out of 69 (55.20%) patients who had insignificant carotid Doppler results, 1 (1.50%) belonged to group 2, 38 (55.07 %) to group 3 and 30 (43.48%) to group 4. Finally, no patient in the group 1 had significant carotid stenosis amongst a total of 13 (10.40%) patients. Only 1 (7.69%) patient was in group 2 while 6 (46.15%) were in group 3 and 6 (46.15%) were in group 4. These results are summarized in Table-3 & Table-4.

Table 3: Age Wise Distribution of Cad According To Severity (N=125).

Age Group S.No	Age Range(years)	Normal study	Insignificant CAD	Significant CAD	TOTAL
1	19-30	1(2.32%)	0(0%)	0(0%)	1(0.8%)
2	31-40	3(6.97%)	1(1.50%)	1(7.69%)	5(4.0%)
3	41-60	33(76.74%)	38(55.07%)	6(46.15%)	77(61.6%)
4	>60	6(13.95%)	30(43.48%)	6(46.15%)	42(33.6%)
	TOTAL	43(34.40%)	69(55.20%)	13(10.40%)	125(100%)

Table 4: Gender Wise Distribution of Patients In The Designed Age Groups (n=125).

Age Group (years)	Gender Of Patients		Total
	Male	Female	
19-30	1(0.8%)	0(0%)	1(0.8%)
31-40	5(4.0%)	1(0.8%)	6(4.8%)
41-60	50(40%)	25(20%)	75(60%)
>60	31(24.8%)	12(9.6%)	43(34.4%)
TOTAL	87(69.60%)	38(30.4%)	125(100%)

DISCUSSION

Atherosclerosis involves large and medium sized arteries such as carotid, coronary, and peripheral arteries, and is one of the leading cause of death.^[8] Cina et al reported that significant carotid stenosis greater than 50% was associated with stroke.^[9] CUS is a valuable and cost effective screening imaging tool to identify significant carotid disease and improve the quality- adjusted life years.^[10]

In a study by da Rosa and Portal, prevalence of CAS

>50% was 17.4% among 393 patients who underwent elective CABG.^[11] Mahmoudi *et al.* included 878 patients in their study before isolated CABG and found that 13% had a carotid stenosis >75%.^[12] Rath *et al.* stated a high prevalence of CAS as 84.5% whereas Cirilo *et al.* reported 61.6% in their study.^[13,14] Shirani *et al.* reported the prevalence of CS >60% as 6.6% and 12.5% in patients who were 65 years and older.^[15] The prevalence of severe ACAS in the general population was reported by Weerd *et al.* to range from 0% to 3.1%, and its prevalence increases with age and with risk factor levels.^[16] Hyuk *et al.* determined 15.2% of severe ICA stenosis in patients with Peripheral Arterial disease by routine screening CUS. These results implicate 15.2% such patients can be protected from stroke by carotid endarterectomy.^[17] Yun *et al.* found that critical ICA stenosis was more common in patients with coronary artery disease.^[18] Kayani *et al.*, conducted a cross sectional study, where 140 patients were evaluated. Insignificant CAS (<50% lesion) was found in 56.6% of patients, while 10.7% of patients had significant carotid stenosis (>50% lesion), and only 8.5% of patients had critical (>70%lesion) carotid stenosis.^[19]

In our study, the prevalence of significant CAS was found to be 10.40 % which is lower than some of the above cited references. The reason for this difference may be that there was no specific selection criteria in our study however in most of the studies mentioned above, specific group of patients were selected and studies for example Da Rosa and Portal^[11] studied prevalence of CAD in patients undergoing elective CABG and all patients undergoing other type of cardiac surgery were excluded. daWeerd *et al.*^[16] studied prevalence of severe ACAS in general population and its relation with the risk factors. While Hyuk *et al.*^[17] studied patients with peripheral arterial disease with which CAD is a common association. Another reason for this difference may be small sample size and results of study on a larger sample size may agree with other studies. We also found that a large proportion of patients i.e 12/13 (92.30%) with significant CAS were above 40 years of age.

Carotid artery stenosis is a major cause of ischemic stroke and consequently high morbidity and mortality especially during cardiac surgery, and the efficacy of carotid endarterectomy in stroke prevention in patients with asymptomatic high-grade ICA stenosis is well established.^[19-23]

Hence it becomes quite reasonable to screen all the adult patients with carotid Doppler ultrasound studies to exclude significant carotid artery disease prior to their cardiac surgical procedure.

Limitations of the study

1. Risk factors were not analyzed in this study.
2. This is a single center study and results consulted with one cardiac surgeon.

CONCLUSION

Pre-operative screening carotid Doppler ultrasound is important and provides valuable information about significant carotid artery disease. So we recommend the use of this readily available technique in routine pre-operative practice as the standard of care in all adult patients undergoing open heart surgery, especially those older than 40 years of age. Doppler ultrasound study is a good modality for screening and it is free of radiation hazards. Patients with significant carotid artery disease on Doppler ultrasound study may be objectively confirmed by subsequent CT carotid angiography. However, further studies are required to assess the efficacy of Doppler ultrasound study in carotid artery disease in comparison to CT carotid angiography.

Routine carotid arteries Doppler ultrasound screening identifies significant carotid artery disease and can help in planning to subsequently reduce the risk of operative stroke in patients undergoing open heart surgery.

List of Abbreviations

Computed Tomography (CT), Common Carotid Artery (CCA), Internal Carotid Artery (ICA), External Carotid Artery (ECA), Carotid Artery Stenosis (CAS), Intima Media Thickness (IMT), CUS (Carotid Ultrasound), Coronary Artery Bypass Grafting (CABG), Medical Teaching Institute (MTI), Hayatabad Medical Complex (HMC).

Declarations

Ethical Approval & Consent to Participate: Doppler Ultrasound study of Carotids is Routine non-invasive harmless investigation in Cardiovascular Patients. All the participants gave informed consent as per the institutional practices & policy.

Consent for Publication: Not Applicable.

Availability of supporting data: The datasets used and/or analyzed during the current study are available from the corresponding author subject to reasonable request.

Funding: No funding is involved in this study. The authors of this study bear Expenses of the study and publication cost from their own income.

Competing interests: The authors have no conflict of interest regarding this study.

Authors' Contributions: Dr. Muhammad Aasim, Dr. Haroon Mustafa and Dr. Raheela Aziz designed the study. Dr. Shahzada Hussain and Dr. Muhammad Salman Khan contributed in data collection and literature search. Dr. Muhammad Aasim and Dr. Haroon Mustafa finalized analysis of the data, writing and editing of the manuscript.

ACKNOWLEDGEMENTS

We are thankful to Dr. Sameer Waheed for his logistic support from USA, in payment of processing fee for publication of this article, as on-line payment system could not be availed easily from Pakistan.

REFERENCES

- Freischlag J, North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *New England Journal of Medicine*, Aug 15, 1991; 325(7): 445-53.
- Durand DJ, Perler BA, Roseborough GS, Grega MA, Borowicz Jr LM, Baumgartner WA, Yuh DD. Mandatory versus selective preoperative carotid screening: a retrospective analysis. *The Annals of thoracic surgery*, Jul., 1, 2004; 78(1): 159-66.
- Chen WH, Ho DS, Ho SL, Cheung RT, Cheng SW. Prevalence of extracranial carotid and vertebral artery disease in Chinese patients with coronary artery disease. *Stroke*, Mar, 1998; 29(3): 631-4.
- Walker MD, Marler JR, Goldstein M, Grady PA, Toole JF, Baker WH, Castaldo JE, Chambless LE, Moore WS, Robertson JT, Young B. Endarterectomy for asymptomatic carotid artery stenosis. *Jama*, May 10, 1995; 273(18): 1421-8.
- Bavil AS, Ghabili K, Daneshmand SE, Nemati M, Bavil MS, Namdar H, Shaafi S. Prevalence of significant carotid artery stenosis in Iranian patients with peripheral arterial disease. *Vascular health and risk management*, 2011; 7: 629-32.
- Hamed HA, Sulieman AA, Osman H, Mahmoud MZ. Sonographic assessment of Common and Internal Carotid Arteries in Type 2 Diabetic Patients. *ejpmr*, 2016; 3(12): 74-9.
- Grant EG, Benson CB, Moneta GL, Alexandrov AV, Baker JD, Bluth EI, Carroll BA, Eliasziw M, Gocke J, Hertzberg BS, Katanick S. Carotid artery stenosis: gray-scale and Doppler US diagnosis—Society of Radiologists in Ultrasound Consensus Conference. *Radiology*, Nov, 2003; 229(2): 340-6.
- Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, Das SR, de Ferranti S, Després JP, Fullerton HJ, Howard VJ. Heart disease and stroke statistics-2016 update: a report from the American Heart Association. *Circulation*, Jan 26, 2016; 133(4): e38.
- Cina CS, Safar HA, Maggisano R, Bailey R, Clase CM. Prevalence and progression of internal carotid artery stenosis in patients with peripheral arterial occlusive disease. *Journal of vascular surgery*, Jul 1, 2002; 36(1): 75-82.
- Yin D, Carpenter JP. Cost-effectiveness of screening for asymptomatic carotid stenosis. *Journal of vascular surgery*, Feb 1, 1998; 27(2): 245-55.
- da Rosa MP, Portal VL. Carotid stenosis and coronary artery bypass grafting. *Revista da Associação Médica Brasileira (English Edition)*, May 1, 2011; 57(3): 317-21.
- Mahmoudi M, Hill PC, Xue Z, Torguson R, Ali G, Boyce SW, Bafi AS, Corso PJ, Waksman R. Patients with severe asymptomatic carotid artery stenosis do not have a higher risk of stroke and mortality after coronary artery bypass surgery. *Stroke*, Oct, 2011; 42(10): 2801-5.
- Rath PC, Agarwala MK, Dhar PK, Lakshmi C, Ahsan SA, Deb T, Kumar S, Narasimham RR, Rao PS, Dixit V. Carotid artery involvement in patients of atherosclerotic coronary artery disease undergoing coronary artery bypass grafting. *Indian Heart Journal*, 2001; 53(6): 761-5.
- Cirilo F, Renzulli A, Leonardo G, Romano G, de Feo M, Della Corte A, Crescenzi B, Cotrufo M. Incidence of carotid lesions in patients undergoing coronary artery bypass graft. *Heart Views*, Jan 1, 2000; 1(10): 402-7.
- Shirani S, Boroumand MA, Abbasi SH, Maghsoodi N, Shakiba M, Karimi A, Davoodi S, Esfandbod M. Preoperative carotid artery screening in patients undergoing coronary artery bypass graft surgery. *Archives of medical research*, Nov 1, 2006; 37(8): 987-90.
- de Weerd M, Greving JP, Hedblad B, Lorenz MW, Mathiesen EB, O'Leary DH, Rosvall M, Sitzer M, Buskens E, Bots ML. Prevalence of asymptomatic carotid artery stenosis in the general population: an individual participant data meta-analysis. *Stroke*, Jun 1, 2010; 41(6): 1294-7.
- Jung HJ, Lee SS, Kim HY, Park BS, il Kim D, Nam KJ, Roh JE, Choo KS. Association between carotid artery stenosis and peripheral artery disease: evaluation by screening carotid ultrasonography (cross-sectional study). *Medicine*, Feb, 2019; 98(6).
- Yun WS, Rho YN, Park UJ, Lee KB, Kim DI, Kim YW. Prevalence of asymptomatic critical carotid artery stenosis in Korean patients with chronic atherosclerotic lower extremity ischemia: is a screening carotid duplex ultrasonography worthwhile?. *Journal of Korean medical science*, Aug 1, 2010; 25(8): 1167-70.
- Kayani AM, Kamran U, Khan N, Jalal A. Frequency of carotid artery disease in candidates undergoing coronary artery bypass graft. *Pakistan Heart Journal*, May 28, 2015; 48(1).
- Walker MD, Marler JR, Goldstein M, Grady PA, Toole JF, Baker WH, Castaldo JE, Chambless LE, Moore WS, Robertson JT, Young B. Endarterectomy for asymptomatic carotid artery stenosis. *Jama*, May 10, 1995; 273(18): 1421-8.
- MRC Asymptomatic Carotid Surgery Trial (ACST) Collaborative Group. Prevention of disabling and fatal strokes by successful carotid endarterectomy in patients without recent neurological symptoms: randomised controlled trial. *The Lancet*, May 8, 2004; 363(9420): 1491-502.
- Chaturvedi S, Bruno A, Feasby T, Holloway R, Benavente O, Cohen SN, Cote R, Hess D, Saver J, Spence JD, Stern B. Carotid endarterectomy—an evidence-based review: report of the Therapeutics

and Technology Assessment Subcommittee of the American Academy of Neurology. *American Journal of Ophthalmology*, Jan. 1, 2006; 141(1): 238-9.

23. Halliday A, Harrison M, Hayter E, Kong X, Mansfield A, Marro J, Pan H, Peto R, Potter J, Rahimi K, Rau A. 10-year stroke prevention after successful carotid endarterectomy for asymptomatic stenosis (ACST-1): a multicentre randomised trial. *The Lancet*, Sep 25, 2010; 376(9746): 1074-84.