

## Ultrasound Based Flow Measurements of the Left and Right Carotid System of Arteries in Bangladeshi Patients

Abdullah Al Mamun<sup>1</sup>, Nazmul Hosain<sup>2</sup>, Farzana Amin<sup>3</sup>

### Abstract:

Carotid arteries are the major supply to the head, neck and brain. The right common carotid artery usually originates from the brachiocephalic artery while the left common carotid artery arises as a direct branch of the arch of the aorta. Common carotid arteries bifurcate at the level of the carotid sinus into the internal carotid artery, which supplies the brain, and the external carotid artery. Approximately 15–20% of the cardiac output is distributed to the brain in healthy adults under resting conditions. Cardiovascular diseases are the leading cause of death globally, taking an estimated 17.9 million lives each year. US 2017 statistics shows that cerebrovascular disease or Stroke alone ranked fifth for males but fourth for females. Ultrasonography can measure the velocity of blood flow in the Carotid system of arteries. A total 139 patients, who underwent Carotid

Duplex study between July 2021 and June 2022 were included in this cross-sectional study. The criteria for exclusion included age less than 13 years, presence of associated peripheral vascular diseases, hemodynamically unstable patients, incomplete data collection and patient's reluctance to join the study. Data analysis was performed using MS Office Excel. The Peak systolic velocity and the End diastolic velocity were measured at four levels, namely the Common carotid arteries and the Internal carotid arteries on the right and the left sides. No significant difference was observed in the Peak systolic velocity and the End diastolic velocity in either Common carotid or the internal carotid arteries between the right and left sides. Moreover, these findings were similar both in age groups above and below 50 years of age.

*Key words:* Carotid ultrasound, Internal carotid arteries,

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### Introduction:

Carotid arteries are the major supply to the head and neck region and also to the brain. Although there may be anatomic variations, the right common carotid artery usually (RCCA) originates in the neck from the brachiocephalic artery while the left common carotid artery (LCCA) arises in the thorax as a direct branch of the arch of the aorta<sup>1</sup>. Furthermore, both right and left common carotid arteries bifurcate in the neck at the level of the carotid sinus into the internal carotid artery (ICA), which supplies the brain, and the external carotid artery (ECA), which supplies the

exterior of the head, the neck and the face. External carotid artery classically has eight branches. These are Superior thyroid artery, Ascending pharyngeal artery, Lingual artery, Facial artery, Occipital artery, Posterior auricular artery, Superficial temporal artery and Maxillary artery (Fig 1A).

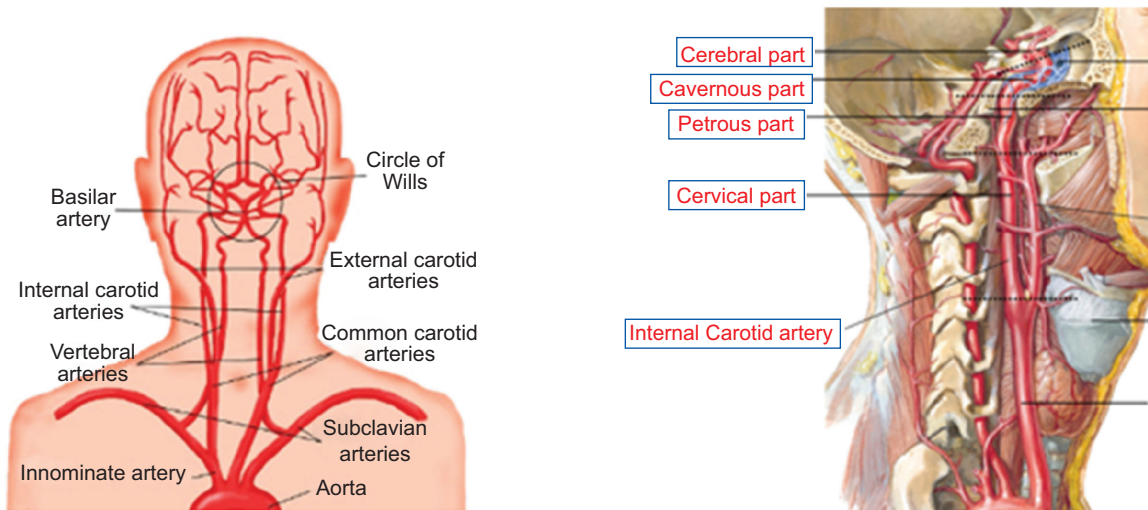
On the other hand, the course of the ICA is described as comprising of four sections. These sections include the cervical, petrous, cavernous, and cerebral parts of the ICA (Fig 1B). Inside the cranium, the ICAs anastomose

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1. Assistant Professor & Head of the Dept. of Vascular Surgery, Chittagong Medical College & Hospital, Chattogram, Bangladesh.
  2. Professor & Head of the Dept. of Cardiac Surgery, Chittagong Medical College & Hospital, Chattogram, Bangladesh.
  3. System Analyst, Northern Health, BC, Canada.

**Address of correspondence:** Prof. Nazmul Hosain, Professor & Head of the Dept. of Cardiac Surgery, Chittagong Medical College & Hospital, Chattogram, Bangladesh. Email: heartsurgeon007@gmail.com.

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**Fig.-1:** A. The Carotid system of arteries with arterial circle of Willis. 1B. Lateral view of Common carotid artery. Its branches and portions of Internal carotid artery.

with the branches of the basilar artery and form the circle of Willis. The ICA divides at the circle of Willis to give rise to the middle cerebral artery (MCA) and anterior cerebral artery (ACA). The MCA supplies the motor and sensory cortices of the upper limb and face, as well as the Wernicke area of the temporal lobe and Broca's area of the frontal lobe. The ACA is mostly responsible for supplying the motor and sensory cortices of the lower limb. The ophthalmic artery is responsible for blood supply to the inner layers of the retina, as well as supplying other parts of the orbit, meninges, face, and upper nose<sup>2</sup>. The neurologists, neurosurgeons, and neuroradiologists often also use the Bouthillier classification to describe the ICA into different parts based on the angiographic appearance of the vessel. According to this classification, the ICA splits into seven parts named as C1 to C7, with each part providing branching into different vessels. These branches of the ICA are generally tiny and inconsistent, and often they might not be present. However, the ophthalmic artery is present pretty much all of the time<sup>3</sup>.

A widely accepted dogma has been that approximately 15–20% of the cardiac output (CO) is distributed to the brain in healthy adults under resting conditions<sup>4</sup>. However, few studies have been conducted to determine whether the distribution of CO directed to the brain alters across the adult lifespan and is influenced by systemic and/or cerebral hemodynamic factors such as physical fitness level, cardiac function, and arterial stiffness<sup>5</sup>. This may play a crucial role in evolution of cerebrovascular diseases later in life.

Cardiovascular diseases (CVDs) are the leading cause of death globally, taking an estimated 17.9 million lives each year, and one third of these deaths occur prematurely in people under 70 years of age<sup>6</sup>. Cerebrovascular diseases are an important component of cardiovascular diseases in this lethal journey. US 2017 statistics shows that cerebrovascular disease or Stroke alone ranked fifth for males but fourth for females. Females had a higher relative burden of mortality from stroke, which accounted for 6.2% of all deaths to females but 4.3% of all deaths to males<sup>7</sup>. Carotid ultrasonography (CUS) is a proven noninvasive diagnostic tool to detect asymptomatic carotid artery stenosis (ACAS). A strong association between atherosclerotic coronary and carotid artery stenosis has been established since atherosclerosis is a progressive and systemic inflammatory disease that is also a forerunner of multiple adverse cardiovascular events<sup>8</sup>. However, studies show that the relationship between the occurrence of CV events and age is nonlinear, characterized with a sudden increase in event rate after age 50 years<sup>9</sup>. The flow pattern of Carotid arteries in Bangladeshi population hasn't been studied well till date. Here we made a small study analyzing the data available on Duplex scan of a small study population of 139 individuals.

**Methods:**

This cross-sectional study was conducted from May 2021 to July 2022. A total 139 patients, who underwent Carotid Duplex study in a vascular center at Dhaka were included in the study. All the patients were examined by the same vascular surgery consultant. Informed consent was

obtained from the patients. Carotid arterial system was assessed using a Philips Affiniti 70G system (Fig 2) equipped with a L12-5 real time linear B. Mode transducer. The severity of stenosis was measured according to consensus panel criteria by considering the following parameters- Peak systolic velocity (PSV) End diastolic velocity and the ratio of the PSV of internal and common carotid artery. Intimal plaque was described according to the Classification by Gray-Weale, as follows: Type I predominantly echolucent plaque with a thin echogenic cap; type II substantially echolucent lesion with small areas of echogenicity; type III, predominantly echogenic lesion with small areas of echolucency; and type IV, uniformly echogenic lesion. A standard data sheet was utilized for each individual patient. Then the data was transferred to a master data sheet. Initially 152 patients were considered for inclusion in the study. However, for various reasons, 13 patients were excluded. The criteria for exclusion included age less than 13 years, presence of associated peripheral vascular diseases, hemodynamically unstable patients, incomplete data collection and patient's reluctance to join the study. Data analysis was performed using MS Office Excel. Velocity of flow at the both common carotid arteries and internal carotid arteries of both sides was measured. Comparison was made between Right and Left common carotid arteries and Right and Left Internal carotid arteries. Student's T Test was applied to compare the data.

**Results:**

The age range of the 139 persons under study ranged from 13 to 88 years. The average age was 54.8± 13.4 years. 101 (72.7%) of these patients were male and 38 (27.3%) were females. The Table 1 demonstrates the Velocity of blood flow at the Common carotid artery Level. As the Table demonstrates, the Peak Systolic Velocity at the Right Common Carotid artery was 74.6±16.1 and whereas that at the Left common carotid was 73.9±17.5. The difference was not significant with p value of 0.79. End Diastolic Velocity at the Right Common Carotid artery was 19.5±5.9 and whereas that at the Left common carotid was 19.5±7.1. There was no significant difference here as well.

**Table-I**  
*Comparison of Flow/ Velocity at Common Carotid Artery Level*

Criteria	CCA Right	CCA Left	P Value
Peak Systolic Velocity	74.6±16.1	73.9±17.5	0.79
End Diastolic Velocity	19.5±5.9	19.5±7.1	0.97

The Table 2 demonstrates the Velocity of blood flow at the Internal carotid artery Level. the Peak Systolic Velocity at the Right Common Carotid artery was 73.3±20.9 and whereas that at the Left common carotid was 71.9±21.5. The difference was not significant with p value of 0.70. End Diastolic Velocity at the Right Common Carotid artery was 24.6±10.1 and whereas that at the Left common carotid was 22.0±8.87. There was no significant difference here as well with p value of 0.47.

**Table-II**  
*Comparison of Flow/ Velocity at Internal Carotid Artery Level*

Criteria	ICA Right	ICA Left	P Value
Peak Systolic Velocity	73.3±20.9	71.9±21.5	0.70
End Diastolic Velocity	24.6±10.1	22.0±8.87	0.47

The age has an effect on carotid flow. It is often found that carotid flow may significantly reduce from sixth decade onwards and internal carotid artery is most commonly involved in cerebral circulation insufficiency. In this study, the flow was separately compared between the right and left internal carotid arteries. Table 3 demonstrates the Velocity of blood flow at the Internal carotid artery Level among 49 persons aged between 13 and 50 years of age. The Peak Systolic Velocity at the Right internal Carotid artery was 68.6±23.0 and that at the Left internal carotid was 70.1±22.8. The difference was not significant with a p value of 0.51. End Diastolic Velocity at the Right internal carotid artery was 22.7±9.0 and that at the Left internal carotid was 24.6±11.1. There was no significant difference here as well with p value of 0.70.

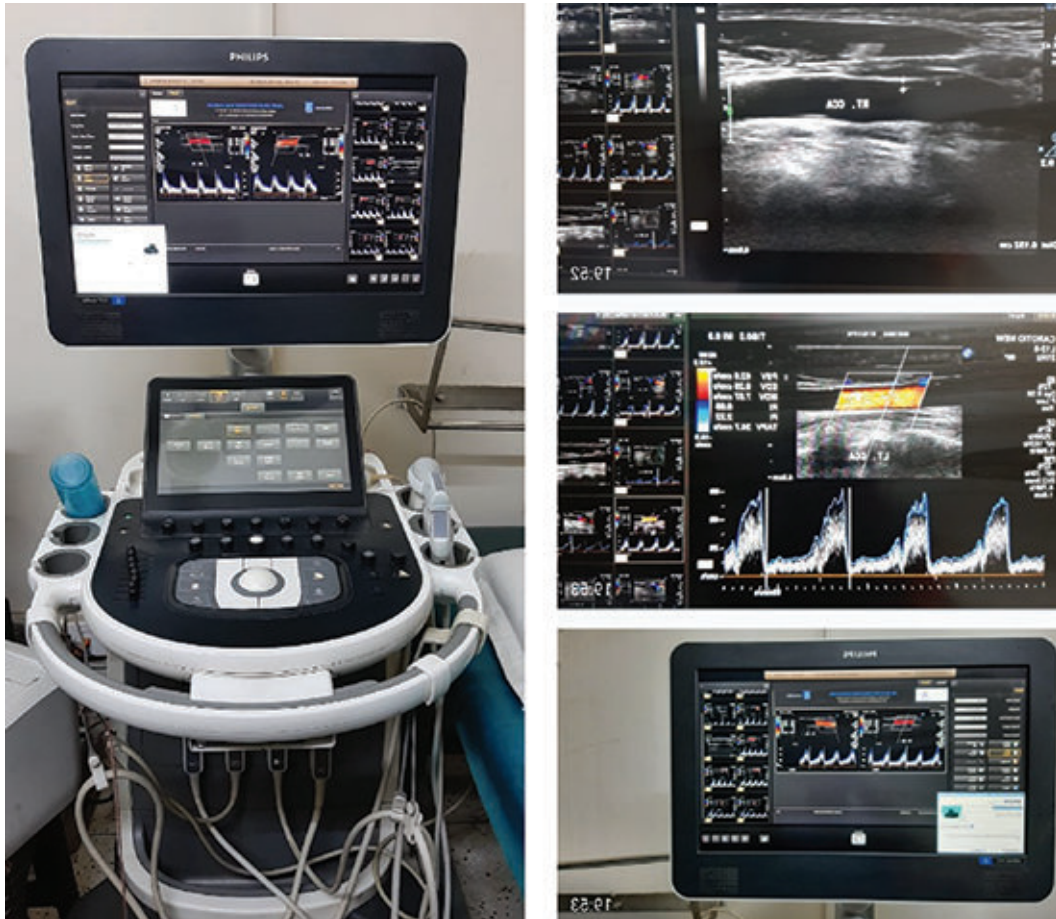
**Table-III**  
*Comparison of Flow/ Velocity at Internal Carotid Artery Level among persons 13 to 50 years old, n=49*

Criteria	ICA Right	ICA Left	P Value
Peak Systolic Velocity	68.6±23.0	70.1±22.8	0.51
End Diastolic Velocity	22.7±9.0	24.6±11.1	0.70

The Table 4 demonstrates the Velocity of blood flow at the Internal carotid artery Level of 90 individuals aged above 50. The Peak Systolic Velocity at the Right internal Carotid artery was 75.9±30.0 and that at the Left internal carotid was 72.8±38.0. The difference was not significant with a p value of 0.35. End Diastolic Velocity at the Right internal carotid artery was 25.6±45.4 and that at the Left internal carotid was 20.7±19.2. There was no significant difference here as well with a p value of 0.47.

**Table-IV**  
*Comparison of Flow/ Velocity at Internal Carotid Artery Level among persons more than 50 years old, n=90*

Criteria	ICA Right	ICA Left	P Value
Peak Systolic Velocity	75.9±30.0	72.8±38.0	0.35
End Diastolic Velocity	25.6±45.4	20.7±19.2	0.47



**Fig.-2:** A The Philips Affiniti 70G system Duplex machine & 2B. a sample carotid duplex report.

**Discussion:**

Carotid artery flow on the right and left side in Bangladeshi individuals was compared in this study. The Peak Systolic Velocity at the Right and Left common carotid arteries were 74.6±16.1 and 73.9±17.5 respectively. The difference was not significant with p value of 0.79. End Diastolic Velocity at the Right Common Carotid artery was 19.5±5.9 and whereas that at the Left common carotid was 19.5±7.1. There was no significant difference here as well. In their study Al-Sabbagh AA et al. (2022) found significant differences between the right

and left common carotid and internal carotid arteries in patients with diabetes and hypertension which were more prominent in the young age group<sup>10</sup>. Loizou CP et al. (2015) observed in their study that values for common carotid Intima Media Thickness and lumen diameter were significantly higher in the left common carotid artery versus the right common carotid artery in both age groups. Differences between the 2 carotid sides may be attributed to anatomic variations in the common carotid artery origins which lead to differences in stress between the 2 sides<sup>11</sup>.



Interestingly in our study, there wasn't any significant difference in terms of peak systolic velocity or end diastolic velocity of blood flow between the persons belonging to the age groups above and below 50 years of age. The peak systolic velocity of blood flow was not significantly different (p value 0.35) between the right and left at the Common carotid arteries in the age group above 50. The difference End diastolic velocity of flow between right and left side at the common carotid arteries was also not significant in persons above 50 (p value 0.45). Similarly, the Peak systolic velocity of blood flow was not significantly different (p value 0.35) between the right and left at the internal carotid arteries in the persons aged below 50. Similarly, the End diastolic Velocity of flow at the common carotid arteries level was also not significant between the sides (p value 0.41). Findings were similar for Internal carotid arteries as well. There has been disagreement in various studies measuring CAIMT in left and right common carotid arteries<sup>12</sup>. Bots et al in their 1997 study found no significant difference (p value 0.65) between the right and the left common carotid artery at the common carotid artery level examining 1500 patients<sup>13</sup>. However, in another large study involving 1655 patients in 2007 by Vicenzini et al, found significant difference between the sides (p value 0.001)<sup>14</sup>.

Limitations of the study include the involvement of a single operator and a single center. There was no randomization of the patients. Some of the patients were left-handed. The issue of being left-handed or right-handed was not taken in consideration while analyzing the data. The study population was also small to assess the status of a country of 170 million people. Similar larger and well-organized studies are recommended to be conducted in future to reach appropriate conclusions.

#### Conclusion:

No significant difference was observed in the Peak systolic velocity and the End diastolic velocity between the Right and Left Common Carotid arteries in the Bangladeshi patients. Similarly, no significant difference was observed in the Peak systolic velocity and the End diastolic velocity between the Right and Left internal carotid arteries in these patients. These findings were similar both in age groups above and below 50 years of age.

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