

Comparison of cardiac output measured by carotid artery Doppler ultrasound and echocardiography in patients admitted to Golestan and Imam Khomeyni Hospitals in Ahvaz

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ABSTRACT

Introduction: Ultrasound is highly effective, safe, and cost-effective for monitoring the hemodynamics and measuring the cardiac output of patients. This study aims to investigate the value of cardiac output by the measurement of common carotid artery flow, which is an inexpensive, simple, and accessible method. **Method:** Doppler ultrasound of the carotid artery at thyroid level was obtained from the patients admitted to Golestan and Imam Khomeyni Hospitals in Ahvaz (the result is recorded medially from the bilateral outputs unless otherwise prescribed on one side due to a problem such as a catheter or specific position). A transthoracic echocardiography was also recorded using a portable device to measure the left ventricular outlet of diameter 0.5 cm below the aortic valve in the left parasternal with a long axis view. **Results:** Of the 94 patients studied between the ages of 25 to 87 years, 53 (56.4%) were males and 41 (43.6%) females with a mean age of 53.61 with a standard deviation of 14.56. There was a direct and significant relationship between age and cardiac output using both echocardiography and color Doppler carotid ultrasound ($P < 0.001$). **Discussion:** The results of this study showed that the measurement of cardiac output using color Doppler ultrasound in the case of inaccessible emergency echocardiography is a cheap, simple, and accessible method for the hemodynamic evaluation of patients.

Keywords: Cardiac output, carotid ultrasound, transthoracic echocardiography

Introduction

Over the past 2 decades, hemodynamic monitoring and cardiac output measurement in ICUs have turned to non invasive approaches.^[1,2] Non invasive monitoring of cardiac output can be valuable in evaluating patient's volumetric conditions, especially in intensive care settings where patients' hemodynamics are rapidly changing.^[3,4] Traditionally, a pulmonary artery catheter is needed to measure cardiac output, which is an invasive procedure and has

several complications.^[1,5] Echocardiography is also unavailable for this purpose due to the need for well-trained staff. This color Doppler ultrasound is very effective, safe, and cost-effective in monitoring the hemodynamics of patients and measuring their cardiac output.^[4,6]

It should be kept in mind that many intensivists are not proficient in ultrasound and therefore have problems in measuring the cardiac output using flow velocity through the left ventricular outflow path. Problems that can be mentioned include the suboptimal cardiac window because of poor patient position, existence of dressing, and other confounding factors such as surgical incisions.^[6] Use of echocardiography in intensive care units also presents challenges. Some of the challenges are the

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difficulty of observing the heart to record left ventricular outflow, which is more common in patients with intubation in supine position. Another issue is the difficulty of working with the echo, the need for operator experience and skill, and the inaccessibility of these tools.^[1,4]

On average, between 15% and 26% of cardiac output volume is allocated to cerebral blood flow.^[1] It seems that ultrasound examination of carotid arterial blood flow can be a cost-effective and safe method for assessing response to fluid therapy as well as the need for more fluid therapy.^[4,5] Various studies have investigated the value of the common carotid artery blood flow in relation to the cardiac function.^[4,6] The rationale for this is that the common carotid artery is superficial and easily diagnosed. Ultrasound is easily reproducible even with low training without the need for specific training courses.^[4,7] The Doppler wave is common in the biphasic carotid artery and it is easy to record blood flow, in addition, this modality indicates the systolic end and diastolic onset.^[4] The carotid flow time (CFT) and carotid blood flow (CBF) criteria are easily measured and it seems that they correlate with intravascular volume.^[5]

There are several controversies regarding the correlation between common carotid artery blood flow and cardiac output measured by echocardiography.^[4] Some studies have shown that this parameter is a good alternative to cardiac output measurement,^[4] in contrast, some studies have also questioned the value of this parameter and reported a poor correlation of carotid artery blood flow with cardiac index, ejection fraction, stroke volume, and cardiac output.^[6] According to the above mentioned content, the present study aims are to investigate the measurement of cardiac output using arterial flow and to compare the results with the cardiac output measured by transthoracic echocardiography.

Method

All patients admitted to the Golestan and Imam Khomeyni Hospital in Ahwaz had bilateral carotid artery Doppler ultrasound and echocardiography in one day at 8 hours intervals. The data were collected based on the data collection form. Patients without consent, patients under 18 years, and patients with cardiac arrhythmias, stenosis, and carotid obstruction were excluded.

Patients were positioned at 30 degrees with the neck bent opposite for ultrasound. Doppler and echocardiography was performed by an experienced radiologist in the field of arterial Doppler and echocardiography, it was again performed by a second radiologist who was unaware of the initial results. If the data matched, registration was done. Images are taken from the bilateral carotid artery at the level of the thyroid (the result is recorded medially from the bilateral output) unless it can be performed on one side due to a problem such as a catheter or specific position. The transthoracic echocardiography also records the left ventricular outflow diameter 0.5 cm below the

aortic valve in the left parasternal with a long axis view using a portable device. Cardiac output will be automatically calculated by echocardiography and sonography devices.

Statistical analysis

Analysis was performed using Statistical Package for Social Science (SPSS) v19 software. The mean and standard deviation of the data are calculated. *P* value of 0.05 was considered significant. Differences between the groups were determined by *t*-test or post-hoc test. A paired *t*-test was also used to compare the outputs obtained from echocardiography and sonography. The correlation between echocardiography and sonography was calculated using 2-way interclass correlation coefficient (ICC).

Results

In the present study, 94 patients participated in projects were between the ages of 25 to 87 years with the mean age of 53.61 years and standard deviation of 14.56, which were about 42.6% younger than 50 years and 57.4% older than 50 years. Out of 94 patients, 53 (56.4%) were males and 41 (43.6%) were females. The mean cardiac output of transthoracic echocardiography was 5.15 (liter/min) with a standard deviation of 0.59. Also, the mean cardiac output by color Doppler carotid sonography was 5.17 (liter/min) with a standard deviation of 0.57.

Table 1 shows the correlation between the age of the subjects and the cardiac output by transthoracic method.

Significant relationship was observed between the age of the patients and transthoracic cardiac output ($P < 0.001$).

Table 2 shows the Pearson correlation between the gender of the subjects studied and cardiac output using the transthoracic method.

There was no significant relationship between gender and cardiac output by transthoracic method ($P > 0.05$).

Table 1: Relation between the age and the cardiac output by transthoracic method

	Coefficient of Determination	<i>P</i>
Age CO. Echocardiography	-0.587**	<0.001

** Significant correlation is considered at 0.01 level

Table 2: Relation between the gender and cardiac output using the transthoracic method

	Coefficient of Determination	<i>P</i>
gender CO. Echocardiography	0.082	0.43

Table 3: Relation between the age and cardiac output by color Doppler carotid ultrasound

	Coefficient of Determination	<i>P</i>
Age CO. carotid Doppler	-0.563**	<0.001

** Significant correlation is considered at 0.01 level

Table 3 illustrates the Pearson correlation between the age of subjects and cardiac output by color Doppler carotid ultrasound.

Significant relationship was observed between the age of subjects and cardiac output by color Doppler carotid ultrasound ($P < 0.001$).

Table 4 illustrates the Pearson correlation between the gender of the subjects and cardiac output by color Doppler carotid ultrasound.

There was no direct and significant relationship between the gender of subjects and cardiac output by color Doppler carotid ultrasound ($P > 0.05$).

Table 5 is shown the Pearson correlation between cardiac output assessment in both transthoracic echocardiography and color Doppler carotid ultrasound.

There was a direct and significant relationship between ventricular septal thickness and gestational diabetes mellitus (GDM) ($P < 0.05$).

Discussion

Color Doppler carotid sonography was 5.17 (liter/min) with a standard deviation of 0.57.

Gassner *et al.* (1) studied 36 patients admitted to intensive care units, comparing point-of-care ultrasound and invasive procedures (Pulse Contour Analysis - PCA and Pulmonary Artery Catheter - PA). Cardiac outputs were reported and finally stated that the correlation between ultrasound and PCA was about 0.84 and the correlation between ultrasound and PA was 0.74, which indicates a significant agreement between ultrasound and these two invasive methods and thus concluded that ultrasound is a non invasive and accessible technique for critically ill patients admitted to intensive care units. In this study, the correlation coefficient between the findings of carotid ultrasound and transthoracic echocardiography was 0.96, which is in agreement with the results of the study by Gassner *et al.*^[1]

Table 4: Relation between the gender and cardiac output by color Doppler ultrasound

		Coefficient of Determination	P
gender	CO. carotid Doppler	0.074	0.47

Table 5: Relation between cardiac output assessment in both transthoracic echocardiography and color Doppler carotid ultrasound

		Coefficient of Determination	P
CO. Echocardiography	CO. carotid Doppler	0.969**	<0.001

** Significant correlation is considered at 0.01 level

In a study, Qian-Yi Peng *et al.*^[6] investigated the accuracy of measurement of cardiac output using common carotid artery Doppler ultrasound flow versus cardiac output measured by transthoracic echocardiography. There were 148 patients who were hospitalized and underwent a common carotid artery Doppler ultrasound for 8 hours and then transthoracic echocardiography, and results were compared. They found that the correlation between Doppler carotid artery ultrasound and echocardiography was moderate, and Doppler ultrasound could be used in the cases of both emergency and inaccessible echocardiography. However, they noted that this method is not recommended in the cases of septic shock, trauma, and respiratory failure. However, the high correlation coefficient in our study (0.96) is close to 1, indicating a strong association between cardiac output assessments in both the ways, i.e transthoracic echocardiography and color Doppler carotid ultrasound. It should be noted, however, that in our study individuals were stable rather than in emergency condition, which could be a compelling reason for the significant discrepancy between our study and Qian-Yi Peng *et al.*

The results of a study by U. Weber *et al.*^[7] investigated the relationship between brachial artery blood flow and the common carotid artery with the cardiac index. They reported that peripheral arterial blood flow was poorly correlated with cardiac index and could not be used as cardiac index markers, which is inconsistent with the results of our study and other studies.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patients have given the consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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