Measurement of Circulation of Blood Volume(CBV) and Total Blood Volume(TBV) in Heart using Doppler Color Flow Imaging in Ultrasound Videos

Dipti Khairkar, Mrunal N. Annadate

***Abstract*: Total blood volume (TBV) analysis is key to manage the patients with cardiopulmonary bypass (CPB) cardiac surgery. Circulation of blood volume (CBV) is essential because the processes that maintain the connection between red cell volume (RCV), plasma volume (PV) and CBV may not be measured. The differences in significant surgery in patients do not always work efficiently and changes in CBV and need intensive care. The visible physiological clinical shock require urgent methods to regulate CBV because the current method is complicated and involves intervention.**

The current approaches to estimating blood quantity are labor-intensive, complex, and time-consuming. Severe depletion of quantity leads to selective vasoconstriction masking. Last decade, science has introduced different techniques for estimating blood quantity. So the scheme that can offer a precise assessment of blood quantity in the human body needs to be implemented. In this paper, a system is proposed where color flow imaging is used to measure TBV and CBV. The videos used are Doppler 2d echocardiogram which shows the color Doppler flow in the heart. The method used in this paper can be an alternative to the present methods of calculating the TBV and CBV as it is easy to measure the parameters with the help of Doppler velocity.

***Keywords* : Blood volume, Blood flow, Velocity, Doppler Effect.**

I. INTRODUCTION

In echocardiography, the technician utilizes a transducer to produce a image of the core by releasing high-frequency sound waves. When they return, the transducer reads the sound waves, producing a map of the chest's inside based on how the sound waves change[1]. Efficient to generate very high-resolution pictures are the latest ultrasound machines, and a three-dimensional echocardiogram can also be created that offers an even greater amount of detail. 2 d echo for echocardiography.

The current approaches to estimating blood volume are labor-intensive, complex, and time-consuming. Severe depletion of quantity leads to selective vasoconstriction masking Science over the past century, study has introduced different techniques for estimating blood volume[14]. So the scheme that can assist offer an precise assessment of blood quantity in the human body needs to be implemented[2].

The first estimates of the quantity stream were produced using Doppler. The ubiquitous equation of Doppler is:

$$\Delta f = 2\left(\frac{v}{c}\right) f0\ cos\Theta \qquad (1)$$

Where, in equation (1) ΔF is the shifted Doppler frequency, V is the speed of the blood flow, C is the speed of sound in Doppler, F0 is the carried frequency in the Doppler, Θ is the angle of Doppler.

The mean velocity or speed can be measured through the sweep gate by determining the speed and opening the sweep gate to provide the full thickness of a blood vessel.

If the vessel is circular in slicing region, the diameter of the blood vessel can be estimated, the slicing region of the vessel can be measured and the flow multiplied by the mean speed defined by the slicing region.

True quantity flow is defined as just the vessel's full flow along a surface. The flux is dependent on the intersecting plane's normal velocity element, which is interesting due to the angle-independent measurement.

$$Volume\ flow = \oiint v \bullet ndA \qquad (2)$$

Where, equation (2), V is the velocity of blood flow.

A tiny surface area with ordinary n unit, and. Is the result of the dot. If the frequency of the Doppler is increased at any place by the infinitesimal region tipped, dA where dA = dA / cos Θ.

II. LITERATURE SURVEY

Yanagisawa categorized visual appearance ductal Doppler flow models into 5 classifications; pattern of pulmonary hypertension, increasing pattern, pattern of pulsation, closing pattern, and closed pattern[16]. Consensus between observer was not screened to categorize patterns. The pulsatile model shows the greatest specificity and sensitivity for clinical signs predicting a persistent DA. Constriction was connected to the closing pattern, often with a flow rate of > 200 centimetre / second and a constant look. Another addition to this technique is Doppler processing, which cancels the Doppler's zero

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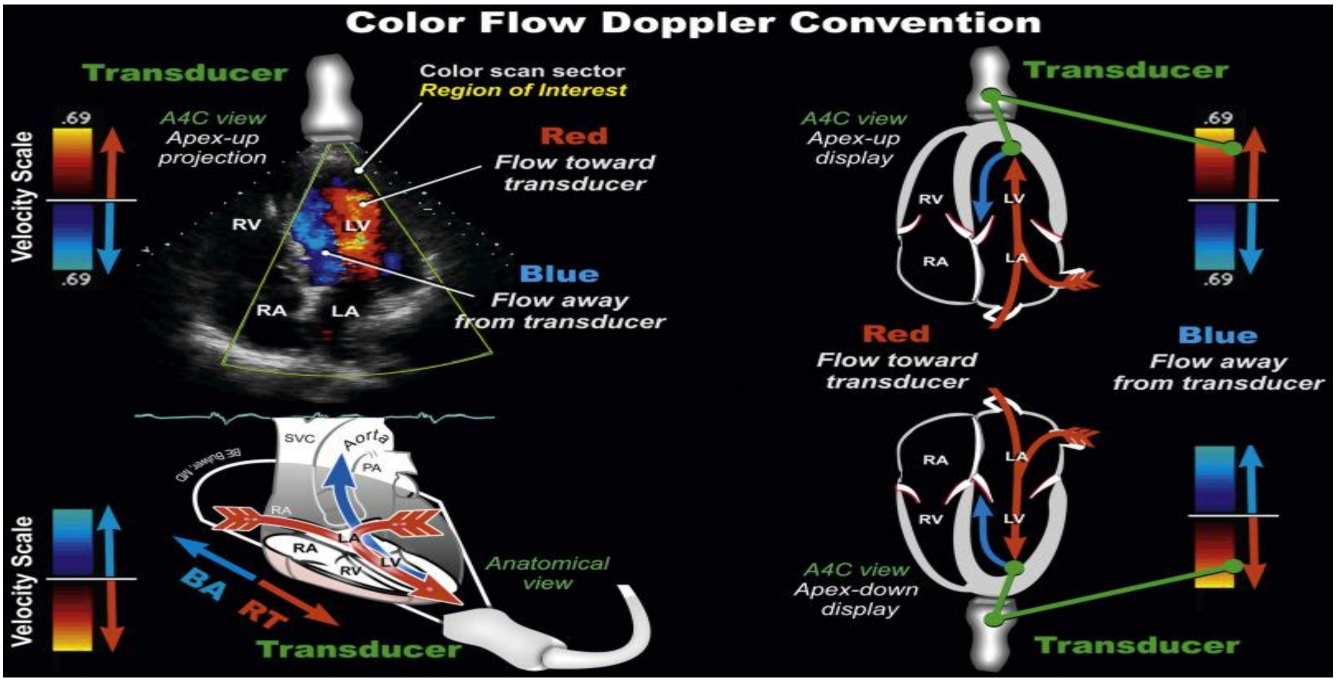

Fig 1. Color Doppler Flow Convention

frequency shift. This also cancels the harmonic tissue, leaving only the bubbles because of their extremely non-linear reaction. This further enhances the rejection of the clutter.

A.C. Santos provided the assessment of coronary blood flow from X-ray angiography picture sequences by computing methods. This technique is based on the spread of contrasts and includes segmentation of the arteries and compensation for movement. Coronary artery segmentation is based on the concept of blurred connectivity and mathematical morphology[12].

Coronary Segmentation: Real image segmentation based on blurred connectivity is used.

Correspondence of Artery Points: Vessel correspondence points are performed using two consecutive frames based on minimizing measurements of deformation between the open curves[8]. Using dynamic programming follows the search approach for optimal matching.

Flow Estimation: The estimation of the flow is based on the propagation of comparison by compensated arteries. In a parametric picture of the corrected range as a function of moment, the propagation of the contrast material bolus is depicted. Instant velocity can be calculated from the parametric picture[3,8]. The blood flow can be achieved by the estimated vessel cross-sectional region multiplying the instantaneous velocity[5,7].

Kluckow and Evans revealed that SVC flow was an average of 37 percent of LVO in children who had a closed duct where LVO and RVO are equivalent to the flow of blood (assuming no important FO shunt)[17]. The average when one observer experiences same variance for measuring SVC flow and the average when two observers experiences same variance between measurements was 8.1% and 14%. Measurement of integral speed moment and diameter led more to the variation than to the heart speed[9].

In clinical neonatology, central blood flow evaluation is exponentially being used[19]. Its significance in clinics for the making decisions in particular circumstances has been defined but some discuss that it is not adequately studied in clinical decision-making[19-20]. However, many imaging methods and diagnosis techniques presently newborn infants medical care (including blood pressure surveillance) were not exposed to assign in random way testing to evaluate their outcome-effect[19,15]. As with all diagnostic techniques, CBF measurements are used to improve physiological and pathological understanding.

III. PROPOSED SYSTEM

Blood is a complicated plasma-formed liquid containing of RBCs, WBCs, and platelets. On an average human adult's blood volume is about 5 liters. Females usually have less quantity of blood than men. People living at elevated altitudes with less oxygen in the air may have more blood than individuals living in low altitude areas.

A. *Video Extraction*

Video is a sequence-based mixture of pictures. For extracting frames from any video format, FFMPEG is used. Extraction of the video frame takes place at 25 frames per second. Each frame is saved in conjunction with the subsequent summary generation frame number.

B. *Color Doppler Velocity*

Therefore, the values of the parts of velocity, described as distinct colors in picture pixels, depend on the angle at each sample volume between the real direction of velocity and the direction of beam. This angle is often unknown, so care must be taken when interpreting pictures as a significant change in color may result from a change in angle rather than a change in speed.

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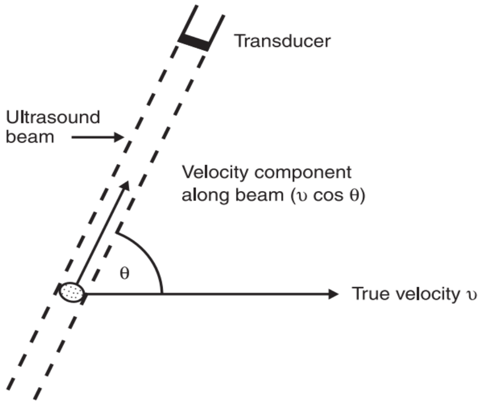

Fig 2. Angle of true velocity

C. *RGB Color Bar and Color Bar Space Mapping*

Doppler color flow imaging is a technique of non-invasive imaging of blood flow through the core by showing flow information on the echocardiographic picture of two dimensions[6]. This ability has created excellent enthusiasm about using the method to identify value, congenital, and other types of heart disease, as the color flow picture provides the Doppler data with spatial information.

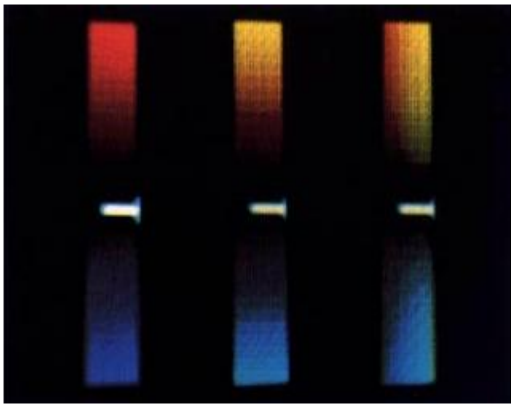

Fig 3. Color bar

Three color bars from a scheme for color flow. When there is no stream, the standard bar (left) shows dark (focus), the stream to the transducer at the top is red, the stream is blue[10]. In shades of red or blue, speeds are performed logically faster[13]. The center bar is in an upgraded manual, and a difference map is in the correct bar (explained later in the text).

D. *Blood Flow Measurement:*

CBF (Circulating blood flow) is evaluated in each patient's body at three places: right ventricular output (RVO) in the pulmonary valve, left ventricular output (LVO) in the aortic valve, and the heart in the upper vena cava (SVC) experiences a flow back estimated to a point at which SVC begins opening in the right chamber[16]. Fundamental blood flow is described as extent of coordinated focal blood flow to internal organs in the body, PBF to the lungs as the coordinated effect of CBF. Pulmonary blood flow was connected with RVO and LVO was associated with fundamental blood flow.

E. *Abbreviations and Acronyms Inference Result (Blood Flow Estimation)*

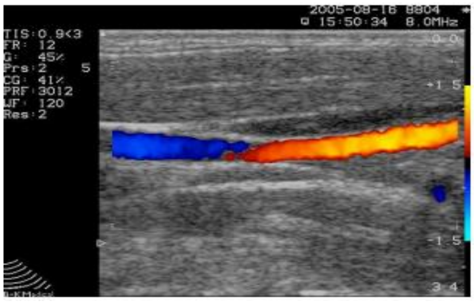

Fig. 4. blood flow in the jugular vein thet carries blood

The figure above depicted the flow of blood in the jugular vein carrying the blood back to the core. Although the quantity flow in the vein is continuous throughout the picture, distinct colours appear along the vessel and no blood flow is detected at all by the scanner at the middle of the picture[11].

$$Vz = \frac{c}{2f0} fp \quad (3)$$

Where, in equation (3), c = 1540 m/s is the speed of sound in the human body. f0 is the center frequency of the signal received by the transducer (transmitted US-frequency), Velocity is Vz, Mean frequency is fp (Doppler frequency).

Analyze Blood Flow Estimation (IN-OUT) technique which is useful in our scenario.

Avg_flow_rate=mean(velocities_(:,1));

Volume=avg_flow_rate*(1/25)*60

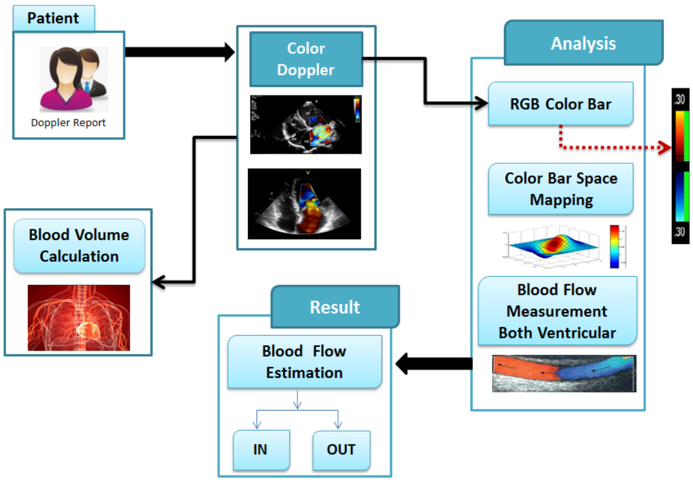

Fig 5. System Architecture

IV. RESULTS AND DISCUSSION

The following table demonstrates the two columns named velocity and flow rate where velocity indicates blood velocity with the assistance of color bar and flow rate indicates blood flow for each pixel coming or going out of the core. Flow Milliliter / min displays blood volume in the core per minute.

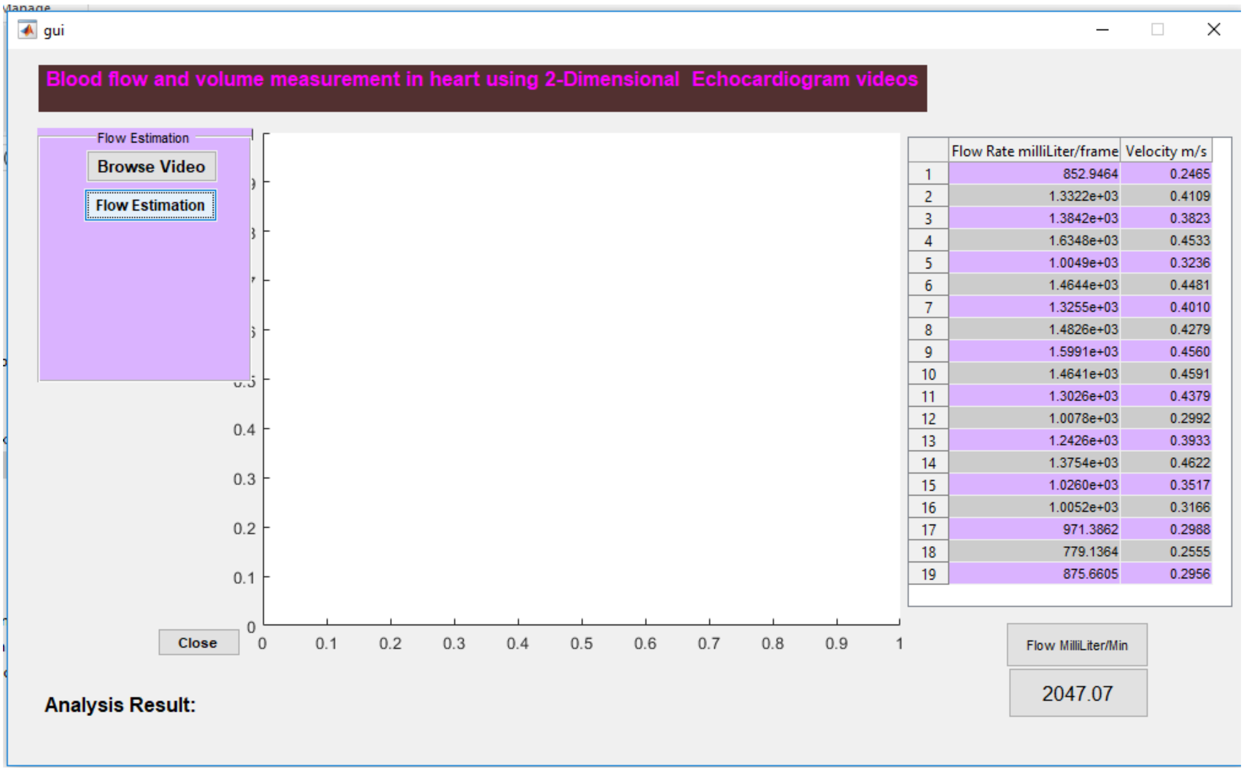

Fig 6. Results for Velocit, Blood Flow and Volume displayed in MATLAB GUI

TABLE I. VELOCITY AND FLOW RATE

Sr No.	Flow Rate Milliliter/ Frame	Velocity m/s
1.	852.9464	0.2465
2.	1.3322e+03	0.4109
3.	1.3842e+03	0.3823
4.	1.6348e+03	0.4533
5.	1.0049e+03	0.3236
6.	1.4644e+03	0.4481
7.	1.3255e+03	0.4010
8.	1.4826e+03	0.4279
9.	1.5991e+03	0.4560
10.	1.4641e+03	0.4591
11.	1.3026e+03	0.4379
12.	1.0078e+03	0.2992
13	1.2426e+03	0.3933
14.	1.3754e+03	0.4622
15.	1.0260e+03	0.3517
16.	1.0052e+03	0.3166
17.	971.3862	0.2988
18.	779.1364	0.2555
19.	875.6605	0.2956

The above table 1 represents the two columns named velocity and flow rate where velocity shows speed of the blood with the help of color bar and flow rate shows the flow of blood coming or going out of the heart for each frame. i.e. CBV. And the TBV can be found in figure 5 as Flow Millilitre / min.

TABLE II. PROPOSED SYSTEM COMPARED WITH TECHNIQUE

	Indicator Dilution Technique		Proposed System	
Parameters	Measured Volume	Ideal Volume	Measured Volume	Ideal Volume
Blood Flow	3480	3790	2047	2182
Percentage	91.82%		93.81%	

The volume analysis indicator dilution technique is here compared with the proposed system. For the analysis, indicator dilution takes 90 minutes whereas by using the proposed system required time depends on the number of frames in the doppler video. Table 2 and figure 6 shows the compared results.

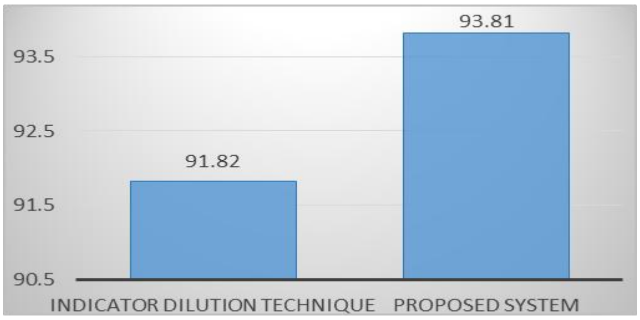

Fig 6. Compared technique percentage graph

V. CONCLUSION

This paper introduces blood volume estimation methods. The techniques of estimating TBV that are simple, fast, can be performed in clinical environments and repeated as per the need. Our study studies primary goal is to develop a current optical system for measuring blood volume in the pneumatic, pulsatile ventricular assist equipment of Para corporeal. By learning all the methods we come to understand that CBV assessment requires an accurate structure. Determining clinically appropriate blood flow parameters to support clinical trials and validation. Support collaboration between physicians and researchers in cardiovascular signal processing applications research and development.

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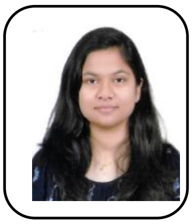

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