

Clinical Utility of CW Doppler Ultrasound for Measuring Cardiac Output (USCOM)

Heerman, William J.; Churchwell, Kevin B.; Taylor, Mary B.
 Monroe Carell Jr. Children's Hospital at Vanderbilt University. Nashville, TN

Purpose: To investigate the clinical usefulness of Continuous Wave (CW) Doppler ultrasound for monitoring cardiac function in a pediatric critical care setting by evaluating intra-user variability and the time necessary to obtain measurements.

Methods: USCOM, Ltd. has developed a trans-cutaneous CW Doppler ultrasound device that measures blood flow across the semilunar valves. An ultrasound probe (3.3 MHz) is placed on the patient's skin in the suprasternal notch or over the 4th intercostal space. The device plots the velocity of trans-valvular blood flow against time. The velocity time integral (vti) is measured manually using the "touch point" feature on the device. The device's algorithm calculates cardiac output:

$$\text{C.O.} = \text{vti} \times \text{cross-sectional area of the outflow tract} \times \text{heart rate}$$

We evaluated cardiac output in seven pediatric patients (< five years old) for twenty-four hours following corrective heart surgery. At each of ten time points we used the USCOM device to record two sequential measurements using either the suprasternal approach (aortic valve) or the intercostal approach (pulmonic valve). Each measurement represents the average of four heartbeats. Thus, at each time point we recorded two equivalent representations of each patient's cardiac output.

Based on a global assessment of the quality of the traces obtained, we chose either the aortic or pulmonic traces to represent the overall trend of cardiac output for each patient. All measurements were taken by a single investigator who was previously untrained in CW ultrasound.

Results: The average time to obtain the initial data measurement was 6.0 min. +/- 3.17 min. The average time to obtain each subsequent measurement was 1.75 min. +/- 0.23 min. The means and 95% confidence intervals are presented.

The Bland-Altman method (Figure 1) evaluates the intra-user variation between the two sequential cardiac output measurements, which are taken at the same time point. The difference between each pair of measurements (y-axis) is plotted against the mean of each pair of measurements (x-axis). 65 of 68 data points fall within the 95% confidence interval of the mean.

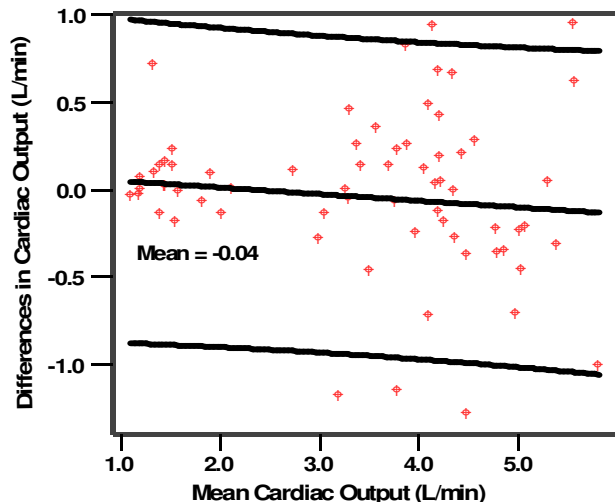


Figure 1. Bland-Altman Method: Differences in cardiac output vs. mean cardiac output at each time point. The mean is -0.04 L/min. The standard deviation is 0.45 L/min. 65/68 data points are within the 95% confidence interval (represented by the lines). This indicates a low level of intra-user variation.

Conclusions: The use of Continuous Wave Doppler ultrasound is a promising new technique for measuring cardiac output non-invasively. The Bland-Altman plot demonstrates low variability, especially at low cardiac output values. The greater variation at higher cardiac output values is explained partially by inter-patient variation but requires further investigation.

With low intra-user variability and an average measurement time of less than 2 minutes, the USCOM device proves to be a practical method of assessing cardiac status in a pediatric critical care setting.