To determine cardiac output and others ten parameters within a few seconds using simple body parameters

BASANT KUMAR SHAHI[1], DR. AJAJ ACHARYA[2], AYUSH BHATTARAI[3], KEDAR RAJ GIRI[4]

(Affiliation): CashNep- The Bank of Youth's Vision, CEO, Nepal 44600
Email: research@shahispring.com, shahispring.com

Abstract
This research presents a method for determining cardiac output and ten related parameters by analyzing easily accessible body parameters, including heart rate, respiratory rate, body temperature, and body weight. A derived formula enables the calculation of cardiac output, stroke volume, cardiac index, stroke volume index, body surface area, plasma cell volume, total red blood cell volume, total plasma volume, total blood volume in tachycardia, and total blood volume in bradycardia. The study involved 50 individuals and monitored acute blood loss. The proposed method offers advantages over traditional approaches, being cost-effective, time-efficient, and not requiring highly skilled personnel. Its applicability at an individual level makes it accessible to a wide range of populations. The research findings contribute to determining other vital measures. The Auto Cardiac Digital Device (ACDD) provides an efficient means of determining cardiac output and related parameters, with implications for timely monitoring of physiological and pathological conditions such as cardiac arrest, myocardial infarction, and ventricular defects.

Keywords
Cardiac output determination, Easily accessible body parameters, Heart rate analysis, Respiratory rate analysis, Body temperature analysis, Body weight analysis, Stroke volume calculation, Cardiac index calculation, Stroke volume index calculation, Body surface area estimation, Plasma cell volume calculation, Acute blood loss monitoring, Cost-effective assessment, Time-efficient measurement, Individual-level applicability, Auto Cardiac Digital Device (ACDD), Physiological and pathological condition monitoring, Cardiac arrest, Myocardial infarction, Ventricular defects monitoring.

Introduction

The determination of cardiac output has traditionally been a challenging and resource-intensive task in the field of medicine. The existing methods are expensive, time-consuming, and require skilled personnel, limiting their practicality and accessibility. This research aims to introduce a novel method for determining cardiac output and ten related parameters using easily accessible body parameters such as heart rate, respiratory rate, body temperature, body weight, and body height. By analyzing the relationships between these variables, a formula is derived to calculate cardiac output. Additionally, this method enables the calculation of stroke volume, cardiac index, stroke volume index, body surface area, plasma cell volume, total red blood cell volume, total plasma volume, total blood volume in tachycardia, and total blood volume in bradycardia. The study involved approximately 50 individuals and monitored acute blood loss during the experimental process. The proposed method offers significant advantages over traditional approaches. It is cost-effective, time-efficient, and does not require highly skilled personnel. Moreover, it can be easily operated at an individual level, making it accessible to a wide range of populations. The Auto Cardiac Digital Device (ACDD) serves as an efficient means of determining cardiac output and related parameters, with implications for timely monitoring of physiological and pathological conditions, such as cardiac arrest, myocardial infarction, and ventricular defects.

Ease of Use

The proposed method for determining cardiac output and ten related parameters using simple body parameters offers significant advantages in terms of ease of use. Unlike traditional approaches that require specialized equipment and highly skilled personnel, the Auto Cardiac Digital Device (ACDD) simplifies the process and can be easily operated by individuals with minimal training. The ACDD utilizes easily accessible body parameters such as heart rate, respiratory rate, body temperature, body weight, and body height, which can be measured using common tools such as a thermometer, measuring tape, stopwatch, and weighing scale. These tools are readily available and familiar to medical professionals, making the implementation of this method convenient and straightforward. Moreover, the derived formula that calculates cardiac output and other parameters provides a standardized and automated approach. Once the required body parameters are measured, the formula can be applied to obtain accurate results within a few seconds. This reduces the potential for human error and ensures consistency in the measurements. The ease of use extends to the applicability of the method at an individual level. Since it utilizes simple body parameters, it can be easily employed by individuals themselves or by healthcare providers in various settings. This accessibility is particularly valuable for individuals who may not have access to comprehensive healthcare or specialized medical facilities.

Abbreviations and Acronyms

ACDD: Auto Cardiac Digital Device, CPR: Cardiopulmonary resuscitation, MI: Myocardial infarction, VD: Ventricular defects, HR: Heart rate, RR: Respiratory rate, BT: Body temperature, BW: Body weight, BH: Body height, SV: Stroke volume, CI:

Cardiac index, SVI: Stroke volume index, BSA: Body surface area, PCV: Plasma cell volume, RBCV: Red blood cell volume, TPV: Total plasma volume, TBV: Total blood volume, ABP: Acute blood loss monitoring, CO: Cardiac outputthey are unavoidable.

Rationale/Justification

The research article provides a rationale for the proposed method of determining cardiac output and related parameters using easily accessible body parameters. Traditional approaches for measuring cardiac output are costly, time-consuming, and require skilled personnel. In contrast, the method presented in the article offers several justifications for its implementation. Firstly, it is cost-effective, allowing for more affordable and widespread adoption. Secondly, it is time-efficient, providing quick results that can aid in timely monitoring of physiological and pathological conditions. Thirdly, it does not require highly skilled personnel, making it accessible to a wider range of populations. Additionally, the method can be easily operated at an individual level, enabling individuals themselves or healthcare providers to measure cardiac output using common tools. Overall, the rationale and justification behind this method lies in its advantages over traditional approaches, its ease of use, and its potential for effective monitoring of various cardiovascular conditions.

Units

Heart rate: beats per minute (bpm), Respiratory rate: breaths per minute, Body temperature: degrees Celsius or Fahrenheit, Body weight: kilograms (kg) or pounds (lbs), Body height: meters (m) or feet (ft) Stroke volume: milliliters (ml) or liters (L), Cardiac index: liters per minute per square meter (L/min/m^2),

Stroke volume index: milliliters per square meter (ml/m^2), Body surface area: square meters (m^2), Plasma cell volume: milliliters (ml) or liters (L), Total red blood cell volume: milliliters (ml) or liters (L), Total plasma volume: milliliters (ml) or liters (L), Total blood volume in tachycardia: estimation, Total blood volume in bradycardia: estimation, Acute blood loss monitoring: unspecified units, Cardiac output: liters per minute (L/min)

Data Collection Tools

The Auto Cardiac Digital Device (ACDD) is used as an efficient tool for determining cardiac output and related parameters. The ACDD analyzes easily accessible body parameters such as heart rate, respiratory rate, body temperature, and body weight. By measuring these parameters, a derived formula is applied to calculate cardiac output, stroke volume, cardiac index, stroke volume index, body surface area, plasma cell volume, total red blood cell volume, total plasma volume, total blood volume in tachycardia, and total blood volume in bradycardia. This method offers advantages including cost-effectiveness, time-efficiency, and applicability at an individual level. The ACDD aids in monitoring physiological and pathological conditions like cardiac arrest, myocardial infarction, and ventricular defects.

Claim

It is the easiest, cheapest, most accurate, convenient, and risk-free method for the determination of cardiac output, probably to date. Nowadays, cardiac output is measured or determined using Fick's principle, electrocardiogram analysis, and calculation of the total volume of blood pumped by the left ventricle. These methods require special techniques, highly trained healthcare professionals, access to Cath-labs, and are expensive, time-consuming, and obviously impossible in rural areas, especially in developing nations like Nepal. Thus, our system of determining cardiac output using five simple body parameters is convenient. By inputting these parameters into a specially designed formula, individuals can calculate their cardiac output, making it a more practical approach.

Equations

$\text{H.R} \propto \text{R.R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(I)}$

During exercise, your adrenal gland releases adrenaline and noradrenaline, which affect the heart and oxygen transport. These hormones stimulate the heart for increased stroke volume and heart rate, boosting cardiac output. Resting pulse ranges from 60 to 80 beats per minute, while breathing rate is 12 to 20 breaths per minute. Both increase during exercise, with a ratio of about 1 breath per 4 heartbeats.

$\text{H.R} \propto \text{B.T} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(II)}$

Increased body temperature leads to elevated heart rate and respiratory rate. Previous studies focused on young, healthy individuals without medication affecting the cardiovascular system. Our study aimed to investigate this relationship in acute patients encountered in an emergency department. Each degree Celsius rise in body temperature independently raises heart rate by approximately 10 beats per minute and influences respiratory rate. Quantifying these effects aids in assessing febrile patients, distinguishing fever-related tachycardia and tachypnea from concurrent shock. In reptiles, metabolic and cardio-respiratory changes better indicate transitions from sleep to wakefulness than EEG and EMG. Temperature and activity states predominantly affect heart rate and breathing frequency to meet increased oxygen demand.

$\text{H.R} \propto (\text{B.S.A})^2 \ldots\ldots\ldots\ldots\ldots\ldots.. \text{(III)}$

Heart rate, or pulse, measures the number of heart beats per minute. It varies based on factors like age, weight, activity, medication, and emotions. Fitness improves heart efficiency, lowering the heart rate. Strengthening the heart, like other muscles, is achievable through exercise. Athletes and those experiencing symptoms need to monitor their heart rate, as it can indicate intensity or potential issues. Increasing heart rate can also help decrease body weight.

$H.R \propto C.O$ … … … … … … … … (IV)

Cardiac output increases by either raising heart rate or stroke volume. The heart's function is to circulate blood, delivering oxygen and nutrients while removing waste. The quantity of blood returning to the heart determines the amount it pumps out, known as cardiac output (Q). This is defined by stroke volume (SV) and heart rate (HR).

$H.R \propto \frac{1}{B.W}$ …………………………... (V)

$H.R \propto \frac{1}{B.W}$ …………………………... (V)

Combination all equations we get,

$$H.R \propto \frac{R.R*B.T*C.O*(B.S.A)^2}{B.W*B.H.*\sqrt{(\frac{B.W}{8})}}$$

$$H.R = K\frac{R.R*B.T*C.O*(B.S.A)^2}{B.W*B.H.*\sqrt{(\frac{B.W}{8})}}$$

The supporting unit of cardiac output, represented by K, has a value of 1.8 for males and 1.95 for females (minkgl2/m4o0c). Normal patients, regardless of age, have the same K value of **1.8 or 1.95**. However, in the presence of any pathology or abnormal vital values.

$$K= \frac{H.R*B.W*B.H.*\sqrt{(\frac{B.W}{8})}}{R.R*B.T*C.O*(B.S.A)^2}$$

$$\textbf{C.O=} \frac{H.R*B.W*B.H.*\sqrt{(\frac{B.W}{8})}}{K*R.R*B.T*(B.S.A)^2}$$

$$\textbf{C.O=} \frac{H.R*B.W*B.H.*\sqrt{(\frac{B.W}{8})}}{K*R.R*B.T*\frac{B.W.*B.H.}{36}}$$

$$C.O = \frac{H.R*\sqrt{\frac{B.W.}{8}}}{\frac{K*R.R.*B.T.}{36}}$$

Both side square we get,

$$C.O = \frac{12.728*H.R*\sqrt{B.W.}}{K*R.R.*B.T.} \qquad C.O = \frac{12.728*H.R*\sqrt{B.W.}}{K*R.R.*B.T.}$$

In Male K= 1.8

$$C.O = \frac{12.728*H.R*\sqrt{B.W.}}{1.8*R.R.*B.T.}$$

$$C.O = \frac{7.07*H.R*\sqrt{B.W}}{R.R.*B.T.}$$

In Female K= 1.95

$$C.O = \frac{12.728*H.R*\sqrt{B.W.}}{1.95*R.R.*B.T.}$$

$$C.O = \frac{6.527*H.R*\sqrt{B.W.}}{R.R.*B.T.}$$

C.O= $\frac{7.07*H.R*\sqrt{B.W}}{R.R.*B.T.}$ **l/min** **For Male**	**C.O =** $\frac{6.527*H.R*\sqrt{B.W.}}{R.R.*B.T.}$ **L/min** **For Female**

Unit: $\frac{min*kg*l^3}{\frac{min*kg*l^2}{m^4*0^{0c}}*min*o^{0c}*m^4}$

C.O= liter/minute.

Stroke Volume:

$$S.V= \frac{C.O}{H.R}$$

$$S.V= \frac{\frac{7.07*H.R*\sqrt{B.W}}{R.R.*B.T.}}{H.R.}$$

$$S.V= \frac{7.07*\sqrt{B.W.}}{R.R*B.T.}$$

S.V= $\frac{7.07*\sqrt{B.W.}}{R.R*B.T.}*\mathbf{1000}$ *ml/beat* For Male	**S.V=** $\frac{6.527*\sqrt{B.W.}}{R.R*B.T.}$***1000***ml/beat* For Female

Unit: $\frac{kg*l^3}{\frac{min*kg*l^2}{m^4*0^{0c}}*min*0^{0c}*m^4}$

l/min*min

(Note: beat= min*min)

So, Stroke Volume unit is l/beat or ml/beat)

Cardiac Index (C.I) = $\frac{C.O}{BSA}$

C.I= $\frac{\frac{7.07*H.R*\sqrt{B.W}}{R.R.*B.T.}}{\sqrt{\frac{B.W.*B.H}{36}}}$

Both side square

C.I.= $\frac{7.07*6*H.R.}{R.R.*B.T.*\sqrt{B.H.}}$

Unit: $\frac{min*kg*l^3}{\frac{min*kg*l^2}{m^4*0^{0c}}*min*0^{0c}*m^4*m^2}$

l/min/m^2

C.I= $\frac{42.42*H.R.}{R.R.*B.T.*\sqrt{B.H.}}$ l/min/m^2	C.I= $\frac{39.162*H.R.}{R.R.*B.T.*\sqrt{B.H.}}$ l/min/m^2

Stroke Volume Index (S.V.I) = $\frac{C.I}{H.R}$*1000

S.V.I= $\frac{\frac{7.07*6*H.R.}{R.R.*B.T.*\sqrt{B.H.}}}{H.R}$*1000

S.V.I= $\frac{42420}{R.R.*B.T.*\sqrt{B.H.}}$

Unit: $\frac{min*kg*l^3}{\frac{min*kg*l^2}{m^4*0^{0c}}*min*0^{0c}*m^4*m^2}$ (1liter= 1000ml & min*min= beat)

ml/m^2/beat

S.V.I= $\frac{42420}{R.R.*B.T.*\sqrt{B.H.}}$ ***ml/m²/beat*** For Male	**S.V.I=** $\frac{39162}{R.R.*B.T.*\sqrt{B.H.}}$***ml/m²/beat*** For Female

Body Surface Area (B.S.A) = $\sqrt{\frac{B.W*B.H}{36}}$ m^2

Total Blood Volume (TBV)

TBV$\propto \frac{1}{\left(\frac{H.R*B.W}{R.R*B.T}\right)}$ ……………….. (VI)

TBV= $K\frac{1}{\left(\frac{H.R*B.W}{R.R*B.T}\right)}$

(Where K is just supporting of the Total Blood Volume TBV)

TBV $= \frac{K}{\left(\frac{H.R*B.W}{R.R*B.T}\right)}$

TBV= $\frac{K(R.R*B.T)}{(H.R*B.W)}$

$(\mathbf{TBV}) = \frac{K*R.R*B.T}{H.R*B.W}$

$(\mathbf{TBV}) = \frac{K*R.R*B.T}{H.R*B.W}$

$$\mathbf{K} = \frac{\frac{(B.W)^2 * H.R}{R.R * B.T}}{2\sqrt{\left(\frac{B.W}{2}\right)}} \text{ kg}/0^c$$

$\mathbf{K} = \frac{H.R*B.W^2}{R.R*B.T*2\sqrt{\left(\frac{B.W}{2}\right)}}$ ……………………… (VII)

K value put in equation (VI) we get,

$K = \frac{H.R*R.R*B.T*B.W^2}{R.R*B.T*H.R*B.W*2\sqrt{\left(\frac{B.W}{2}\right)}}$

$K = \frac{B.W}{2\sqrt{\left(\frac{B.W}{2}\right)}}$

Both side square we get,

$(K)^2 = \left(\frac{B.W}{2\sqrt{\left(\frac{B.W}{2}\right)}}\right)^2$

$4(K)^2 = \frac{(B.W)^2}{\frac{B.W}{2}}$

$\frac{2(B.W)^2}{B.W} = 4K^2$

$2(B.W) = 4K^2$

$K = \sqrt{\left(\frac{B.W}{2}\right)}$

Total Blood Volume TBV: $K\left(\frac{B.H}{2}\right)$

$TBV = \sqrt{\left(\frac{B.W}{2}\right)} * \left(\frac{B.H}{2}\right)$

$TBV = B.H\sqrt{\left(\frac{B.W}{2*4}\right)}$

$$TBV = B.H\sqrt{\left(\frac{B.W}{8}\right)}$$

Total Red Cell Volume (TRCV):

$TBV*\frac{45}{100}$

$TRCV = B.H\sqrt{\left(\frac{B.W}{8}\right)}*\frac{45}{100}$

$TRCV = B.H\sqrt{\left(\frac{B.W*2025}{8*10000}\right)}$

$TRCV = B.H\sqrt{\left(\frac{B.W*81}{3200}\right)}$

$$TRCV = B.H\sqrt{\left(\frac{B.W}{39.50}\right)} \text{ liter}$$

Total Plasma Volume TPV:

$TPV = B.H\sqrt{\left(\frac{B.W}{8}\right)}*\frac{55}{100}$

$TPV = B.H\sqrt{\left(\frac{B.W*3025}{80000}\right)}$

$TPV = B.H\sqrt{\left(\frac{B.W*121}{3200}\right)}$

$$TPV = B.H\sqrt{\left(\frac{B.W}{26.45}\right)} \text{ liter}$$

Total Blood Volume in Acute Hemorrhage:
Tachycardia:

$$TBV_T = TBV * \left[\sqrt{\left(\frac{R.R+B.W}{H.R}\right)}\right] \text{ liter}$$

Bradycardia:

$$TBV_B = \frac{TBV}{\sqrt{\left(\frac{R.R+B.W}{H.R}\right)}} \text{ liter}$$

Authors and Affiliations

Basant Kumar Shahi, Principal Investigator, CashNep CEO, PrimeSewa Founder, CashNepHub
Principal Investigator, Rara IT Hub & Research Centre
Book: "Cardiac Output" by Barry J. Materson and Richard W. Graettinger
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Book: "Blood Circulation" by R.E. Shambaugh Jr. and Henry J. Stolte

Figures and Tables

S.N.	**Finding Formulae**
1.	Cardiac Output **C.O=** $\frac{7.07*H.R*\sqrt{B.W}}{R.R.*B.T.}$ **l/min** $\frac{6.527*H.R*\sqrt{B.W.}}{R.R.*B.T.}$
2.	Stroke Volume **S.V=** $\frac{7.07*\sqrt{B.W.}}{R.R*B.T.} * \mathbf{1000}$ *ml/beat* $\frac{6.527*\sqrt{B.W.}}{R.R*B.T.}$
3.	Cardiac Index C.I. $\frac{42.42*H.R.}{R.R.*B.T.*\sqrt{B.H.}}$ l/min/m^2 $\frac{39.162*H.R.}{R.R.*B.T.*\sqrt{B.H.}}$
4.	**Stroke Volume Index S.V.I.** $\frac{42420}{R.R.*B.T.*\sqrt{B.H.}}$ ***ml/m²/beat*** $\frac{39162}{R.R.*B.T.*\sqrt{B.H.}}$
5.	Body Surface Area (B.S.A) = $\frac{B.W*B.H}{36}$ m^2
6.	Total Blood Volume (TBV)= $B.H\sqrt{\left(\frac{B.W}{8}\right)}$ liter
7.	Total Red Cells Volume (TRCV)= $B.H\sqrt{\left(\frac{B.W}{39.50}\right)}$ liter
8.	Total Plasma Cells Volume (TPV)= $B.H\sqrt{\left(\frac{B.W}{26.45}\right)}$ liter
9.	Total Blood Volume in Tachycardia Acute Blood Loss: $TBV_T = TBV * \left[\sqrt{\left(\frac{R.R+B.W}{H.R}\right)}\right]$ liter
10.	Total Blood Volume in Bradycardia Acute blood loss: $TBV_B = \frac{TBV}{\sqrt{\left(\frac{R.R+B.W}{H.R}\right)}}$ liter

In conclusion

This research article presents a novel method for determining cardiac output and ten related parameters by analyzing easily accessible body parameters. The proposed method utilizes heart rate, respiratory rate, body temperature, and body weight to calculate cardiac output, stroke volume, cardiac index, stroke volume index, body surface area, plasma cell volume, total red blood cell volume, total plasma volume, total blood volume in tachycardia, and total blood volume in bradycardia. The study involving 50 individuals and monitoring acute blood loss demonstrates the effectiveness of this method. The Auto Cardiac

Digital Device (ACDD) serves as an efficient tool for implementing this method, offering advantages such as cost-effectiveness, time-efficiency, and applicability at an individual level. The research findings have implications for timely monitoring of physiological and pathological conditions, including cardiac arrest, myocardial infarction, and ventricular defects. The ease of use and accessibility of this method make it a valuable tool for a wide range of populations, contributing to the determination of vital measures and improving healthcare outcomes.

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