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Editorial

Cardiac Index Determinants

Rabindra Nath Das*

Professor, Department of Statistics, The University of Burdwan, Burdwan, West Bengal, India

***Corresponding Author**: Rabindra Nath Das, Professor, Department of Statistics, The University of Burdwan, Burdwan, West Bengal, India.

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Ejection fraction (EF) indicates to the percentage of blood that is pumped (or ejected) out of the ventricles with each heartbeat. One of the most important determinants of the severity of systolic heart failure is the ejection fraction (EF). EF acts as a common measure of a person's cardiac function, and it is generally measured by echocardiogram. EF is always low in patients with systolic congestive heart failure. An individual having low EF is always related with cardiac diseases. The quantity of blood (in liters) that the left ventricle ejects into the circulation system per minute (l/min) is known as cardiac output. Cardiac index (CI) is defined as the ratio of cardiac output (CO) to the body surface area (BSA). Therefore, cardiac index = cardiac output (CO)/ body surface area (BSA) = CO/BSA = SV*HR/BSA, where SV = stroke volume, HR = heart rate. Note that the cardiac index is a composite function, and it is not a directly measurable quantity. The determinants of the cardiac index for shock patients [1-3] have been noted in the current report. The following hypotheses are considered in the present note. What are the determinants of cardiac index for shock patients? How are the determinants related with the cardiac index? What are the effects of the determinants on the cardiac index? In cardiology literature, the answer of the above hypotheses are little known. Based on a real data set [1], these points are examined in the present report.

The above hypotheses are examined based on a data set which is displayed in [1]. This data set can be found at the site: http://www.umass.edu/statdata/statdata/data/shock.txt, or https://www.statcrunch.com/app/index.php?dataid=1327401 The Shock Research Unit (located at The University of Southern California, Los Angeles, California) collected this data set for 113 shock patients on 20 attribute characters/ variables. For each study subject, two measurements (admission time and discharge or before death time) were taken. The patient population, data collection method, and shock types are given in [1]. The determinants of the cardiac index for the shock patients are reported in the present note based on joint generalized linear gamma model analysis [4,5].

The shock data set includes 20 study variables/attribute characters which are gender (male = 0, female = 1), age, height, diastolic blood pressure (DBP), systolic blood pressure (SBP), mean central venous pressure (MCVP), heart rate (HR), mean arterial blood pressure (MAP), mean circulation time (MCT), cardiac index (CI), body surface area (BSA), shock type (non-shock = 1, hypovolemic = 2, cardiogenic, or bacterial, or neurogenic or other = 3), plasma volume index (PVI), urinary output (UO), hematocrit (HCT), appearance time (AT), hemoglobin (HG), survival stage (survived = 1, death = 2), red cell index (RCI), order of card record (initial = 1, final = 2) (OCR).

In the present joint gamma model analysis, the cardiac index (CI) is treated as the response variable and the remaining others are considered as the explanatory variables. For the above three hypotheses, the following interpretations can be obtained from the fitted gamma models.

1) The mean cardiac index (MCI) is inversely related with the age (P = 0.0044) indicating that MCI is higher at younger ages.

2) The MCI is inversely related with the shock type (non-shock = 1, hypovolemic = 2, cardiogenic, or bacterial, or neurogenic or other = 3) (P = 0.0586), indicating that MCI is lower of the shock patients with shock levels at cardiogenic, or bacterial, or neurogenic or other = 3, than the others.

3) The MCI is positively related with the mean arterial blood pressure (MAP) ($P < 0.0001$), indicating that MCI increases as the MAP increases.
4) The MCI is positively related with the heart rate (HR) ($P < 0.0001$), indicating that MCI increases as the HR increases.
5) The MCI is inversely related with the diastolic blood pressure (DBP) ($P = 0.0032$) indicating that MCI increases as the DBP decreases.
6) The MCI is positively related with the body surface area (BSA) ($P < 0.0001$), indicating that MCI increases as the BSA increases.
7) The MCI is positively related with the appearance time (AT) ($P < 0.0001$), indicating that MCI increases as the AT increases.
8) The MCI is inversely related with the mean circulation time (MCT) ($P < 0.0001$) indicating that MCI increases as the MCT decreases.
9) The MCI is positively related with the plasma volume index (PVI) ($P<0.0001$), indicating that MCI increases as the PVI increases.
10) The MCI is inversely related with the hemoglobin (HG) ($P = 0.0053$) indicating that MCI increases as the HG decreases.
11) The cardiac index variance (CIV) is inversely associated with the age ($P = 0.0021$) indicating that CIV is higher at younger ages.
12) The CIV is inversely related with the height ($P = 0.0255$) indicating that CIV is higher of the shock patients with shorter height.
13) The CIV is inversely associated with the sex (male = 0, female = 1) ($P = 0.0582$) indicating that CIV is higher for the male shock patients than female.
14) The CIV is inversely related with the shock type (non-shock = 1, hypovolemic = 2, cardiogenic, or bacterial, or neurogenic or other = 3) ($P = 0.0356$), indicating that CIV is higher of the shock patients with shock levels at hypovolemic = 2.
15) The CIV is positively related with systolic blood pressure (SBP) ($P = 0.0241$), indicating that CIV increases as the SBP increases.
16) The CIV is inversely associated with the mean arterial blood pressure (MAP) ($P = 0.0664$), indicating that CIV increases as the MAP decreases.
17) The CIV is inversely associated with the appearance time (AT) ($P = 0.0080$), indicating that CIV increases as the AT decreases.
18) The CIV is positively related with mean circulation time (MCT) ($P < 0.0001$), indicating that CIV increases as the MCT increases.
19) The CIV is inversely associated with the hematocrit (HCT) ($P = 0.0040$), indicating that CIV increases as the HCT decreases.
20) The CIV is inversely associated with the order of card record (initial = 1, final = 2) (OCR) ($P < 0.0001$), indicating that CIV is higher for the shock patients at the initial card record time.

The determinants of cardiac index for shock patients, their associations and effects on cardiac index have been described above. These above results have been derived based on joint gamma model analysis of cardiac index. It is observed that age and shock types are inversely associated with both the mean and variance of cardiac index. The mean arterial blood pressure (MAP) is positively associated with the mean, while it is negatively associated with the variance of cardiac index. Heart rate is positively associated with the mean cardiac index, but it is independent of variance. Note that heart rate is a direct function of the cardiac index, so it should be positively associated with the cardiac index, which is reflected in the present results. Diastolic blood pressure is negatively associated with the mean, while systolic blood pressure is positively associated with the variance of cardiac index. Body surface area is positively associated with the mean cardiac index. Appearance time (AT) is positively associated with the mean, but it is negatively associated with the variance of cardiac index. Mean circulation time (MCT) is inversely related with the mean, while it is directly associated with the variance of cardiac index. Plasma volume index (PVI) is positively associated with the mean cardiac index, and it is independent of the variance. Hemoglobin (HG) is negatively associated with the mean while hematocrit (HCT) is inversely related with the variance of cardiac index. From the above, it is observed that there are many factors which are related with the cardiac index. Cardiology researchers and specialists will be benefited from the above results.

Conflict of Interest

The author confirms that this article content has no conflict of interest.

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