Cardiometric signs of performance of arteriovenous anastomosis in human cardiovascular system

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Abstract
The detected phenomena of shunting of blood from large arterial trunks into large venous vessels is considered herein. The Cardiocode device is capable of detailed visual interpreting of a change or a significant reduction of a rheographic wave of the ascending aorta. Such a visual interpretation demonstrates some portion of blood is bypassing from large vessels via opening anastomoses into the venous bed. Shown is a variety of sensations and states in patients with this phenomenon. Raised are several issues on future studies and further interpretation of the phenomenon and taking into account the given anatomical & physiological mechanism when assessing the patient’s clinical state and dynamics of the treatment and rehabilitation process.

Keywords
Heart rate variability, Arteriovenous anastomosis, Shunting, Organ failure, Organopathy, Blood circulation

Introduction
The fact itself that there are large anastomoses between arteries and veins available in a human body remains still a debatable topic, while the presence of arteriovenous fistulas of the circulatory system is a long-established factual matter. V. Kulchitsky was the first scientist who detected the arteriovenous fistulas of the circulatory system in extremities. A.G. Fedorova observed in her laboratory a significant vasodilatation of the direct arteriovenous fistulas in the crural fascia and the tendon in a human, when examining anatomical specimens prepared from amputated extremities of patients with obliterating endarteritis. However, as for large hemodynamic arteriovenous anastomoses (AVA), they deserve further consideration and investigation. Nowadays it is not accepted to consider the presence of large arteriovenous anastomoses (shunts) as a norm. Nevertheless, large shunts existing between the arterial and the venous networks are well known for a long time. For example, the Bot-talo’s duct, the largest arteriovenous anastomosis, which sometimes remains in a human since birth. Expanding the methods applied for studies of arteriovenous fistulas in a living individual, for example, by an introduction of microscopic glass balls into arteries in various organs with their further calculation in the flow-back venous blood or serial roentgenography of blood vessels in a living individual, as well as different methods utilized for blood vessel examinations in a dead body, has led to detection of such shunting vessels in almost all the organs in a human.

The aim of the present paper is to identify some cardiometric signs indicating the existence of arteriovenous anastomoses as a phenomenon featuring the vascular system anatomy and physiology and clearly demonstrate the markers of their presence and the objective evidence to support their detection.

Materials and methods
According to the evidence data obtained by Russian scientist T.A. Grigoriev (1954), the arteriovenous anastomoses are located not only in some external parts of the body, but they are also found in the brain circulatory system, the retina and almost all the viscera.

When analyzing the said topic, our special consideration has been given to different materials offered by specialized medical Internet resources devoted to detection of arteriovenous shunts in large arterial and venous basins: “AV shunt between the portal vein and the superior mesenteric artery” furnishes an example thereof [1-3]. Some expert findings, reported
upon examination of the aorta abdominal region with the contrast-enhanced X-ray computed tomography, are good case in point: “No evidence indicating the aortic aneurysm available. Arteriovenous anastomosis between the superior mesenteric artery and the portal vein is available. Portal vein venectasia. Type of the right renal artery anatomical constitution. 60% stenosis of celiac trunk.”

Thus, the arteriovenous anastomoses detected in almost all the human organs should be considered as a natural phenomenon in the circulatory system having a great significance for the local circulation regulation [3].

**Results**

Upon completion of studies conducted with the Cardiocode hemodynamic analyzer [1], it has been established that symptoms of some patients show certain specificity and are correlated to a definite type of hemodynamic pattern. 12 patients were examined with the use of Varicard and hemodynamic analyzer Cardiocode [4-7].

Our more profound targeted studies in patients with different poorly interpretable symptoms have resulted in revealing some signs of anatomical and physiological features of their circulatory system with the arteriovenous anastomoses, which were opened under exercise loading (30 squats).

One of the typical approach to examination of such patients is described below. Figure 1 below exhibits an ECG and a Rheogram of a patient in lying position. The Rheogram demonstrates insignificant signs of a venous outflow disorder.

Figure 2 herein below shows ECG and Rheo curves of the same patient in sitting position; the curves were 30% stenosis of celiac trunk.

Figure 3. An exercise ECG curve accompanied by the respective Rheo tracing of the same patient after completion of 30 squats; standing position.

**Legend:**

1. A decrease in amplitude of the Rheo indicates a sudden pressure release in the aorta. It corresponds to the time of opening of the arteriovenous shunt.

2. The shape of the rheographic curve is changing. The signs indicating an increase in pressure in the venous bed are found (the venous outflow hindrance) during and after the pressure decrease in the aorta.

3. The signs of the normal rheogram curvature before opening of arteriovenous anastomosis and within 2 cycles after the AVA closure.

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recorded immediately after the rest tracings. The signs of the venous outflow disorders are almost not found.

Then an exercise test ECG accompanied by Rheo tracing for the same patient was recorded (30 squats, squat intensity: 1 squat for each 2 seconds). The tracing of the exercise ECG and the respective Rheogram represent standing position of the patient immediately after his exercise loading. The Rheogram has assumed the shape demonstrating alternate segments as follows: the normal rheographic curvature (3) and the next rheographic curvature with a considerably smaller amplitude (1), with pronounced signs of the venous outflow hindrance (2), the significance of which decreases, so that, as a result, the rheographic curve becomes normal again.

In later recordings, an atypical cardiointervalogram of the same patient was recorded, when his heart rate variability was brought under close study [8-17]. Considering the patient's symptoms, taken into account were periodical headaches, some “strange” feelings in the body under exercise loading, which disappeared at rest. In examination, upon completion of 30 squats, the patient reported some strange feelings, which he was not able to exactly describe in detail; it should be mentioned, that the patient's description of his condition was similar to that given above herein: “After the squats I could feel my own heart. My heart was beating too frequently, and I felt as if my heart were moving up and down. After two or three heart beats, I felt something like a side push. So, my feeling was: the heart was moving up and down, and then suddenly I could feel a strange movement to the left.”

Below we take one typical example to illustrate opening of arterioventricular anastomosis that is similar to the case with the above exercise recordings for all the examined patients.

The patient in question reported his symptoms as follows: “Pulsations in the abdominal area, then heart beating. It is starting with periodical pulsations in the abdominal area. It occurs alternately in the pancreatic gland area, in the abdominal area at the left and simply in the abdomen. I can report the same symptoms: first the pulsations take place in the abdomen, and later it appears in the heart! Tachycardia and arrhythmia are developing. Sometimes the heart pulsations disappear, and the heart beating is normalized. In other cases, the heart pulsations give way to cardiac pains. I was examined more than once by different governmental and private clinical institutions, but the medical experts were not able to find something special. They say: it is vegetative-vascular dystonia and gastritis, but nothing else. The cardiologist's record stated arrhythmia and tachycardia.”

In my opinion, the above data can be interpreted as opening of an arteriovenous anastomosis in the abdominal area.

So, the final report should be that the primary cause of the conditions of the given patient and the similar conditions of the other patients is the anatomical & physiological feature of the cardiovascular system along with opening of an arteriovenous anastomosis within the abdominal vascular area. In connection with the above, the following issues for further investigations arise:

1. Should we consider such findings to be a variant of the normal structural design of the vascular system?
2. How often might patients with such functional peculiarities of the vascular system appear in clinical practice?

3. What prognostic value does the detected phenomenon have and how does it influence the organism functional reserves?

The given mechanism, namely the blood bypassing to the venous bed, is tested to be used for correcting the state of patients with hypertension [18, 19]. It seems that some researchers think AV shunting undertakes some preventive functions and can be a part of the protective-adaptive mechanism. Some researchers even suppose that such shunting tactics could be a panacea against hypertension [20]. In any case, it is evident that the described anatomical & physiological phenomenon requires further clarification of a number of questions and searching for adequate and experimentally evidenced answers.

Conclusions

Considering the above typical examples demonstrating the AVA phenomenon, the following conclusion can be reached: the cardiometric method is informative enough to detect the performance of arteriovenous anastomoses as individual anatomical & physiological feature of the vascular system in a human, when using ECG & RHEO exercise recording, capable to identify the relevant markers of opening of arteriovenous anastomoses. The cardiometric method is a simple non-invasive method of examination which is widely available and which is capable of detecting such phenomenon in the performance of the human vascular system.

The final chapter in “Theoretical Principles of Heart Cycle Phase Analysis”, it should be stressed that this book is a result of more than 25
years’ research work by the Russian CARDIOCODE R & D team, states that further research work will make it possible to achieve much success in scientific discoveries and that the design & development of the new medical device CARDIOCODE will provide fresh possibilities practically for every doctor to participate in further scientific studies and investigations. The description of the syndrome complex in the above patients was submitted to Prof. Mikhail Rudenko, Chief of the CARDIOCODE R & D team, for his evaluation. Following his advice, the said syndrome was named after its discoverers: they are Valdimir I. Ermoshkin, an expert in physics, who described the possibility of the existence of the above mentioned mechanism from the point of view of physics, and Vladimir A. Lukyanchenko, a physician, who has identified the syndrome in practice during the relevant tests and examinations. So, the given phenomenon of the anatomical & physiological feature of the vascular system is designated the cardiometric Ermoshkin-Lukyanchenko syndrome.

Statement on ethical issues
Research involving people and/or animals is in full compliance with current national and international ethical standards.

Conflict of interest
None declared.

Author contributions
The author read the ICMJE criteria for authorship and approved the final manuscript.

References