Journal of Clinical and Experimental Cardiology

Cheriff and Debbal, J Clin Exp Cardiolog 2017, 8:10
DOI: 10.4172/2155-9880.1000550

Research Article Open Access

Variability of Pulmonary Blood Pressure, Splitting of the Second Heart Sound and Heart Rate

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Received date: May 24, 2017, **Accepted date:** October 18, 2017, **Published date:** October 30, 2017

Abstract

The study of variation and the change of the second heart sound split (a change related to the inspiration and the expiration) can determine at what time in a cardiac cycle is the inspiration and the expiration. The heart rate increases during the inspiration and decreases during the expiration. It would also be interesting to study the variation in systolic pulmonary artery pressure (SPAP) estimated over several cardiac cycles and understand its evolution since its variation is related to the pulmonary valve on the one hand and the inspiration and the expiration of another part. The algorithm developed based on the Hilbert transform and the energy of Shannon give the second heart sound split. The SPAP will be estimated from the spectral parameters of the second heart S2.

Keywords: Heart sound; Valvular pathologies; Split; Pulmonary blood pressure; Hilbert transform; Heart rate

Introduction

The heart rate increases during inspiration and decreases during expiration. The respiratory sinus arrhythmia (RSA) is a natural variation in heart rate that occurs during a respiratory cycle on an electrocardiogram this phenomenon is considered too subtle changes in the RR interval synchronized with the respiration. The RR interval on an ECG is reduced during inspiration and prolonged during expiration [1]. The following figure 1 shows the anatomy of the heart.

Against the phonocardiogram by changing the interval (split) between the aortic and pulmonary component in a normal subject is indicative since the split increases with inspiration and decreases with expiration. RSA becomes less important with age, diabetes and cardiovascular disease. The following figure 2 shows the variation of the RR interval of an inspiration accompanied by a change in the split of the second heart sound.

Consideration rhythmic variations in cardiovascular disease may better understand the pathophysiological mechanisms involved. Pulmonary hypertension is often accompanied by disturbances of the circadian rhythm of arterial pressure. It has been shown that the reduction in the variability of the heart rate after a myocardial infarction is a predictor of mortality and serious arrhythmias independent of other predictors [2,3]. The study of the change in pulmonary arterial systolic pressure (PASP) in a same cardiac pathology is indicative.

The respiratory sinus arrhythmia may be experiencing cardiac arrhythmia connected to breathing. This arrhythmia is observable by the heart rate variability. Generally, the heart rate increases during inspiration and decreases during expiration. The respiratory sinus arrhythmia is recognized as an index of parasympathetic activity. This idea was proposed by Pagani et al. [4]. Although this concept is used in many studies, it nevertheless emerges from observations without definitively know the origins. Indeed, the origins of the respiratory sinus arrhythmia are not yet clearly identified and are the source of considerable debate within the scientific community. The three hypotheses that are proposed by the scientific community are: The direct influence of medullary respiratory neurons of neurons cardio engines; [5,6]. The indirect influence of changes in heart rate and arterial pressure in response to respiratory movements *via* arterial baroreceptors; [5,7]. A reflex directly in response to lung expansion [5,8,9].

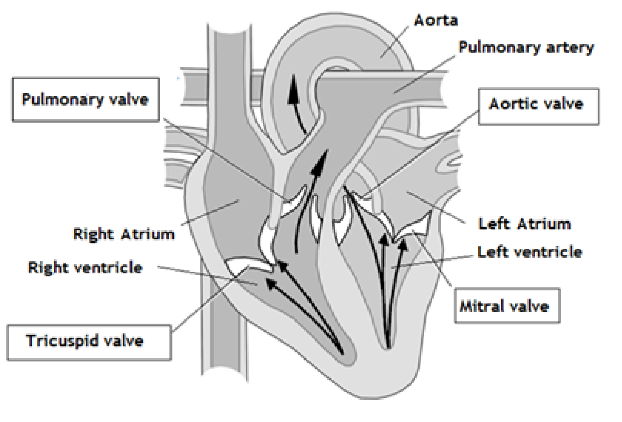

Figure 1: Heart anatomy illustrates

Thus, when analyzing by RR intervals, there is an increase in respiratory sinus arrhythmia in increased respiratory intervals (reduced respiratory rate) [10]. The great influence of respiration on the RR interval is also underlined by the study conducted by Badra and Eckberg [11,12]. This article, which is a carrier of current knowledge regarding the respiratory sinus arrhythmia, allows highlighting the hypothesis proposing the indirect influence of changes in heart rate and blood pressure in response to respiratory movements. This paper argues that it is breathing that controls autonomic rhythms. Thus, this article retrieves the idea of periodicity of the efferent cardiovagal activity that would be influenced by breathing [13]. Indeed, the

Citation: Cherif LH, Debbal SM (2017) Variability of Pulmonary Blood Pressure, Splitting of the Second Heart Sound and Heart Rate. J Clin Exp Cardiolog 8: 550. doi:10.4172/2155-9880.1000550

cardiovagal motoneurons are more likely to be stimulated by the end of inspiration and at the initiation of the expiry. This statement follows the observation that a negative pressure suction applied at the neck creates a larger response of baroreceptors when applied during expiration [12]. The reactivity of baroreceptors depending on when the breathing cycle during which they are stimulated. Baroreceptors react better when stimulated towards the end of the inspiration and the initiation of the expiry. The values presented in this figure 2 represents changes pp intervals that were measured during brief sucking the neck at different times of the respiratory cycle.

Our goal in this paper is to study the variations of three parameters, the heart rate, the split of the second heart sound S2 and the estimated SPAP, a change that can be related to inhalation and exhalation. The heart rate increases during inspiration and decreases during expiration [14] one student variation in the latter as well as the split of the change of heart sound S2 (a change related to the inhalation and exhalation) can be determined what time is in a cardiac cycle to inspiration and expiration. It would also be interesting to study the variation of the SPAP estimated for several cardiac cycles and understand its evolution since its variation is related to the pulmonary valve on the one hand and the inspiration and expiration of the other. Our contribution will also study the influence that can have heart disease on the change in heart rate, the split of the second heart sound S2 and estimated SPAP on cardiac signals that represent the mechanical activity of the heart (PCG signals) and not on cardiac signals that represent the electrical activity of the heart (ECG signals).

Methods

In the first phase we will focus on the study of variation of the heart rate during a period which comprises a plurality of cardiac cycles and the relation of this variation with the change in the split of the second heart sound S2 and the change of the estimated SPAP. It is therefore important to isolate the sound S2 of each PCG signal studied using the separation algorithm based on segmentation PCG signal [15,16]. The location moments of beginnings and ends of each S2 sound allows us to appreciate the duration of the cardiac cycle, From the results obtained, we can calculate the average duration of the cardiac cycle (over several cardiac cycles), then the frequency heart which is shown in beats per minute (bpm). (S2 is taken as a benchmark in all these calculations). As a result we will calculate the split of the second heart sound S2 by the application of the developed algorithm. The ASP will be estimated from the spectral parameters of the S2 sound.

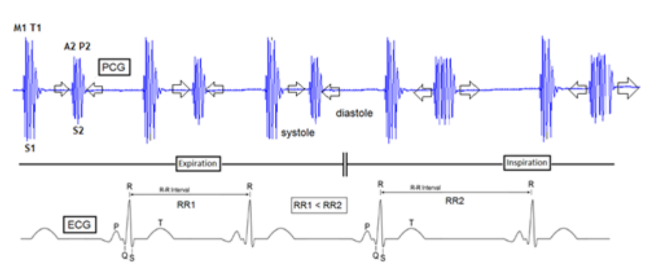

Figure 2: Changing in the RR interval and splitting of second Heart sound in the normal ECG and PCG signal during inspiration and expiration

PCG signals used are signals which may have at least 35 cardiac cycles; the calculation of the split and the estimation of the ASP will be conducted for each of the noise signal S2. The following algorithm describes the different stages of our analysis (figure 3).

Results

Valvular heart diseases are diseases of the heart valves: mitral valve or aortic valve mainly, although other heart valves may also be affected. We have seen that the normal physiological duplication is characterized by a widening of the gap between the two components of the second heart sound S2 inspiration and a narrowing of the same space during expiration. The calculation of the split (term physiological duplication) and the heart rate is important for seeing whether valvulopathie influences their variations and changes in the estimated SPAP.

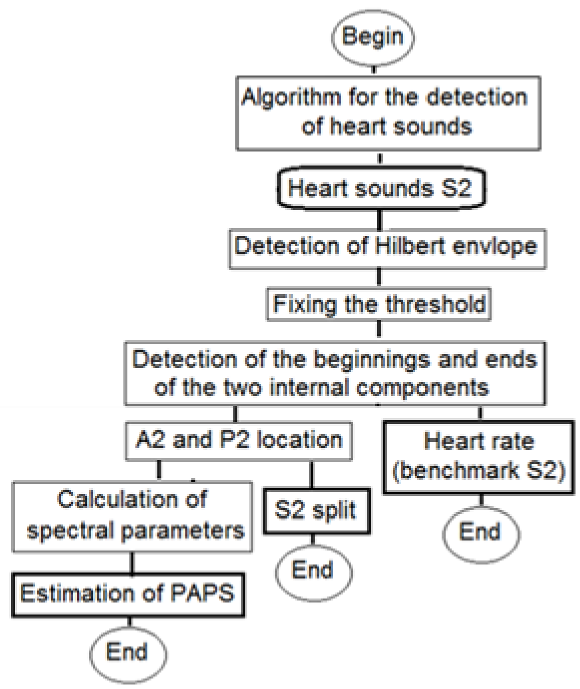

Figure 3: Algorithm for calculating heart rate (S2 reference), the split of the second heart sound S2 and the estimated SPAP.

Our algorithm is applied on two PCG signals which have reached a mitral (MR and MS), three PCG signals affecting the aortic valve (SA5, SA6 and SA7) and a signal having a pulmonary stenosis (PS). When blood flow is slowed, the heart is then obliged to work more to operate normally. These disorders cause a dilation and heart fatigue; breathlessness and risk of lower limb edema, malaise sometimes fainting and palpitations and advanced heart failure. Valvular heart diseases are often asymptomatic, and did reveal that during a sudden complication. Often the disease is silent, and the patient does not necessarily realize signs of valvular disease. This can therefore evolve until the symptoms generally indicative of a more serious offense, occur.

However, some signs may indicate heart valve disease: shortness of breath on exertion and/or at rest, palpitations..etc [17]. The medical auscultation can detect the presence of a heart murmur or irregular heartbeat (calculates the heart rate) which can be signs of heart valve disease. This will be confirmed by the split and calculates the estimate of SPAP, which also measures the impact of valve disease [18]. The following figures show the application of the developed algorithm for calculating heart rate, the time interval between the internal components of the second heart sound and the results of the SPSP estimated for each heart sound signal S2 of each PCG cited above.

The application of the algorithm developed on the various PCG signals is very revealing; the variability of the heart rate and duration of the split of the second heart sound S2 and the estimated value of the SPAP are one harmony. If there is an increase, the duration of the cardiac cycle was in a parallel increase in the split of S2 and even the value of the estimated SPAP and the opposite is checked (in the case of a decrease).

The measures presented in our study highlight the change of the cardiac cycle during inspiration and expiration. This variation varies from one signal to another. An inspiration or expiration can contain 3 to 5 cardiac cycles in a period that changes.

Conclusion

The study of the variability of the heart rate, the split of the second heart sound S2 and pulmonary blood pressure appears to be a practical indicator for the diagnosis, prognosis and treatment of certain cardiac pathologies. The developed algorithm allows the observation of the heart rate (in case of disorder). One of the symptoms of valve disease is palpitations (increased heart rate) which sometimes manifest no symptoms. Only a heart murmur, audible with a stethoscope, a testament to his presence. Heart rate can have a very significant change in a disorder of the electrical activity of the heart (arrhythmia cases) compared to a disorder of the mechanical activity of the heart (the case of valve disease). The value of the split of S2, if it is considered as a variable along a normal heart activity can become relatively constant for some pathological cases. The duration of the split S2 increases during inspiration and decreases during expiration. The developed algorithm allows monitoring of systolic pulmonary artery pressure; it presents an effective means of diagnosis of clinical manifestations and complications of valvular heart disease. It allows discerning increases in pressure that cause expansion and enlargement of the left atrium with a long-term consequence is the occurrence of atrial arrhythmias as atrial fibrillation.

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