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Case Report

Practical Applications of Simultaneous Posture Analysis during Ambulatory Electrocardiogram Monitoring: Case Series

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Abstract

Ambulatory Electrocardiogram (ECG) monitoring is the gold standard for the diagnosis of arrhythmia. The same ECG can have a different clinical significance according to the patient's posture such as supine or running. However, widely used ambulatory ECG monitoring does not contain the information regarding posture. Here, we describe three cases that showed practical applications of simultaneous posture analysis when a documented ambiguous arrhythmia was interpreted for its clinical significance.

Keywords: Ambulatory; Electrocardiogram; Posture; Simultaneous

Introduction

Ambulatory Electrocardiogram (ECG) monitoring remains an essential diagnostic modality when arrhythmia is clinically suspected. However, it is insufficient to analyze the clinical significance of arrhythmia by ECG rhythm alone. Brady-arrhythmia documented during sleep or tachy-arrhythmia during exercise is not generally an indication for aggressive treatment [1]. Therefore, both abnormal ECG and the patients' activity when it is registered should be considered simultaneously to make a decision for a suitable care. For some of the patients, in particular who are elder or in poor conditions, cannot remember their previous activity accurately. In such situations, additional information regarding activity of patients is needed. However, existing ambulatory ECG monitoring system does not contain the information [2-5]. The current study investigated the clinical significance of simultaneous posture analysis during 24-hour ambulatory ECG monitoring.

Methods

We used an inertial measurement unit-based sensor (Cubemotion; Seedtech, Bucheon, South Korea) for human posture analysis after modifying the hardware for patients' convenience (Figure 1A). The sensor was attached on the upper sternum simultaneously with electrodes for 24-hour ambulatory ECG monitoring (Figure 1B). After 24-hour examination, data stored in sensor were extracted and analyzed using our own software. The activities were roughly categorized as two static (supine and sitting or standing) and three dynamic (walking, running, and fast running) postures. Each activity was displayed as a linear graph continuously during 24 hours (Figure 2A). Therefore simultaneous posture state could be assessable during clinically ambiguous ECG (Figure 2B). Informed consent was obtained from participants, and this study was approved by the Institutional Review Board (IRB) of Pusan National University Hospital, Busan, South Korea (IRB number: H-1709-015-058).

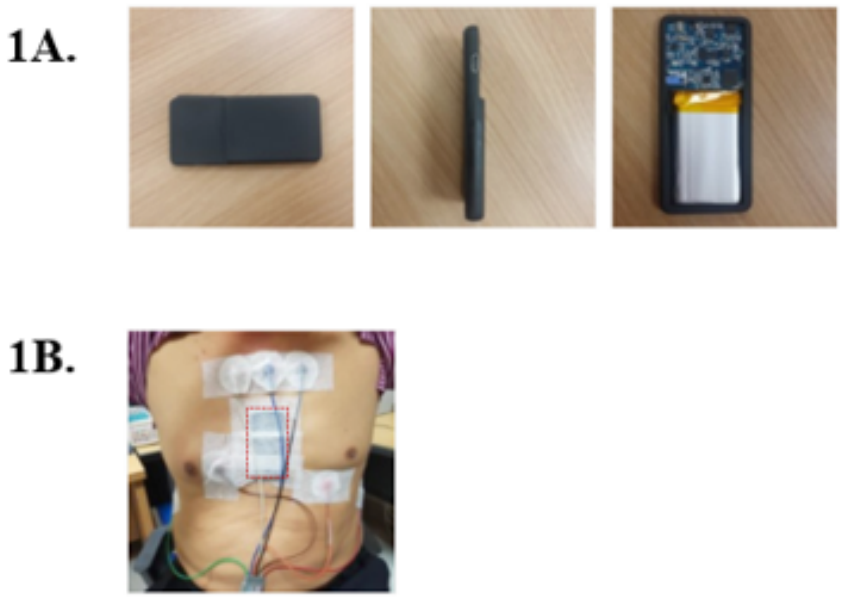

Figure 1: The inertial measurement unit-based human motion sensor: front (left), side (middle), inside (right) **(A)**. The sensor was attached on the upper sternum (red quadrangle) simultaneously with electrodes for electrocardiogram monitoring **(B)**.

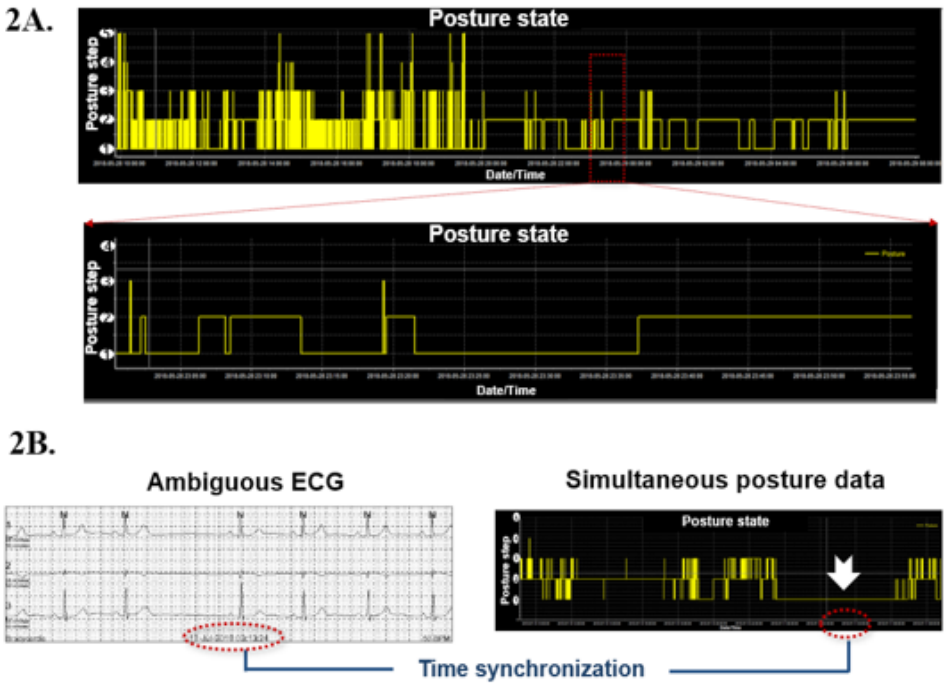

Figure 2: Display of posture state. Date/time and posture step (1: supine, 2: sitting or standing, 3: walking, 4: running, 5: fast running) are shown on the horizontal and vertical axis, respectively (upper figure). Magnified specific part (marked red quadrangle) is shown in the lower figure **(A)**. Simultaneous posture state (right) can be assessable by searching the same time of clinically ambiguous electrocardiogram (left) **(B)**.

Case Presentation

Case 1

A 49-year-old male came to our institute due to first degree Atrioventricular (AV) block revealed in his ECG during a regular check-up. He insisted he had no complaints during soccer game, once a week, and strongly denied any bradycardia-related symptoms in his life. However, ambulatory ECG showed a high-grade AV block preceded by Mobitz type I AV block with long pause of 7.53 seconds at 11:29pm (Figure 3A-1). He did not record what he did during the episode and remember when he went to sleep on the examination. He strongly refused Pacemaker (PM) implantation. Sensor data was reviewed and showed 'supine' position simultaneously with the changes in ECG, which meant the long pause occurred at resting state during nighttime (i.e. sleeping) (Figure 3A-2). Electrophysiology (EP) study revealed that it was supra-His level AV block. Although high-grade AV block generally requires a permanent PM, it has been deferred in this patient due to his strong refusal and clinical suspicion of vagally mediated bradycardia, based on the sensor data and result of EP study.

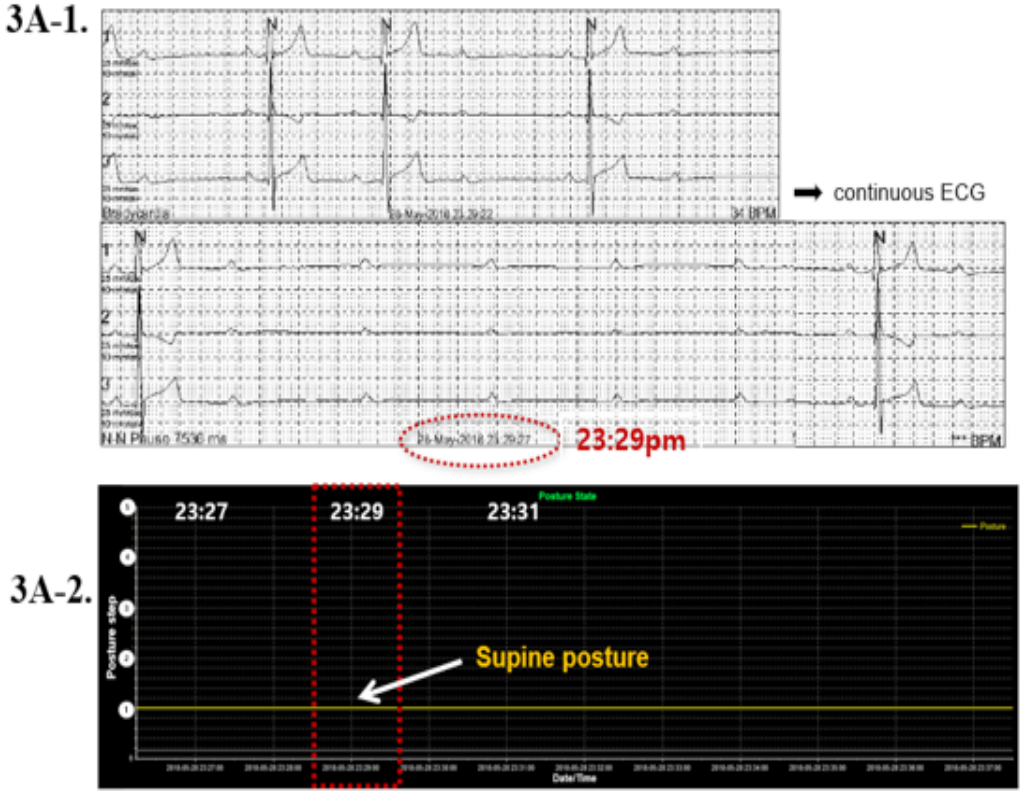

Figure 3A: Vagally mediated high grade atrioventricular (AV) block following Mobitz type I AV block with long pause of 7.53 seconds at 11:29pm **(1)**. Motion data showing supine posture (posture step 1) simultaneously with the bradycardia **(2)**. Number 1 to 5 on vertical axis indicate supine, sitting or standing, walking, running, or fast running, respectively.

Case 2

The 24-hour ambulatory ECG of 76-year-old male complaining of palpitations showed Sinus Tachycardia (ST) 144 Beats Per Minute (bpm) at 10:44am (Figure 3B-1). Simultaneously the sensor data showed 'running' position, therefore, physiologic response was a reasonable diagnosis rather than inappropriate ST, supraventricular tachycardia occurring near sinus node and resembling ST, or psychological problem in this patient (Figure 3B-2).

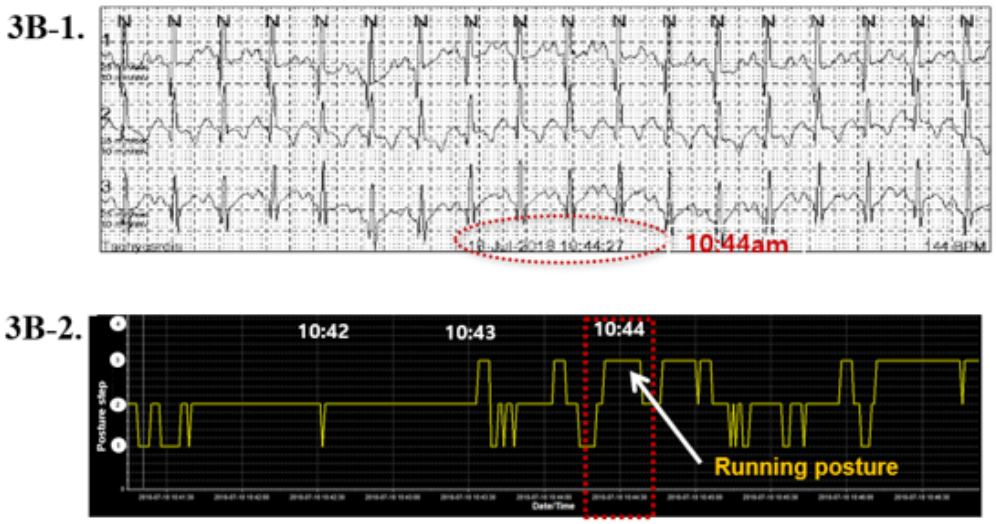

Figure 3B: Electrocardiogram showing supraventricular tachycardia **(1)**. The posture data indicates running state at the same time **(2)**. Tachyarrhythmia on figure considered as sinus tachycardia **(1)**.

Case 3

We noticed ST of 122bpm during daytime in a 21-year-old male patient (Figure 3C-1). The sensor simultaneously recorded his activity as 'supine' position (Figure 3C-2). Medical conditions such as anemia, dehydration, pulmonary embolus, hyperthyroidism, and fever were excluded. The average Heart Rate (HR) in 24 hours was 114 bpm; therefore, inappropriate ST was diagnosed in this patient. He was suffering from autonomic nervous dysfunction due to traumatic brain injury and bed-ridden state due to semi-comatose mentality. After a 5-week therapy with beta-blocker and ivabradine, the average HR decreased to 94 bpm.

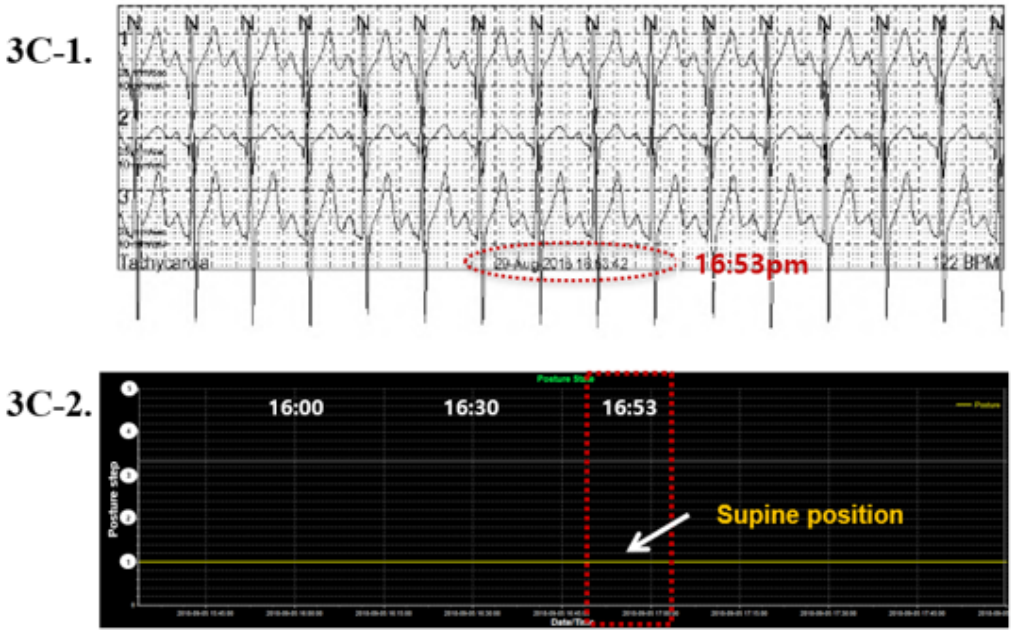

Figure 3C: Electrocardiogram showing sinus tachycardia, as in Figure 3B-1 **(1)**. The motion data showing supine position, meaning this arrhythmia is non-physiological response **(2)**.

Discussion

To the best of our knowledge, this is the first report demonstrating the relationship between ECG and simultaneous patients' activity data. We would like to highlight the importance of information about posture when clinical significance of ambiguous arrhythmia was interpreted from the current cases. The changes in physical activity influence heart rhythm probably due to cardiac autonomic modulation [6,7]. It is affected by altered autonomic balance between sympathetic and parasympathetic functions, i.e. the rise in sympathetic and the withdrawal of parasympathetic components increases the HR, and vice versa [8]. Both systems might be responsible for the electrophysiological trigger of arrhythmia [9]. In the first case, high grade AV block during the nighttime was noticed. Generally, the nocturnal period is characterized by vagal predominance, but it is restricted during not 'nighttime' itself but 'sleeping' state [10]. That is, what the patient did during marked bradycardia at nighttime is a fundamental information to decide whether permanent PM should be implanted.

In our case, the sensor objectively noticed a supine posture simultaneously with AV block occurrence, therefore vagally mediated high grade AV block was clinically suspected and then PM was deferred. Transient vagally mediated AV block is considered to be related to neural reflexes, therefore, may be an incidental finding during sleeping at night [11]. It is characterized by paroxysmal AV block associated with preceding simultaneous slowing of the sinus rate with irregular PP intervals, heterogeneous presentation of AV block, ventricular asystole, and supra-His level block, as it was in our case [12]. Vagally mediated AV block could be differentiated from intrinsic AV block if bundle branch or bifascicular block is present, triggered by a premature beat without sinus slowing or PR prolongation, or block level is localized in the His-Purkinje system [13]. Medical treatment or permanent PM is not indicated for vagally mediated AV block, unless the patient has any associated cardiac symptoms [14].

Both of the second and the third case were associated with ST, but their clinical background was completely different.

In the second case, rhythm during light palpitations was registered as ST with 144bpm. But, since the patient did not record what he did during the episode on ambulatory ECG monitoring, it could not be differentiated from sinoatrial reentrant tachycardia or atrial tachycardia originated very close to sinoatrial node. However, because the sensor data showed running posture during tachycardia documentation, the rhythm was interpreted as ST, most likely, in our case. Acceleration of sinus rate in response to exercise, due to increased sympathetic tonicity is a physiologically normal phenomenon. On the other hand, ST during resting state might be pathologic. Inappropriate ST is defined as a sinus rate higher than 100 bpm, mean 24-hour HR higher than 90 bpm, without reversible causes, and is associated with any uncomfortable symptoms or signs of tachycardia [15]. In the third case, inappropriate ST was considered to occur due to the central nervous system damage. Physiologic ST rarely needs management, whereas inappropriate ST sometimes requires medical treatment.

Therefore, differentiation between both is clinically important, and the posture data may give significant value in establishing diagnosis, as it was in our case. Recently various types of devices for ambulatory ECG monitoring are widely available [2-5]. Some of them can provide activities of users, however to the best of our knowledge, none of these devices provide the information of examinees' posture simultaneously with ECG [16]. Previous studies investigating physical activity or posture have focused on HR variability, burden of arrhythmia, cardiovascular prognosis, or association with sleeping behavior, but not ECG finding itself. In this study, activities were roughly classified in 5 postures [17-20]. It might be insufficient to figure out the accurate condition of the patients, however, this study hypothesized that a cardiac rhythm was mostly influenced by gross motor skills rather than fine movements.

Conclusions

Simultaneous posture analysis with ambulatory ECG monitoring has strong practical implications for interpreting the clinical significance of an ambiguous arrhythmia. Based on this study, simultaneous side-by-side display of posture and ECG would help clinicians to make a decision independent of patients' self-reports or further diagnostic examination.

Conflicts of Interest

The authors have no competing interests.

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