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Saah electrocardiogram at the Doctor's Office

Abstract

Since the invention of the electrocardiogram in 1903 and the refinement of the methodology in 1909 by Willem Einthoven, there have been few variations in obtaining electrocardiographic recordings until Gary Chen observed in 2015 that what is called the baseline in the electrocardiogram (ECG) contains very low-voltage microwaves that can be recorded from the surface. These microwaves are found before the P wave, prior to the beginning of ventricular depolarization, and after ventricular depolarization (ST segment). In the doctor's office, the same model that recorded PHS-A10 microwaves in a patient with asymptomatic extreme bradycardia at rest was used. This model simultaneously compared the conventional ECG with the Saah ECG (SAN-Atrial-AVN-His). Both methods detected a third-degree complete AV block, with the advantage of the Saah ECG providing measurements analyzed by intelligent high-resolution analysis (IHRA).

Conclusion: In the doctor's office, this is a tool that complements the conventional ECG by providing measurements of the cardiac conduction system that could aid in the localization of His bundle blocks.

Keywords: new wavelets, Saah ECG, AH interval, Bundle of His, HV interval, Non-invasive electrophysiology, PA interval, PR interval.

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Abbreviations: Atrial fibrillation (AF); AH interval (Atrium to His); bs BHE (Bundle of His Electrogram); Dual-chamber rate modulation (DDDR); Electrocardiogram (ECG); Glomerular filtration rate (GFR); Intelligent high-resolution analysis (IHRA); His-bundle pacing (HBP); HV interval (His to ventricle); Left Bundle Branch Block (LBBB); Left bundle branch area pacing (LBBAP); Right Bundle Branch Block (RBBB); Saah ECG (SAN-Atrial-AVN-His); Sinus rhythm (SR)

Introduction

A bit of history. In 1873, Augustus D. Waller recorded the first cardiac activity in a rudimentary form, calling it an Electrocardiogram (ECG). Years later, in 1903, Willem Einthoven, born in a Dutch colony at the time, recorded cardiac electrical potentials with a string galvanometer. This admirable scientist perfected the methodology of electrical recordings, and in 1924, Einthoven was awarded the Nobel Prize for his remarkable work in inventing the first practical electrocardiography system used for the medical diagnosis of cardiovascular diseases. Since then, there were no major substantial changes to this ingenious diagnostic method in everyday use until 2015, when Gary Chen's group first recorded microwaves on human ECGs non-invasively from the surface, using the same 12-lead standards. Initially, the technique was called "Electrophysiocardiogram (EPCG)".[1] This was achieved using a PHS-A10 electrocardiograph, which was subsequently successfully tested on one hundred healthy patients and others with cardiac arrhythmias.

In 2017, Gary Chen coined the name Saah ECG (SAN-Atrial-AVN-His) because it can discriminate the different segments of the cardiac conduction system from the surface with greater precision, non-invasively, and in real time. It was initially performed in animal models and subsequently in human models.[2] An internet search revealed no information in the medical literature regarding the use of the PHS-A10 device for simultaneous recordings (ECG and Saah ECG) in patients during routine medical check-ups, nor regarding its potential utility in urgent medical decision-making. This integrated review aims to share comprehensive information on a non-invasive diagnostic intervention in a patient with extreme bradyarrhythmia requiring an urgent medical decision.

Material and methods

The recordings were obtained from a patient in the doctor's office using a PHS-A10 device, following standard procedures for conventional ECG recording and adhering to the Saah ECG recording methodological guidelines (avoiding noise, telephone communications, technical interference with magnetic fields, or devices emitting frequency waves that could interfere with the recording). The patient was placed in a relaxed prone position with their eyes closed to prevent body movement. The skin was then cleaned with a wipe moistened with rubbing alcohol. Subsequently, the electrodes, which contained a paste with a non-cytotoxic silver/silver chloride substrate, were applied.[1,3]

The recordings were obtained simultaneously: conventional 12-lead ECG at 25 mm/s and 10 mm/mV, Saah ECG/conventional ECG at 25 mm/s and 20 mm/mV, and bsBHE (His bundle electrogram) at 25 mm/s and 80 mm/mV. In the last recording, 3 beats were analyzed, the heart rate in milliseconds and its equivalent in beats per minute, the PA, AH, HV intervals and the PR interval in milliseconds. This PHS-A10 device detects very low-intensity (0-150 Hz) "microsignals" or "microwaves" corresponding to cardiac electrical potentials of the cardiac conduction system, reflected in the different segments and intervals of the conventional P-QRS-T wave.

These analyzed microwaves can be found in a total of 11 to 19 microwaves (3-6 preceding the P wave, 4-6 preceding the QRS complex, and 4-7 following the QRS complex). These latter ones are located in the ST segment.[4] Microwave recordings are taken simultaneously with P-QRS-T recordings from the conventional ECG. The recordings are scanned and processed simultaneously with an "intelligent high-resolution analysis" (IHRA) that provides us with precise measurements, microvoltage relationships between the recorded elements, ECG quantification, microwave evaluation, and even the absence of microwaves.

Regarding a cardiology case: a 72-year-old male patient with controlled type 2 diabetes (metformin 850 mg twice daily), a body mass index (BMI) indicating mild overweight, non-hypertensive, non-smoker, dyslipidemic treated with atorvastatin 20 mg/day, and a glomerular filtration rate (GFR) of 74.86 mL/min/1.73 m², presented because during a recreational gymnastics activity, his pulse was taken with a portable pulse oximeter due to listlessness, weakness, and dizziness. The gym instructor found a regular pulse rate of 30 beats per minute with an indirect pulse oximetry saturation of 97%, and he was therefore referred to a medical clinic.

Following simultaneous ECG recording (Figure 1), simultaneous analysis of the AV node and His bundle branch (Figure 2), and simultaneous graphical representation of the two ECGs (Saah ECG and conventional ECG) (Figure 3), a diagnosis of third-degree AV block with minimal symptoms was established. The conduction system measurements obtained were analyzed, and the patient was immediately transferred to the Intensive Care Unit. Figure 4 shows amplification of the P-QRS-T complex and its intervals with their respective measurements.

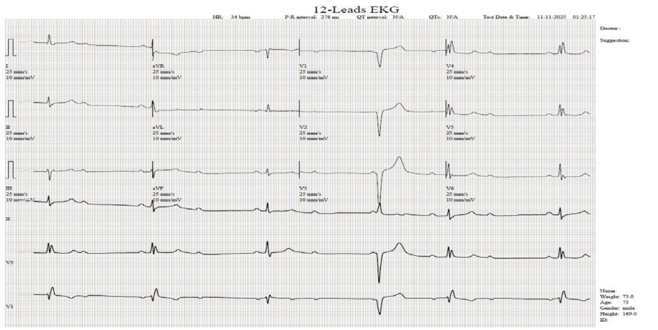

Figure 1 12-lead electrocardiogram (ECG). Third-degree AV block, wide QRS complex (RBBB) and one escape rhythm (LBBB).

Figure 2 Saah vs ECG. They alternate between the upper line with Saah ECG and the lower line with conventional ECG (simultaneous ECGs).

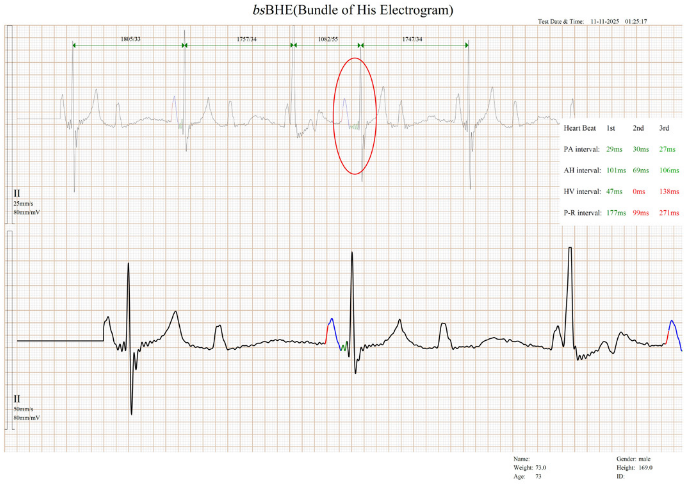

Figure 3 ECG lead (DII). Upper line: 25 mm/sec/mV; lower line: 80 mm/sec/mV. Red circle analyzed by Saah ECG and represented in the box on the right as the 3rd beat (HV 138 ms). RR 1805 ms. Complete 3rd-degree AV block. No HV is recorded during the 2nd beat (N/A).

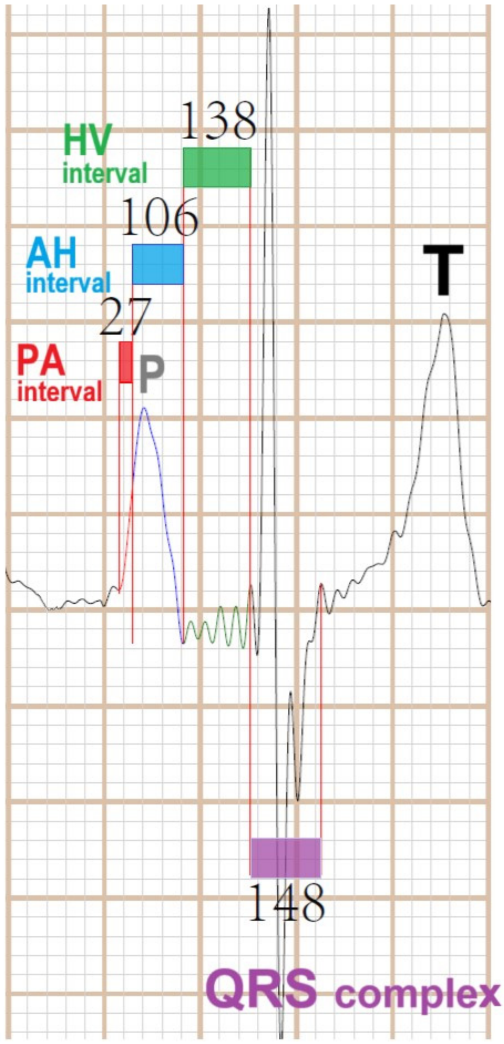

Figure 4 Magnified image of the P-QRS-T complex obtained from the His bundle electrogram (bsBHE) in lead II (25 mm/s). Red bar: PA interval = 27 ms. Light blue bar: AH interval = 106 ms. Green bar: HVinterval = 138 ms (prolonged). Purple bar: 148 ms (wide QRS complex). Microwaves preceding the QRScomplex are shown in green.

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Results

The Saah ECG shows: "bs BHE (Bundle of His Electrogram) a 3rd degree AV block, wide QRS complex with a Right Bundle Branch Block (RBBB) pattern, measured from three consecutive heartbeats (referred to as the first, second, and third beats). The RR interval between the first and second beats was calculated as 1805 ms (33 beats per minute), and the interval measurements were: PA interval (25 ms, 27 ms, and 30 ms), AH interval (106 ms, 46 ms, and 106 ms), HV interval (48 ms, 0 ms or N/A, and 138 ms), and PR interval (179 ms, 73 ms, and 272 ms). During the conventional ECG, a single wide QRS escape pattern with a Left Bundle Branch Block (LBBB) pattern was observed.

Discussion

When no reversible causes of third-degree AV block are found, regardless of symptoms, in a physically active patient with a good life expectancy of one year, definitive dual-chamber pacing (DDDR, or dual-chamber rate modulation) is recommended. If possible, the ventricular catheter should be placed for physiological pacing: his-bundle pacing (HBB) or left bundle branch area pacing (LBBAP).

According to the 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy, this indication is Class I with a level of evidence C: "Dual-chamber pacing is indicated in patients in sinus rhythm (SR) with permanent or paroxysmal 2:1 infranodular AV block of the second or third degree (advanced or high-grade), regardless of symptoms".[5]

In the recording table, HV interval data cannot be established or are not recorded during the second beat (N/A) because no electrical inflection or passage of the bundle branches of the His bundle is detected. During the third heartbeat, a clear prolongation of the HV interval (138 ms, normal: 30 to 55 ms) and the PR interval (236 ms, normal: 120 to 210 ms) is observed. This is a practical and cost-effective procedure that can be performed simultaneously with a conventional ECG. The PHS-A10 model allows recordings at 12, 30, 60 seconds and 3, 5, and 10-minute intervals, which can be saved for later analysis. Furthermore, it is a non-invasive procedure that can be used in supraventricular arrhythmias to determine their duration, onset, and termination.

The new images clearly show the widening of the QRS (148 ms) caused by conduction block in the His-Purkinje system, including local images of HV interval block and block at terminal positions of Purkinje fibers. The Saah ECG was used in experimental animals to demonstrate immediate changes in post-QRS microwaves (ST segment) following controlled experimental coronary occlusions in pigs. Early changes were observed that anticipated the ST segment elevations induced in the experimental animals.[6] These findings in experimental animals require further study to draw definitive conclusions.

The future is promising, as predictive models of atrial fibrillation (AF) are being studied in patients with high cardiovascular risk and, therefore, high risk of developing it, especially in patients with paroxysmal AF. There are few reports of patients with coronary artery disease undergoing Saah ECG before and after percutaneous transluminal coronary angioplasty (PTCA), but there are still no conclusive data. Case reports and controlled comparative studies are needed.

Limitations

Although the simultaneous recordings of the conventional ECG and Saah ECG of this patient presented demonstrate with evidence the Complete 3rd degree Block, they provide us with measurements to understand the cardiac conduction system. This data can help us in the medical office for entities such as patients with a prolonged ST segment, differences between ventricular arrhythmias, aberrant supraventricular arrhythmias or 2nd degree AV Blocks. Randomized, controlled, comparative studies in patients with cardiac arrhythmias are needed.

Conclusion

The Saah ECG could be useful in clinical practice, as it allows simultaneous comparison with the conventional ECG and provides non-invasive measurements of the conduction system, complementing them with the likely localization of the His bundle in extreme bradyarrhythmias.

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Conflicts of interest

I declare that I have no conflict of interest.

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