Point-of-care aid-to-diagnosis for heart failure using artificial intelligence based on seismocardiography acquired with a smartphone in the emergency department

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Background: The number of new heart failure (HF) diagnoses in hospitals constantly increases. The associated clinical signs lead to a delay in treatment. Reliable and rapid diagnostic assistance is needed at earlier stages and can be an added value to accelerate the process. Kinocardiography (KCG), based on Seismocardiography (SCG), allows the computation of non-invasive cardiac kinetic energy that is used to characterize the cardiac function and could detect HF among patients at risk.

Purpose: In a multi-centric study, test the performance of smartphone-based KCG recording in diagnosing HF in the emergency department.

Methods: Adult patients who presented with dyspnea in the emergency department (ED) were recruited. Clinical characteristics were recorded, including demographics, symptoms, medication use, and diagnostic studies. Additionally, a blood sample was collected for NT-proBNP measurement, and a 180-second KCG acquisition was acquired with a smartphone. The patient is placed supine on the back, and the smartphone is placed on his chest to acquire the precordial vibrations due to the heartbeats. From these vibrations, cardiac kinetic energy (CKE) metrics are derived, including diastolic gradient kinetic energy (\(\Delta_iK_{diastolic}\)). The final HF diagnosis was assessed from the medical record at discharge from the ED. The primary outcome is the performance of an AI based on CKE metrics at classifying HF, measured using metrics including the area under the receiver operating characteristic curve (AUROC), negative predictive value (NPV), and specificity, with two-sided 95% CIs.

Results: 295 patients were recruited; among these, 106 patients were diagnosed with HF (78 [69;83] years, 26.9 [23.2;29.3] kg/m², 42% male, 4933.0 [3299;8055] pg/ml, 67 HFpEF, 10 HFmrEF, 29 HFrEF) and 189 without HF (64 [55;74] years, 28.1 [25.5;31.4] kg/m², 51% male, 297.0 [90;813] pg/ml). \(\Delta_iK_{diastolic}\) was significantly lower in patients with HF (0.35 [0.08;0.70] vs. 0.06 [-0.04;0.32]%, p < 0.005). The AI approach resulted in an AUROC of 0.82 (0.80 – 0.89), sensitivity of 82.5% (72.7 – 90.9%), and NPV of 79.3% (77.5 – 82.6%).

Conclusion: This study shows that an AI system applied to SCG acquired during a 3-minutes examination with a smartphone can detect HF among patients presenting dyspnea. These findings highlight the potential for non-invasive, workflow-adapted, point-of-care, aid-to-diagnosis for earlier diagnosis and prognostically beneficial treatment.
Figure 1: Receiver operating characteristic curves based on the smartphone SCG acquisition for the detection of heart failure among patients with dyspnea symptoms.