Computer based Digital Phonocardiography Screening for Heart Disease in Childhood

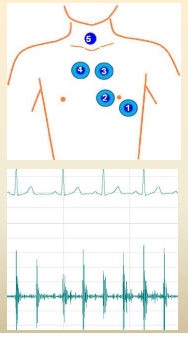
Germanakis I. (1), Antonakakis M. (2), Giakoumaki D.(2), Gianikaki S.(2), Stylianou Y. (2)
Pediatric Cardiology Unit, Dpt of Pediatrics, Faculty of Medicine, University of Crete, Greece (1);
Computer Science Dpt, School of Sciences and Engineering, University of Crete, Greece (2)

Objectives. To evaluate whether an **automated computer-based algorithm** for **digital phonocardiogram (PCG)** interpretation **could detect systolic murmurs** and **differentiate** innocent from abnormal murmurs, thus being capable of **supporting large scale screening systems** for structural heart disease **in childhood**.

Methods

A. Database:

- ***Retrospective study*** including anonymized ***PCGs*** obtained from ***820 children***, (age 1-14yrs) either during **school screening program (S.P)** or during their visit in a **pediatric cardiology outpatient clinic (P.C).**
- ***In each*** case ***3-5 recordings*** were obtained (apical, lower and upper left sternal border) by using
- a commercial digital stethoscope allowing for ***3-lead ECG and PCG channel*** simultaneous recording.
- PCGs have been ***off-line labelled*** by an expert pediatric cardiologist as corresponding to ***absence of a murmur (A)***, presence of ***innocent murmur (I.M)*** or of ***abnormal systolic murmur (A.M).***
- All P.C cases and all S.P cases with abnormal murmurs had confirmatory ***echocardiographic evaluation*** data, ranging from normal to a wide range of CHD.



B. Automated PCG analysis:

- Recordings with unacceptable noise were manually removed.
- ***ECG channel R peaks*** and an ***envelope-based detection algorithm*** were used to define the ***systolic interval.*** Fig. 1
- Following ***band-pass filtering*** of PCG signals a ***classification scheme*** using ***Support Vector Machines*** have been used. Fig. 2
- ***System training*** was performed by a dataset of 450 subjects with I.M (n=329) and A.M (n=121).
- ***Sensitivity (Sens.)*** and ***specificity (Spec.)*** in detecting: 1) the presence of a ***murmur*** and 2) of an ***abnormal murmur*** has been estimated in various scenarios.

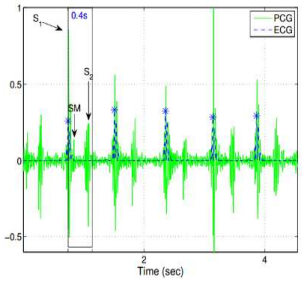


Fig 1. PCG signal (solid) with innocent murmur (IM) and envelope of ECG signal (dash). Stars at maximima of ECG envelope (R-peaks), point to the beginning of heart cycles.

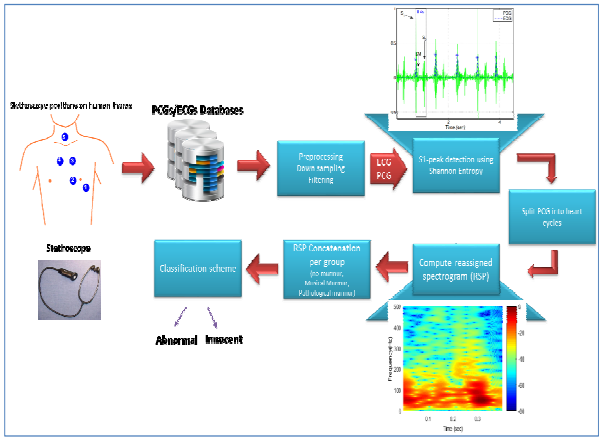


Fig 2. Block diagram of PCG classifier

Results

783 cases (95%) with **2677 recordings** of acceptable quality have been analyzed. They represented cases with **absence of murmur** (A =256), **innocent murmur** (I.M =352) or **abnormal murmur** (A.M=175).

Presence vs absence of murmur

Performance in detection of systolic murmur (against murmur's absence)

In *complete database* (S.P+ P.C)

- **Sensitivity 93%**
- **Specificity 88%**

Abnormal vs Innocent murmur

Performance in detection of an abnormal murmur (against innocent) Fig.3

A. In *complete database* (S.P+ P.C)

- **Sensitivity 95%**
- **Specificity 35%**

B. In *school obtained database* (S.P)

- **Sensitivity 84%**
- **Specificity 72%**

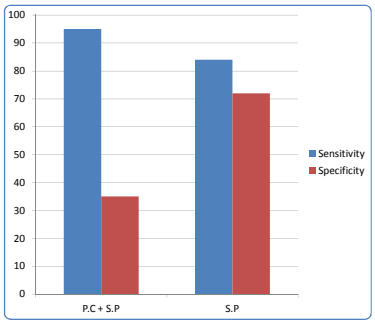


Fig 3. Correct classification of abnormal murmurs (against innocent) when validating all (left) and only school obtained (right) digital phonocardiograms.

Conclusions

Automated PCG classifiers could serve as useful means in **supporting pediatric cardiac auscultation interpretation**. Further software developments and large prospective studies **could allow for cost-effective heart disease screening systems in childhood**.

Authors declare that there is no conflict of interest