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Computer based Digital Phonocardiography Screening for Heart Disease in Childhood

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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: 1) 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 from apical, lower and upper left sternal border positions, by using a commercial digital stethoscope, allowing for 3-lead ECG and PCG channel simultaneous recording. PCGs have been off-line labeled 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, from normal to a wide range of CHD. Recordings with unacceptable noise artifacts were manually removed. 2) Automated PCG analysis: ECG channel R peaks and an envelope-based detection algorithm were used to define the systolic interval. Following band-pass filtering of PCG signals a classification scheme using Support Vector Machines have been used. 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 the presence of a murmur and of an abnormal murmur has been estimated in various scenarios.

Results: 783 cases (95%) with 2677 recordings of acceptable quality have been analyzed, belonging either to A (n=256), I.M (n=352) or A.M (n=175) group. When validating the complete database, the Sens / Spec. of the automated classifier was 93% / 88% to detect the presence of a systolic murmur (against absence of a murmur) and 95% / 35% to detect abnormal systolic murmurs (against innocent murmurs). When validating exclusively S.P cases (70 I.M, 7 A.M) the corresponding Sens./Spec. was 84% / 72%.

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.