Building New References of Normality for ECG Parameters in Children

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Background: Literature regarding pediatric electrocardiogram is poor, particularly with respect to aspects as growth and development of heart, and the need of robust references and ranges of normality is apparent. Even most recent publications fail to address the design of a predictive model.

Purpose and Methods: The goal of this work is to characterize the distribution of ECG features from an ongoing cross-sectional study conducted at the Buzzi Children's Hospital (Milan, Italy) in children aged between 0 days to 16 years. All ECGs data digitally acquired from 2011 to 2022 (more than 90,000) have been initially collected. ECGs were subsequently excluded according to a few pre-defined criteria such as ECGs of children with known cardiovascular anomalies, lost during follow-up (at least three years) or deceased. In case of same-day duplicates, only a single ECG (based on best quality in term of noise content) was retained. Lastly, two independent algorithms have been applied to automatically compute a large and comprehensive set of ECG parameters, and ECGs where one of the two algorithms provided abnormal measurements were also excluded. The ECG variables included both parameters of duration (all intervals and sub-intervals), amplitude and energy measurements of all ECG waves, and indices of morphology of the repolarization segment. The final dataset consisted of 54,839 ECGs (47% females and 53% males).

Because of the large physiologic variability in the first weeks and years of age, the population was divided in 12 age groups and all parameters were analyzed with a specific statistical approach. First, all variables were adequately transformed to meet normality criteria. Subsequently, median values for different age groups were estimated using a mixed regression model. Based on the absolute residuals of the regressions, percentile curves were estimated with a non-parametric model and percentile curves (2°, 25°, 50°,75° and 98°) were finally derived for all ECG parameters, with separate curves for males, females, age groups < 1 year (30,885 ECGs), and age groups > 1 year (23,954 ECGs). The accuracy of the prediction models was validated on the observed data. Final step was to create graphs of centile charts visualizing the scatter plot of the data and the 2nd, 50th and 98th percentile lines. Tabular and chart results will be shown.

Conclusions: The impact from this large cohort can be significant for pediatricians in providing a more accurate and up-to-date clinical assessment of the children population.