Cyprus University of Technology

Department of Electrical Engineering and Computer Engineering and Informatics

Master's Thesis

Motion analysis for the diaphragmatic function from ultrasound videos in newborns

Giannis Christofi

Limassol, May 2022

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Approval Form

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Presented by

Giannis Christofi

Supervisor: Department of Electrical Engineering, Computer Engineering and Informatics, Prof. Christos P. Loizou

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ABSTRACT

Objective: Ultrasound analysis of the diaphragmatic motion can provide useful information of the diaphragm function in newborns, which could potentially enable doctors to identify whether the motion is normal or abnormal. Currently the assessment of the diaphragm is performed by doctors based on their subjective experience using manual image processing methods. The aim of this study is to propose, develop and evaluate an integrated semi-automated offline video analysis system that could provide accurate and consistent diaphragmatic motion measurements for newborns. The system is able to automatically generate diaphragmatic motion measurements obtained from the video under study (i.e., Diaphragmatic Excursion (DE), Inspiration time (T_{insp}), Total breathing time (T_{tot}), diaphragmatic curve slope (SLP), and Relaxation Rate (RR)). These measurements will assist doctors to conclude about the normal or abnormal function of the newborns diaphragm.

Methods: We used 20 simulated videos generated based on parameters of normal diaphragmatic motion of neonates available from the literature. The videos were analyzed using the proposed system and a statistical analysis and evaluation was performed for assessing the systems' accuracy. Then manual (-/) vs automated (/-) measurements were extracted from all simulated (-/) and real (/-) diaphragmatic newborn videos: DE, Tinsp, Ttot, SLP, and RR. The proposed system avails the following functions: simulated video generation with addition of speckle noise, M-mode image generation, video normalization, snakes segmentation, states-diagram generation, and motion parameters measurements.

Results: The following manual (-/) vs semi-automated (/-), (median ± IQR) measurements were computed for the simulated videos; also the correlation coefficient (ρ) and its p-value are summarized showing the correlation of the parameters measured by the proposed system compared with the manual theoretical values: (i) DE: 3.67±0.11 / 3.73 ± 0.27 mm (ρ=0.64, p=0.002), (ii) T_{insp}: 0.56 ± 0.19 / 0.56 ± 0.16 sec (ρ=0.96, p=0.000), (iii) T_{tot}: 1.31 ± 0.19 / 1.31 ± 0.19 sec (ρ=1.00, p=0.000), (iv) SLP: 6.64 ± 2.73 / 6.60 ± 2.30 mm/sec (ρ=0.92, p=0.000), (v) RR: 4.89 ± 0.15 / 5.08 ± 0.58 mm/sec (ρ=0.88, p=0.000).

Conclusions: This is the first study presented in the literature, where a semi-automated integrated system is proposed for the measurements of diaphragmatic motion parameters in simulated videos of newborns. Manual and semi-automated measurements were not found to be statistically significantly different. The system could be therefore useful for the offline clinical assessment of the diaphragmatic motion of neonates. Further work and validation will be performed on a larger sample with real ultrasound videos of newborns diaphragm with normal and abnormal diaphragmatic motion.

Keywords: Neonates diaphragmatic motion, Diaphragmatic ultrasound video, video analysis, Infant's diaphragm.