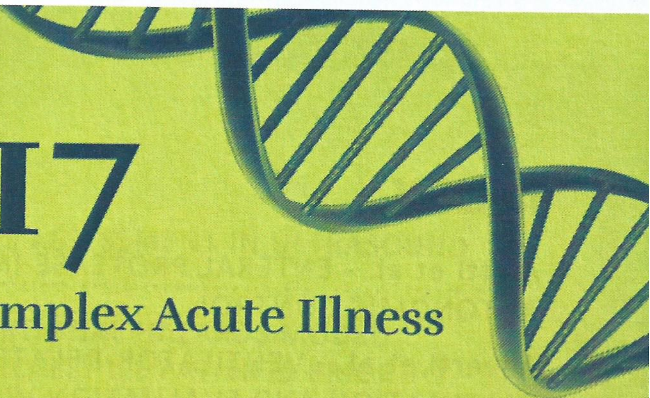

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HAND MOTION ANALYSIS FOR SKILLS ASSESSMENT IN ULTRASOUND EXAMINATIONS

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Objectives:
The Focused Assessment with Sonography for Trauma (FAST) is considered the gold standard for the initial detection of intrathoracic and intrabdominal free fluid and the related bleeding caused by trauma (Zago 2014). The purpose of the present work is to define a FAST-oriented tool which enables the extraction of variables and the quantitative assessment of the operator's skills performing ultrasound examination. The skills assessment allows: (i) to classify operators' level of experience; (ii) to determine experience-dependent FAST tasks to design improved educational pathways for the MUSEC E-FAST course. Hand Motion Analysis (HMA) is widely spread as an objective measure of medical procedure skills, including surgery and ultrasound examination (Ziesmann et al., 2015).

Methods:
Two groups of ten Experts (EG) and 13 Beginners (BG) performed a FAST exam on a male and a female healthy volunteers (equipment: Esaote MyLab Alfa, IT). BG were residents with no previous personal US experience; they were tested immediately after the theoretical and practical sessions of the MUSEC E-FAST course. EG were instructors of the same course, with 5 or more years of experience. Hand kinematics was recorded with a 3D motion analyser (SMART-E, BTS Spa, IT). An independent instructor approved the obtained view of the anatomical structures, considered the clinical target of the exam. Participants were also rated according to the QUICk score, a tailored qualitative existing scale for US assessment. Custom Matlab software yielded the following hand kinematic variables: (i) a set of three previously validated HMA parameters (strongly experience-related and considered efficiency indicators), including scan duration, distance travelled and number of movements; (ii) normalized version of the last two parameters with respect to scan duration; (iii) working volume. The hand kinematic variables were calculated both on the total exam and on the four single scan sessions the FAST procedure is divided in: (i) pericardial; (ii) Right Upper Quadrant (RUQ), for the view of Morrison's space between the liver and right kidney, (iii) Left Upper Quadrant (LUQ), for the view of the perisplenic area, and (iv) pelvic. For the definition of the scan duration, virtual spherical proximity volumes were defined. Scan session duration was computed as the time in which the operator's hand remains in the corresponding volume. A 2-way ANOVA (group × model) was conducted on the parameters, including QUICk score. A 3-way ANOVA (group × model × scan) was performed on the kinematic variables values for each scan.

Results:
The QUICk scores significantly differed between groups (group factor, $p<0.001$): 19.2 (SD 1.1) for the male and 18.7 (1.6) for the female model in EG, and 16.7 (1.8) and 15.4 (4.1) in BG. The first group of parameters was also significantly different between groups for the global examination: as expected, total duration was significantly lower in EG: 60.2 (27.1) s and 68.2 (19.3) s compared to 206.8 (49.7) s and 274.5 (106.0) s in BG, for the male and female models, respectively. Distance travelled was lower in EG: 409.7 (108.2) cm and 374.2 (97.5) cm compared to 888.8 (214.0) cm and 787.3 (174.4) cm in BG. Similarly, the total number of movements were: 131.5 (57.8) and 107.6 (58.7) for EG; 525.7 (235.3) and 367.6 (123.4). The group of kinematic parameters presented coherent differences in the single scans analysis. The normalized Number of movements did not show experience-related differences, both in global (group factor, $p = 0.944$) and single scans (group factor, $p = 0.509$) analysis. The global values were: 1.96 (0.88) s-1 and 1.73 (0.36) s-1 for EG; 1.93 (0.36) s-1 and 1.75 (0.27) s-1 for BG. The normalized distance travelled was higher for the EG (group factor, $p<0.001$): 6.1 (1.0) cm·s-1 and 6.7 (1.3) cm·s-1 compared to 3.6 (1.4) cm·s-1 and 3.9 (0.75) cm·s-1 in BG. Working volume presented significantly higher values for BG on a single view, the LUQ: 0.87 (SD 1.02) dm3 and 0.29 (0.11) dm3 compared to 1.60 (9.94) dm3 and 5.14 (5.49) dm3 in BG.

Conclusions:
The considered variables were able to distinguish between EG and BG. The single scan analysis and parameters normalization allowed to get deeper information both on (i) the practical meaning of each parameter coming from previous studies; (ii) the differences in the movement strategies among BGs and EGs; (iii) which tasks are more critical for the exam. The obtained results allow to state that EG movements were limited, with a lower number of probe heading and pointing adjustments, in the same or in a smaller working volume. Furthermore, the working volume was higher for the BG in the most difficult area to scan, the perisplenic one. Instructors can focus on these results, in order to enhance training and test phases in the education of resident students. In sum, HMA proved to have a great potential for a deeper description of the operators' skill in US scanning, and it introduced quantitative insights that provide further guidance for educational purpose.

Zago, M., 2014. Essential US for Trauma: E-FAST Springer, ed. 2, London (UK).

Ziesmann, M.T. et al., 2015. Validation of hand motion analysis as an objective assessment tool for the Focused Assessment with Sonography for Trauma examination. Journal of Trauma and Acute Care Surgery, 79(4), pp.631–637.