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Short Communication

A Biomechanics Analysis of Ventilation in Thorax Operated Patients

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Abstract
This short paper presents an experimental evaluation of the biomechanics of ventilation in thorax operated patients by using a specially developed device. The SENSIRIB device has been designed for a minimal invasive wearing to detect main motion parameters of a rib during a ventilation test. The biomechanics of the ventilation act is detected to analyze the status of ventilation in thorax operated patients with the aim to give indications for diagnostics in breathing conditions.

Keywords: Respiratory Medicine; Biomechanics of ventilation; Rib motions; Device operation; Thorax operated patients

Few existing devices detect main breathing data, and none is aimed to monitor the biomechanics of ventilation during breathing, as reported in [1-6]. At the laboratory LARM2 in Rome in collaboration with doctors of the thoracic unit of Department of Surgical Sciences of the Rome Tor Vergata University, the new device SENSIRIB, [7,8], has been used for monitoring the biomechanics of ventilation during breathing in thorax operated patients. The used SENSIRIB devices is a new portable device for measuring the movement of individual human ribs for determining biomechanical characteristics of movement during respiratory acts. The SENSIRIB device is characterized by small components for a portable structure with cables for data transmission that can be stored and viewed in a computer or tablet, as a display unit [7], The used prototype of the SENSIRIB device is shown in Figure 1a) with its conceptual sensing on rib motion in Figure 1b) whereas its practical installation is illustrated in Figure 1c). Referring to Figure 1a), the portable device SENSIRIB consists of a motion IMU sensor, whose data are acquired and elaborated in a processing unit that can be connected to a laptop via USB cables for data display and storage. A shown in Figure 1a) the IMU sensor unit is made with a small box of 1.2 x.1.2 x 0.4 cm and the electronics in the processing unit is in a box of 10.0 x 4.0 x 3.0 cm. The practical implementation of the device

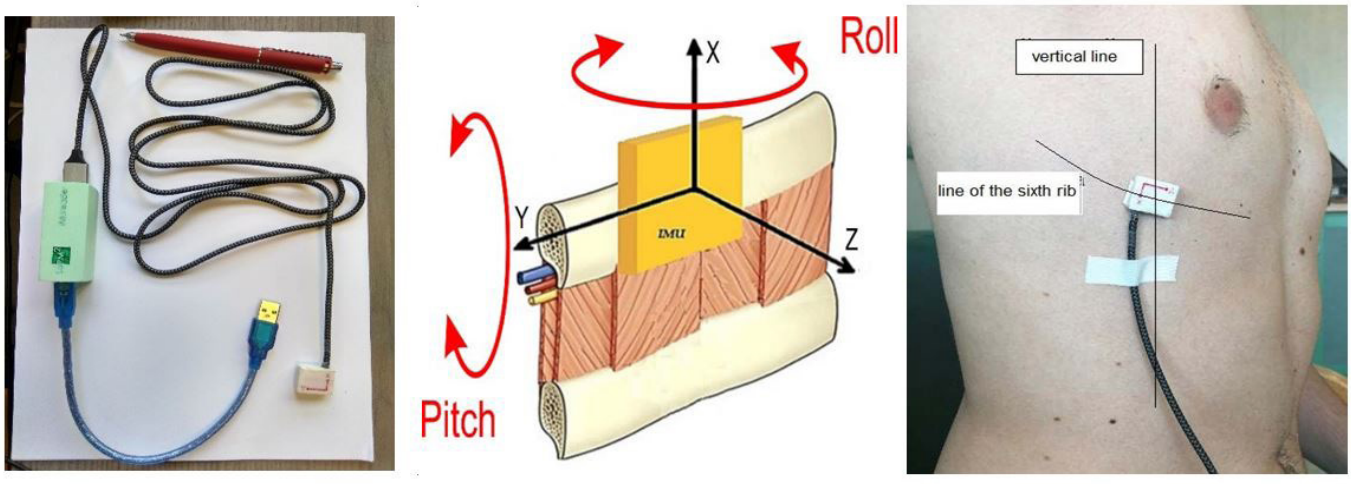

Figure 1: A SENSIRIB device: a) a prototype; b) sensed rib motion; c) installation on the sixth rib for testing

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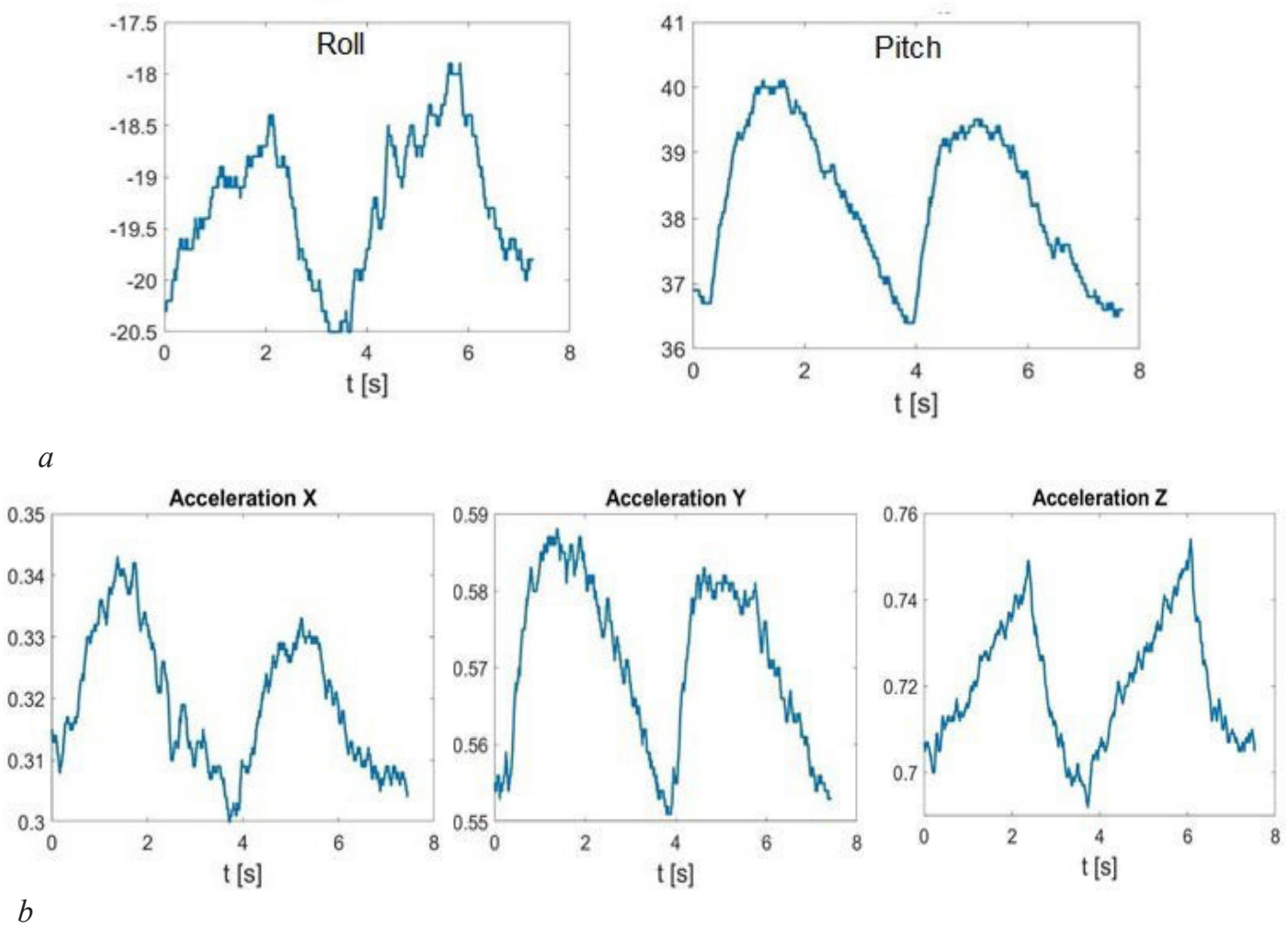

Figure 2: Examples of testing rib motion in thorax operated patients with SENSIRIB device, Fig.1: a) roll and pitch angles; b) acceleration components

with an easy installation as shown in Figure 1c) is planned for clinical-medical purposes through a protocol for diagnosis and pos-operation evaluations. The experimental validation was worked in preliminary medical-clinical testing campaign as reported in [9]. Figure 2 show examples of the results of a test for a biomechanical characterization of the ventilation act in thorax operated patients to monitor the evolving status of their respiration conditions. Plots in Figure 2 show an example of the acquired time evolution of the main kinematic characteristics of the motion of the sixth rib as the most motion-sensitive rib in terms of pitch and roll angles and Cartesian components of the acceleration as indicated in Figure 1b), considering the typical caliper motion and combined pump and bucket handles of the thorax during breathing. Those results of biomechanical characteristics can also be used to evaluate and extrapolate physiological information, such as the respiratory frequency and its regularity, the depth of respiration and the regular continuity of the ventilation act. In particular, Figure 2 show examples of the results of a test for a biomechanical characterization of the ventilation act in the patients before the surgical procedure to monitor the baseline status of their respiration conditions. The patient is a 64-year-old woman who referred to the thoracic surgery department due to right thoracic pain, a moderate Chronic Obstructive Pulmonary Disease (COPD) [GOLDCOPD] and a right superior lobe solitary pulmonary nodule. the reported example in Figure 2 it can be noted that the angular motion is little reduced as in comparison to the average values of range of 19 and 5 degrees, respectively, for healthy people, [9]. COPD may be the reason underlining the reduced angular width. The expected COPD reduction in respiratory compliance following pulmonary hyperinflation may alter chest wall biomechanics. At the same time, the emphysematous respiratory pattern is underlined by the prolonged and slower expiratory phase depicted in the plots. The acceleration components show larger values within a similar range for healthy people. The specific behaviour and the numerical values can be interpreted for a diagnosis indicating the ventilation running with proper regular timing, but with reduced biomechanics mainly in impulsive action of the thorax inhalation and exhalation still enough smooth as per a recovered condition without pain. Nonetheless, the three-dimensional analysis of the acceleration components shows a homogeneous plot in the inspiratory and expiratory phases along the anteroposterior direction while the early inspiratory phase and the late inspiratory phase prevail along the inferior-superior and lateral to lateral direction, respectively. The accessory respiratory involvement in basal respiration in this emphysematous patient may explain this deranged respiratory pattern.

References

1. Folke M, Cernerud L, Ekström M, Hök B. Critical review of non-invasive respiratory monitoring in medical care. Medical and Biological Engineering and Computing, 2003; 41: pp. 377-383.
2. Krehel M, Schmid M, Rossi RM, Boesel LF, Bona G-L, Scherer LJ. An Optical Fibre-Based Sensor for Respiratory Monitoring. Sensors, 2014; 14: pp. 13088-13101.
3. Ciocchetti M, Massaroni C, Saccomandi P, Caponero MA, Poli-

madei A, Formica D, et al. Smart Textile Based on Fiber Bragg Grating Sensors for Respiratory Monitoring: Design and Preliminary Trials. Biosensors, 2015; 5: pp. 602-615.
4. Ono T, Takegawa H, Ageishi T, Takashina M, Numasaki H, Matsumoto M, et al. Respiratory monitoring with an acceleration sensor. Phys Med Biol., 2011; 56: pp.:6279-6289. doi: 10.1088/0031-9155/56/19/008
5. Yang J, Chen B, Zhou J, Lv Z. "A Low-Power and Portable Biomedical Device for Respiratory Monitoring
6. with a Stable Power Source". Sensors, 2015; 15: pp 19618-19632.
7. Massaroni CNA, Schena E, Sacchetti M. Remote Respiratory Monitoring in the Time of COVID-19. Frontiers in Physiology, 2020; 11: Article no. 635. doi: 10.3389/fphys.2020.00635.
8. Ceccarelli M, Portable device for measuring the movement of human ribs, patent pending n. 102021000005726, 2021; 13-23.
9. Ceccarelli M, Puglisi L, Mesiti F, Ambrogi V. A device for experimental characterization of biomechanics of breathing and coughing, Proceedings of 26th International Conference of Mechanical Engineering COBEM2021, Virtual conference, 2021; 0273.
10. Ambrogi V, Tajè R, La Rocca E, Mesiti F, Ceccarelli M. Evaluation of chest-wall motion for gender and age by a novel non-invasive measuring device, Respiration: International Journal of Thoracic Medicine, (under review), 2021.