

Assessment of PIV performance in validating CFD models from nasal cavity CBCT scans

Objective: The aim of our study was to investigate how well Particle Image Velocimetry (PIV) measurements could serve Computational Fluid Dynamics (CFD) model validation for nasal airflow.

Material and methods: For the PIV measurements, a silicone model of the nose based on cone beam computed tomography (CBCT) scans of a patient was made. Corresponding CFD calculations were conducted with laminar and two turbulent models (k- ω and k- ω SST).

Results: CFD and PIV results corresponded well in our study. Especially, the correspondence of CFD calculations between the laminar and turbulent models was found to be even stronger. When comparing CFD with PIV, we found that the results were most convergent in the wider parts of the nasal cavities.

Conclusion: PIV measurements in realistically modelled nasal cavities succeed acceptably and CFD calculations produce corresponding results with PIV measurements. Greater model scaling is, however, necessary for better validations with PIV and comparisons of competing CFD models.

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Organisations: Automation Technology and Mechanical Engineering, Clinical Medicine, BioMediTech, Research group: Sensor Technology and Biomeasurements (STB), Tampere University, Tampere University Hospital, Texas Tech University Health Sciences Center at Lubbock, Ear & Sinus Institute, Boston Children's Hospital

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Tidal breathing flow profiles during sleep in wheezing children measured by impedance pneumography

For the first time, impedance pneumography (IP) enables a continuous analysis of the tidal breathing flow volume (TBFV), overnight. We studied how corticosteroid inhalation treatments, sleep stage, and time from sleep onset modify the nocturnal TBFV profiles of children. Seventy children, 1–5 years old and with recurrent wheezing, underwent three, full-night TBFVs recordings at home, using IP. The first recorded one week before ending a 3-months inhaled corticosteroids treatment, and remaining two, 2 and 4 weeks after treatment. TBFV profiles were grouped by hour from sleep onset and estimated sleep stage. Compared with on-medication, the off-medication profiles showed lower volume at exhalation peak flow, earlier interruption of expiration, and less convex middle expiration. The differences in the first two features were significant during non-rapid eye movement (NREM), and the differences in the third were more prominent during REM after 4 h of sleep. These combinations of TBFV features, sleep phase, and sleep time potentially indicate airflow limitation in young children.

General information

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Organisations: Research group: Physiological Measurement Systems and Methods Group, BioMediTech, Revenio Research Ltd., Tampere University Hospital

Contributors: Gracia-Tabuenca, J., Seppä, V., Jauhiainen, M., Paasilta, M., Viik, J., Karjalainen, J.

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Research output: Contribution to journal > Article > Scientific > peer-review

Vibration transmittance measures sternotomy stability - a preliminary study in human cadavers

Background: Stability is essential for the normal healing of a sternotomy. Mechanical vibration transmittance may provide a new means of early detection of diastasis in the sternotomy and thus enable the prevention of further complications. We sought to confirm that vibration transmittance detects sternal diastasis in human tissue. Methods: Ten adult human cadavers (8 males and 2 females) were used for sternal assessments with a device constructed in-house to measure the transmittance of a vibration stimulus across the median sternotomy at the second, third, and fourth costal cartilage. Intact bone was compared to two fixed bone junctions, namely a stable wire fixation and an unstable wire fixation with a 10 mm wide diastasis mimicking a widely rupturing sternotomy. A generalized Linear Mixed Model with the lme function was used to determine the ability of the vibration transmittance device to differentiate mechanical settings in the sternotomy. Results: The transmitted vibration power was statistically significantly different between the intact chest and stable sternotomy closure, stable and unstable closure, as well as intact and unstable closure (t-values and p-values respectively: $t = 6.87$, $p < 0.001$; $t = 7.41$, $p < 0.001$; $t = 14.3$, $p < 0.001$). The decrease of vibration transmittance from intact to stable at all tested costal levels was 78%, from stable to unstable 58%, and from intact to unstable 91%. The vibration transmittance power was not statistically significantly different between the three tested costal levels (level 3 vs. level 2; level 4 vs. level 2; level 4 vs. level 3; t-values and p-values respectively $t = -0.36$, $p = 0.723$; $t = 0.35$, $p = 0.728$; $t = 0.71$, $p = 0.484$). Conclusions: Vibration transmittance analysis differentiates the intact sternum, wire fixation with exact apposition, and wire fixation with a gap. The gap detection capability is not dependent on the tested costal level. The method may prove useful in the early detection of sternal instability and warrants further exploration.

General information

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Organisations: BioMediTech, Tampere Heart Hospital Co., Tampere University of Applied Sciences, Department of Cardiothoracic Surgery, National Public Health Institute, Tampere University Hospital

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Measuring ventilation and modelling M. Tuberculosis transmission in indoor congregate settings, rural KwaZulu-Natal

SETTING: Molecular epidemiology suggests that most Mycobacterium tuberculosis transmission in high-burden settings occurs outside the home. **OBJECTIVE:** To estimate the risk of M. tuberculosis transmission inside public buildings in a high TB burden community in KwaZulu-Natal, South Africa. **DESIGN:** Carbon dioxide (CO₂) sensors were placed inside eight public buildings. Measurements were used with observations of occupancy to estimate infection risk using an adaptation of the Wells-Riley equation. Ventilation modelling using CONTAM was used to examine the impact of low-cost retrofits on transmission in a health clinic. **RESULTS:** Measurements indicate that infection risk in the church, classroom and clinic waiting room would be high with typical ventilation, occupancy levels and visit durations. For example, we estimated that health care workers in a clinic waiting room had a 16.9-24.5% annual risk of M. tuberculosis infection. Modelling results indicate that the simple addition of two new windows allowing for cross-ventilation, at a cost of US\$330, would reduce the annual risk to health care workers by 57%. **CONCLUSIONS:** Results indicate that public buildings in this community have a range of ventilation and occupancy characteristics that may influence transmission risks. Simple retrofits may result in dramatic reductions in M. tuberculosis transmission, and intervention studies should therefore be considered.

General information

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Organisations: University College London, Wellcome Trust Africa Centre for Population Health, University of KwaZulu-Natal, Centre for the AIDS Programme of Research in South Africa

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Research output: Contribution to journal › Article › Scientific › peer-review

Tidal flow variability measured by impedance pneumography relates to childhood asthma risk

Lung function variability is a fundamental feature of asthma but has been difficult to quantify in children due to methodological limitations. We assessed the feasibility and clinical implications of overnight flow variability measurement at home using impedance pneumography in young children. 44 children aged 3-7 years with recurrent or persistent lower airway symptoms were recruited. Patients were divided into high- or lower-risk groups (HR and LR groups) based on their risk of asthma (modified Asthma Predictive Index), and a third group was formed of children who had a history of wheeze and who were treated with inhaled corticosteroids (ICS group). Tidal volume and the derived flow were recorded through skin electrodes using impedance pneumography at home during sleep. Quantities describing overnight change in expiratory flow-volume minimum curve shape correlation (CSRmin) and respiratory chaoticity (minimum noise limit (NLmin)) were derived. Recordings were successful in 34 children. CSRmin differed between the HR and LR groups (p=0.002) and between the HR and ICS groups (p=0.003), indicating a stronger change in flow profile shape in the HR group. NLmin differed between the HR and LR groups (p=0.014), indicating momentarily lowered chaoticity in the HR group. Impedance pneumography was found feasible for quantifying nocturnal lung function variability and the measured variability was associated with risk of asthma in young children.

General information

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Organisations: Department of Electronics and Communications Engineering, Research group: Physiological Measurement Systems and Methods Group, University of Helsinki

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Assessment of respiratory effort during sleep with noninvasive techniques

General information

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Organisations: Department of Electronics and Communications Engineering, BioMediTech, Department of Clinical Neurophysiology, Department of Medical Physics, Tampere University Hospital, Pirkanmaa Hospital District, University of Tampere

Contributors: Tenhunen, M., Hasan, J., Himanen, S. L.

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Research output: Contribution to journal > Article > Scientific

Intrapleural photodynamic therapy for mesothelioma: What place and which future?

In the surgical multimodal management of malignant pleural mesothelioma, it seems crucial to proceed with an efficient local adjuvant treatment to kill residual tumor cells. Intrapleural photodynamic therapy has recently emerged as a potential candidate in this goal. In this review, we analyzed and classified 16 articles in which patients with malignant pleural mesothelioma received intrapleural photodynamic therapy after maximal surgical resection. The toxicity, effect on survival, and development of the technique were assessed. After two decades of clinical studies, intrapleural photodynamic therapy after surgical resection became a safe treatment that significantly improved the survival of patients.

General information

Publication status: Published

MoE publication type: A2 Review article in a scientific journal

Organisations: Frontier Photonics, Univ Paris 06, Centre National de la Recherche Scientifique (CNRS), Pierre & Marie Curie University - Paris 6, Institut de Recherche pour le Developpement (IRD), Inria, Institut National de la Sante et de la

Recherche Medicale (Inserm), Univ Sorbonne, CNRS,ICM,UMR S 1127,UMR 7225,U1127, INSERM,Inria Paris Rocquencourt,Inst Cerveau & Mo, Lille University Hospital - CHRU
Contributors: Munck, C., Mordon, S. R., Scherpereel, A., Porte, H., Dhalluin, X., Betrouni, N.
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Disconnection between periodic leg movements and cortical arousals in spinal cord injury

Objective: In this study we examine the temporal connection between periodic leg movements (PLMs) and cortical arousals, as well as the treatment effect of pramipexole, in a clinical case with spinal cord lesion. **Methods:** A patient with complete cervical spinal cord injury and PLMs during sleep underwent two baseline sleep recordings, one recording with dopaminergic treatment, and one recording with adaptive servoventilation. **Results:** The PLMs were temporally dissociated from cortical arousals as well as from respiratory or heart rate events. PLMs were suppressed by pramipexole and persisted after treatment of apnea. **Conclusion:** The disconnection of PLMs from arousals supports a spinal generator or peripheral trigger mechanism for PLMs. The suppression of movements by a dopamine agonist suggests that its site of action is caudal to the cervical lesion and outside of the brain. Our observation provides significant new knowledge about the pathogenesis of PLMs and warrants studies in larger populations.

General information

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Organisations: Integrated Technologies for Tissue Engineering Research (ITTE), Unesta Research Centre, Civic Hospital of Lugano, Tampere University Hospital, Oasi Research Institute (IRCCS)

Contributors: Salminen, A. V., Manconi, M., Rimpilä, V., Luoto, T. M., Koskinen, E., Ferri, R., Öhman, J., Polo, O.

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