ABSTRACT:

This work investigates the use of High Frequency Percussive Ventilation (HFPV) as a technique for respiratory motion mitigation in radiotherapy. This technique was extensively investigated in several prospective and retrospective studies.

In an initial prospective study, we evaluated the feasibility of HFPV and the chest-wall motion reduction by recruiting 15 healthy volunteers to undergo HFPV with three commercially available interfaces. For direct tumor motion immobilization, a second prospective study was performed with ten lung cancer patients who underwent HFPV while imaged with a high frame rate fluoroscopy. Diaphragm motion and image artifacts were quantified in a prospective study of a healthy volunteer who underwent magnetic resonance imaging (MRI) while undergoing HFPV. Several retrospective studies were performed to quantify the interplay effects as well as gradient effects of HFPV vs. free breathing in photon and proton radiotherapy. Furthermore, a retrospective phantom study was performed for quantifying planning target volume (PTV) reduction as well as doses to the organs at risk (OARs). Reproducibility of the HFPV was evaluated in a prospective study of five volunteers who underwent five sessions of HFPV on three different days. Lastly, as part of this study, a HFPV mask was designed and prototyped for better comfort, prolonged percussive time, minimal baseline drifting with a patient-controlled valve.

HFPV provides prolonged breath-hold like apnea in awake patients that could last as long as 16 minutes. In this first ever study, direct tumor motion was drastically reduced from > 10 mm to < 3 mm. Similarly, diaphragm motion was reduced by as much as > 90 %. HFPV proved significantly beneficial in reducing the effects of interplay in proton radiotherapy and photon dose gradient measurements, increasing the gamma index by as much as 20 to 30 % from free breathing to HFPV. Similarly, hot and cold spots were reduced by > 50 %. HFPV is reproducible within < 2 mm both intra- and inter-fractionally, but it can be further improved by applying minor adjustments to the pressure and frequency of the Percussionaire unit. Although further modifications will be made, the newly designed prototype provided less leakage and better comfort as well as providing patients with the direct ability to switch between room air and HFPV. HFPV is a novel and promising technique for tumor immobilization in a radiotherapy setting.

References to author publications that relate specifically to the dissertation:

MANUSCRIPTS:

1) Ina M. Sala, Girish B. Nair, Beverly Maurer, Thomas M. Guerrero, “High frequency percussive ventilation for respiratory immobilization in radiotherapy.” Technical Innovations & Patient Support in Radiation Oncology, Volume 9, 2019, Pages 8-12, ISSN 2405-6324, https://doi.org/10.1016/j.tipsro.2018.11.001

2) Ina M. Sala, Beverly Maurer, Cristian Solano, and Thomas M. Guerrero, “Fluoroscopic demonstration of thoracic tumor immobilization with high frequency percussive ventilation.” Global Journal of Cancer Case Reports, Volume 01, Issue 02, 2020, Pages 1-06, DOI: http://dx.doi.org/10.47733/GJCCR.2020.1207
**ABSTRACTS**

1) **Ina M. Sala**, Hazel Ramirez, Mark Pankuch, Thomas M. Guerrero, *Particle Therapy Co-Operative Group (PTCOG) North America: Annual Meeting, Miami, FL. Interplay evaluation of high frequency percussive ventilation (HFPV) for motion greater than 10 mm during proton beam scanning*, October 2019.


7) **Ina M. Sala**, Girish B. Nair, Beverly Maurer, Thomas M. Guerrero, *High frequency percussive ventilation for respiratory immobilization in radiotherapy*, Technical Innovations & Patient Support in Radiation Oncology, Volume 9, 2019, Pages 8-12, ISSN 2405-6324. [https://doi.org/10.1016/j.tipsro.2018.11.001](https://doi.org/10.1016/j.tipsro.2018.11.001)