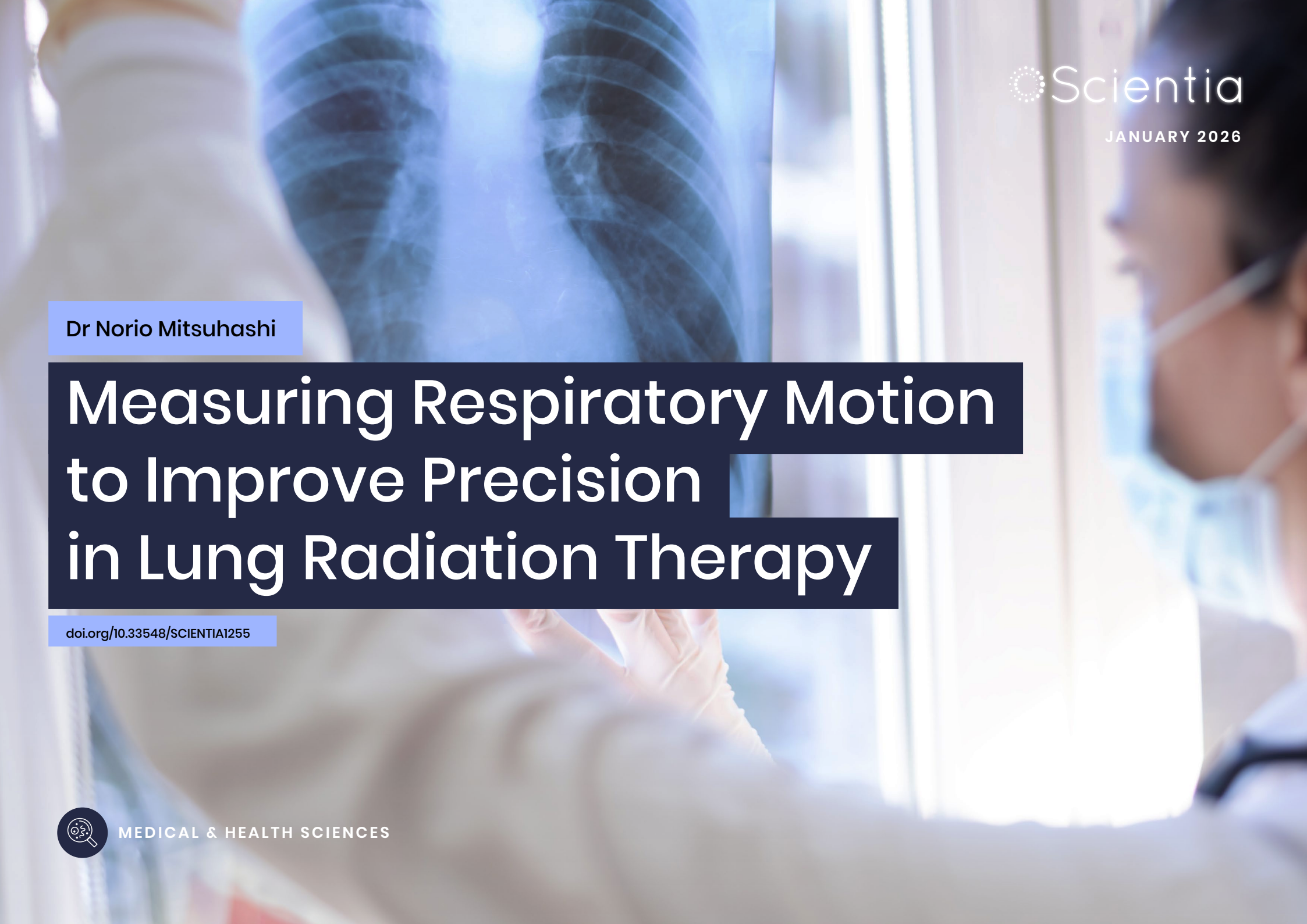

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Dr Norio Mitsuhashi

Measuring Respiratory Motion to Improve Precision in Lung Radiation Therapy

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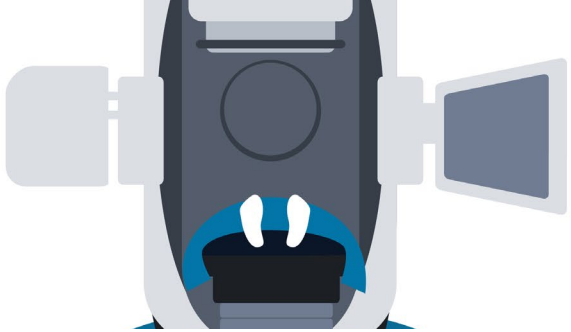

Dr Norio Mitsuhashi, former Professor of the Department of Radiation Oncology at Tokyo Women's Medical University, leads revolutionary clinical research into optimising stereotactic body radiation therapy for lung cancer. Dr Mitsuhashi and his colleagues examine whether routinely available patient and tumour characteristics can predict respiratory tumour motion, a critical source of uncertainty in high precision radiotherapy. Their findings suggest that respiratory motion cannot be reliably inferred, and must instead be measured directly in every patient.

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Precision radiotherapy and the challenge of breathing motion

Stereotactic body radiation therapy has transformed the treatment of early-stage non-small cell lung cancer. Allowing high radiation doses to be delivered accurately over a small number of treatment sessions, stereotactic radiation is a method that delivers very high doses of radiation to a small, well-defined target over a few treatment sessions. But targeting requires extremely accurate positioning of the beam. This approach offers excellent local control and is particularly valuable for elderly patients and those who are medically inoperable, for whom surgery may not be an option. However, the very precision that defines stereotactic treatment also makes it vulnerable to errors caused by respiratory motion.

Lung tumours move continuously during normal breathing as the diaphragm rises and falls. As patients breathe in and out, tumours within the lungs move along with the surrounding lung tissue. If this movement is underestimated during treatment planning, parts of the tumour may fall outside the high dose region, reducing treatment effectiveness. Conversely, if motion is overestimated, larger safety margins are applied, increasing radiation exposure to surrounding healthy lung tissue. Accurately characterising respiratory motion is therefore essential to balancing tumour control with treatment safety.

Despite its importance, respiratory motion is often assumed rather than measured. Factors such as patient age, lung function, tumour size, and anatomical location are commonly thought to influence the extent of motion. Dr Mitsuhashi and colleagues set out to test whether these assumptions are supported by clinical evidence.

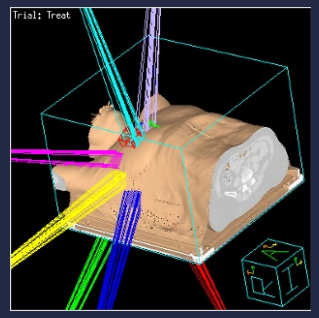
Assessing motion using a volumetric approach

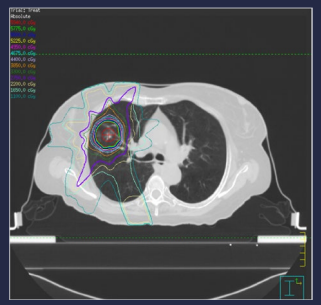
The research team conducted a retrospective analysis of patients with early-stage peripheral lung cancer treated with stereotactic body radiation therapy at their institution. All patients were treated using abdominal compression, a respiratory restriction technique commonly used in centres without access to respiratory gating technology. This latest enables practitioners to time scans or radiotherapy to a person's breathing, meaning the body is in the right position — reducing blur and protecting healthy tissue from radiation. However, as this technology is not always available, the researchers provided a real world setting in which to examine motion variability under standard clinical conditions.

Instead of measuring tumour movement as displacement along specific anatomical directions, the investigators used a volumetric surrogate. Respiratory motion was assessed by comparing the clinical target volume with the internal target volume. The clinical target volume represents the visible tumour, while the internal target volume includes the space the tumour occupies as it moves during breathing. The relative difference between these volumes was used as an index of respiratory motion, allowing comparison across tumours of different sizes. This provided a practical way to estimate motion indirectly, by measuring how much the apparent tumour volume changed with breathing.

Patient characteristics analysed included age, sex, body mass index, smoking history, and pulmonary function. Tumour related variables included 'Tumour' or T classification (an internation classification describing the size of the tumour and how far it extends into surrounding tissue), clinical stage (a system which reflects the difficulty of a tumour to cure, and patient prognosis), the location of the tumour within the lung, and characteristics at the microscopic and cellular level. Statistical analyses were performed to determine which factors, if any, were associated with increased respiratory motion. This type of analysis evaluates the influence of several factors at the same time, rather than examining each one in isolation.

> By highlighting the unpredictability of respiratory motion, the work reinforces the importance of motion assessment as a standard component of stereotactic body radiation therapy planning.





What predicts tumour movement and what does not

In initial analyses, increasing age was associated with greater respiratory tumour motion. This finding appeared to support the idea that elderly patients may experience larger or less predictable breathing related tumour movement. However, when multiple patient and tumour characteristics were considered together, only the size/extent of the tumour affected how much it moved with breathing.

Other commonly assumed predictors, including pulmonary function, smoking exposure, body mass index, and type of ventilatory impairment, showed no significant association with respiratory motion. Tumour location within the lung and patient age showed signs of exerting an effect, but did not reliably predict which patients would experience substantial motion.

A striking finding was the degree of variability observed between individual patients. Even among patients with similar clinical characteristics, respiratory motion varied widely. Patients with the greatest motion were predominantly in late older age, but this could not be explained by reduced lung function alone, suggesting that behavioural and physiological factors also play an important role.

Rethinking assumptions in treatment planning

The findings challenge the common practice of inferring respiratory motion from demographic or clinical characteristics. The team from Kyoto University have demonstrated that such assumptions are unreliable and risk either underestimating or overestimating tumour movement during treatment planning.

The study supports a shift toward direct measurement of respiratory motion for all patients undergoing stereotactic body radiation therapy. Rather than selecting patients for motion assessment based on perceived risk, the authors argue that universal evaluation is necessary to ensure treatment accuracy and safety. This approach is particularly relevant in elderly populations, where assumptions about reduced respiratory excursion may be misleading.

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Implications for future radiotherapy practice

As stereotactic techniques continue to evolve, accurate motion management will remain central to improving outcomes in lung cancer radiotherapy. Future work may integrate volumetric motion assessment with four-dimensional imaging - capturing how the tumour moves over time as the patient breathes, adaptive planning strategies, and real time image guidance to further personalise treatment delivery.

More broadly, the study underscores a growing emphasis on measurement-based precision in radiotherapy. By replacing inference with direct assessment, clinicians can better balance tumour control with normal tissue protection, ensuring that the benefits of stereotactic body radiation therapy are realised across diverse patient populations.

Article written by Chris Barton, BSc (Hons), MSc

MEET THE RESEARCHER

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Dr Norio Mitsuhashi used to be a Professor and Chairman of the Department of Radiation Oncology at Tokyo Women's Medical University. He is now the Vice Director of the Radiation Therapy Center at Hitachinaka General Hospital. He is a senior radiation oncologist and academic leader, with a long and distinguished career in clinical radiotherapy, translational research, and oncology education.

He obtained his Medical Degree and Doctor of Medical Science from Gunma University School of Medicine. His clinical qualifications span radiation oncology, cancer therapy, and hyperthermic oncology. He has held leadership and honorary roles across multiple Japanese and international professional societies.

Dr Mitsuhashi's research focuses on stereotactic body radiation therapy, namely head & neck, lung, and prostate cancer, but also brachytherapy, hyperthermia, and palliative radiotherapy. A consistent theme of his work is optimizing radiation therapy delivery in elderly and medically vulnerable patients, with attention to motion management, morbidity reduction, and quality of life outcomes.

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FURTHER READING

Mitsuhashi, N., Tominaga, D., Ikeda, H., Shiina, F., Fukaya, K. and Nemoto, Y., 2024. Effect of patient and tumor characteristics on respiratory motion in early-stage peripheral lung cancer treated with stereotactic body radiation therapy. Reports of Practical Oncology and Radiotherapy, 29(4), pp.468–477. https://doi.org/10.5603/rpor.101531