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In Regard to Boda-Heggemann et al

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Towards the ultimate radiotherapy goal- "freezing" the tumour in a known position during radiotherapy

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It was always hoped that if patients held their breath, tumours would stay still. The introduction of multiple short (roughly 20 second) breath-holds in air, to reduce the movement of target organs, is improving radiotherapy delivery for breast cancer [¹] and ought to improve the delivery for other thoracic and abdominal tumours. It is important however to be aware that tumours do not stay completely still during breath-holding [²⁻⁴]. First, there is settlement of the chest, diaphragm and abdominal organs when the breath-hold is first established [^{3,5,6}]. Secondly, there is shrinkage of the chest volume throughout breath-holding because oxygen continues to be extracted from alveolar gas and is not replaced by an equal volume of carbon dioxide [⁷]. These physiological changes are in addition to the issues of reproducibility of organ position between each breath-hold.

Colleagues should also be aware that patients with cancer can already breath-hold for more than 10 times longer than in these multiple short breath-holds using air [¹]. Parkes *et al.*, have just achieved single prolonged breath-holds [³] for more than 5 minutes using a non-invasive mechanical ventilation technique with 60% oxygen. Here, the initial settlement movement over the first 10-15 seconds of the breath-hold was typically 3 mm and in 15 patients the chest deflated by about 2 mm/minute in the inferior-superior direction (the direction of largest motion in this study). Peguret *et al.*, have achieved single "apnea-like breath-holds" for more than 11 minutes using a high frequency percussive ventilation technique with 100% oxygen [²]. Movements during "breath-holding" were measured with CT and evaluated in detail in 2 patients revealing movement from the start to the end of the breathing that was typically 2-4mm and occasionally larger.

While such prolonged breath-holding techniques have further clinical potential to optimise both imaging and delivery of x-ray and particle beam therapy in a single breath-hold, they also emphasise the urgent need for more research on the position changes of both tumours and healthy tissue throughout breath-holding.

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