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Editorial for JMRI-25-1812 : “Analysis of Upper Airway Morphology Using Four-dimensional Dynamic MRI with Active Deep Learning-based Automatic Segmentation”

Neil J Stewart, Jim M Wild

Division of Clinical Medicine, School of Medicine & Population Health, Faculty of Health, University of Sheffield, Sheffield, UK.
Insigneo Institute for In Silico Medicine, University of Sheffield, Sheffield, UK.

There is growing interest in upper airway morphometry at high resolution using 3D ultra-short echo time (UTE) MRI. In particular, non-invasive, non-ionizing methods to assess airway abnormalities are needed to better understand airway contributions to lung disorders in children (1). In infants with tracheomalacia, 3D UTE MRI acquired during free-breathing and retrospectively gated to reconstruct images at end tidal inspiration and expiration provides an alternative to traditional bronchoscopy to assess tracheal collapse (2). Airway segmentation further down the airway tree is also informative of bronchial abnormalities; recently, the segmentation of bronchiectatic airways from UTE MRI in people with cystic fibrosis was demonstrated, using a deep learning approach trained on pairs of UTE and CT images (3).

In obstructive sleep apnea (OSA), a common disorder of breathing during sleep characterised by loss of airway patency causing disrupted breathing, dynamic imaging of airway morphology would allow improved detection and assessment of sites of obstruction. 3D high-resolution UTE imaging requires continuous acquisition over a period for minutes and is therefore not suitable for this purpose. To date, to obtain sufficient temporal resolution, dynamic MRI studies of airway morphology have been limited to either 2D single-slice (4) or pseudo-3D approaches (5). More recently, 3D sequences typically used for ciné or dynamic contrast-enhanced MRI have been used to provide the best compromise between spatial and temporal resolution, e.g. using Cartesian samples derived from golden-angle radial trajectories (6).

In this issue of JMRI --- et al. investigate the use of a Time-resolved Imaging with Interleaved Stochastic Trajectories (TWIST) sequence for dynamic 3D imaging of airway morphology with a spatial resolution of 1.25 x 1.25 x 2 mm^3 and temporal resolution ~ 1 s, during 20 s of normal breathing (7). The authors recruited healthy volunteers with no history of OSA to be scanned during both closed- and open-mouth breathing, the latter a feature of OSA. The open mouth protocol involved biting down on a 10 mL syringe during the scan to keep the mouth open. The airways were segmented using an nnU-Net framework trained using “active learning”, wherein the model trained several times with progressively increasing dataset size and identifying the best and worst performing datasets to feed that information into the next iteration. This process allows a considerable reduction in manual segmentation effort.

The total upper airway length was increased during open-mouth breathing, consistent with previous observations (8). Known sex-related differences in airway morphology were measurable using this method, such as increased total (and epiglottic) airway length in male participants. Changes in other metrics depending on mouth status, e.g. reduction in retropalatal cross-sectional area whilst retroglossal cross-sectional area was unchanged in open-mouth status, warrant further investigation. Although all participants were healthy, the authors separated out participants who self-reported sleep-related symptoms including snoring. Interestingly, these individuals showed increased total airway length, consistent with previous CT findings in patients with OSA, where open-mouth breathing is more common (9). Symptomatic individuals also exhibited narrowing and increased variability in retropalatal cross-sectional area over the 20 s scan in open mouth status, compared with asymptomatic participants. The retropalatal region is typically narrower and more collapsible than the retroglossal region in patients with OSA (10) and therefore these findings in symptomatic participants may indicate increased propensity of future apneic events.

This study has demonstrated the feasibility of 3D ciné MRI for dynamic imaging and quantification of airway morphology during tidal breathing with the mouth both open or closed. However, in the healthy participants studied, there was relatively little change in airway morphometry metrics within each time series of images and therefore the utility of this approach to assess transient airway collapse requires further study. A follow-up investigation in people with OSA is needed next to determine to what extent this approach is feasible in the target population and during sleep. MRI-based approaches should enable such studies to be performed in pediatric patients, where invasive or ionizing modalities are less feasible.

Conflict of interest

None to declare.

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