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Impact of airway management strategies on magnetic resonance image quality

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Abstract

Background: Use of general anaesthesia or deep sedation during magnetic resonance imaging (MRI) studies leads to pharyngeal muscle relaxation, often resulting in snoring and subsequent vibrations with head micromotion. Given that MRI is very susceptible to motion, this causes artifacts and image quality degradation. The purpose of our study was to determine the effectiveness of different airway management techniques in overcoming micromotion-induced MRI artifacts.

Methods: After obtaining institutional review board approval, we conducted a retrospective study on the image quality of central nervous system MRI studies in nine patients who had serial MRIs under general anaesthesia. All data were obtained from electronic records. We evaluated the following airway techniques: use of no airway device (NAD); oral, nasal, or supraglottic airway (SGA); or tracheal tube. To assess MRI quality, we developed a scoring system with a combined score ranging from 6 to 30. We used the linear mixed model to account for patient-dependent confounders.

Results: We assessed 85 MRI studies from nine patients: 48 NAD, 27 SGA, four oral, four nasal, and two tracheal tube. Arithmetical mean combined scores were 21.6, 27.6, 20.3, 15.3, and 29.5, respectively. The estimated mean combined scores for the NAD and SGA cohorts were 22.0 and 27.3, respectively, showing that SGA use improved the combined score by 5.3 (P<0.0001).

Conclusions: The use of an SGA during MRI studies under general anaesthesia or deep sedation significantly improves image quality.

Key words: airway management; artifacts; magnetic resonance imaging

Magnetic resonance imaging (MRI) is instrumental for the evaluation of central nervous system (CNS) pathology. In oncological patients, it is frequently used to establish an initial diagnosis, to assess patient response to treatment, and to perform surveillance for possible recurrence. The major drawback of MRI is its long acquisition time, during which the patient must lie still inside the bore of the magnet. Almost all paediatric patients[1–3] and many adult patients undergoing MRI studies are unable to cooperate and require sedation or general anaesthesia (GA).

Propofol is the preferred agent for deep sedation and GA in the MRI setting because of its short half-life and rapid metabolism.[4] However, propofol frequently leads to relaxation of the pharyngeal muscles, often resulting in snoring and subsequent vibrations and head micromotions. As MRI is susceptible to motion, this causes

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Editor's key points

- The image qualities of magnetic resonance imaging (MRI) can be affected by movement of patients.
- The MRI qualities of the central nervous system were compared retrospectively between anaesthetized patients whose airways were managed with different methods (no airway device, the use of an oral or a nasal airway, a supraglottic airway, or a tracheal tube).
- The use of a supraglottic airway was associated with the best MRI qualities.

artifacts and image quality degradation, and lowers the diagnostic value of the studies. To prevent airway obstruction and improve image quality, various airway devices have been used. To our knowledge, previous studies have addressed the safety, compatibility, and ferromagnetic interference of airway devices in the electromagnetic field, but not the effects of anaesthesia-induced micromotion artifacts on image quality.[5–7] We hypothesized that by preventing anaesthesia-induced partial airway obstruction, through the use of various airway devices, we would mitigate MRI motion artifacts, which would result in improvements in image quality.

Given that oncological patients undergo multiple MRI studies at regular intervals, the use of different airway techniques, ranging from no airway device (NAD) to pharyngeal or tracheal airways, can be studied in the same patient. Also, studying patients who have undergone serial MRI studies would reduce patient-related variables, such as differences in airway anatomy or body habitus. In this retrospective study, we evaluated the image quality of serial CNS MRI studies in nine patients for whom different airway management techniques were used.

Methods

After obtaining institutional review board approval, we conducted a retrospective review of the CNS MRI studies of patients at The University of Texas MD Anderson Cancer Center who met all of the following inclusion criteria: (i) the patient had undergone sedation or GA; (ii) the patient had at least five serial MRI studies performed at our institution; (iii) there was at least one MRI session with an airway device and one session without an airway device; and (iv) only one type of airway device was used during each session. All imaging studies reviewed were performed between September 2007 and August 2015.

Information regarding patient characteristics and the airway management technique used to maintain a patent airway were collected from the electronic medical records. The airway management techniques used in the study participants were NAD, oral airway, nasal airway, supraglottic airway (SGA), or tracheal tube. The subtypes of SGA used included the disposable Laryngeal Mask Airway (LMA Unique™), the LMA Supreme™, the classic LMA™ (all manufactured by Teleflex Inc., Research Triangle Park, NC, USA), and the iGel (Intersurgical Ltd, Wokingham, UK).

To determine the image quality of each MRI sequence, we developed a scoring system with the following scores: score of 1 (non-diagnostic), score of 2 (poor quality but some diagnostic value), score of 3 (average), score of 4 (good), and score of 5 (excellent). Six standard MRI sequences were analysed [axial T2, axial fluid-attenuated inversion recovery (FLAIR), axial T1 precontrast, and T1 postcontrast in the axial, coronal, and sagittal planes], and a combined score ranging from 6 to 30 was assigned to each MRI session. The scoring was performed by a neuroradiologist with >20 yr of experience (T.L.C.), who was blinded to the type of airway management technique used. If there were repeated sequences (during the same study session), the one with the higher score was counted, because the better sequence determines the ultimate image quality. Magnetic resonance imaging was performed using a 1.5 or 3 T system.

Our study used series of MRI studies from a limited number of patients. For each patient, there was at least one study with and one without an airway device. For statistical analysis, we used the linear mixed model, which is a method of analysing repeated measurements, which in our study corresponded to serial MRI acquisitions. The model took into account correlations of the scores within the same patient, thus eliminating patient-dependent variables (e.g. individual airway anatomy or body habitus) as potential confounders, and enabled the use of each patient as their own control. A compound symmetry structure was used when estimating the covariance structure and mean scores. All tests were two sided, and P-values of ≤ 0.05 were considered statistically significant. Statistical analysis was carried out using SAS version 9 (SAS Institute, Cary, NC, USA). If a statistical analysis using the linear mixed model could not be performed for an airway management technique because of small group size, and thereby an estimated mean score could not be calculated, only the simple arithmetic mean was used for comparison.

Results

A total of 85 MRI studies were conducted in the four paediatric and five adult patients (four females and five males, with ages ranging from 10 months to 72 yr; Table 1 and Fig. 1). The

Table 1 Patient characteristics. Age range is related to the period of time in which the series of MRI studies were conducted. F, female; M, male; MRI, magnetic resonance imaging

Patient no.	Sex	Age range (yr)	Height [cm; mean (SD)]	Weight [kg; mean (SD)]	BMI [kg m^{-2}; mean (SD)]	No. of MRI studies
1	F	18–19	168.5 (0.47)	112.0 (15.3)	39.7 (5.4)	7
2	M	8–14	149.7 (13.7)	43.4 (10.7)	19.0 (1.3)	14
3	M	10 months to 2 yr	83.97 (6.18)	13.7 (1.8)	19.4 (1.3)	14
4	M	8–11	130.9 (1.7)	26.0 (1.4)	15.2 (0.84)	9
5	F	42–45	183 (0)	64.4 (1.3)	19.2 (0.4)	5
6	F	72	167.6 (0)	51.9 (5.2)	18.5 (1.9)	7
7	M	63–66	182 (0)	96.4 (6.4)	29.1 (1.9)	14
8	F	47–49	148.4 (0.6)	85.6 (4.5)	38.8 (1.6)	5
9	M	4–6	117.7 (1.5)	21.8 (1.5)	15.7 (1.1)	10