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ORIGINAL ARTICLE

In vitro study of magnetic resonance imaging artefacts of six supraglottic airway devices

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Summary

We investigated the artefacts created during magnetic resonance imaging by five different laryngeal mask airways: the Classic (cLMA™); the LMA ProSeal™; the LMA Unique™; the Ambu® Disposable Laryngeal Mask; the LMA Supreme™; and one other supraglottic airway device, the i-gel supraglottic airway. The devices were placed on top of and inside a phantom simulator to resemble the position in vivo. The artefacts with the cLMA, Unique and Supreme were similar and related to ferromagnetic material in the pilot balloon valve. Artefacts were more prominent with the ProSeal. There were no artefacts with the Ambu Disposable Laryngeal Mask or the i-gel.

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General anaesthesia is often necessary for magnetic resonance imaging (MRI), especially when patients cannot remain still and then the airway is often managed with a supraglottic airway such as a laryngeal mask airway (LMA) [1]. With the exception of the MRI-safe LMA (which has a non-magnetic silicone spring in the pilot balloon), LMA devices have a variable quantity of ferromagnetic material that could reduce image quality and affect patient safety because of potential dislodgement [2]. Because little information is available on safety or artefacts during MRI with newer LMAs and other supraglottic airway devices, we wished to assess six supraglottic airway devices during MRI.

Methods

We evaluated six supraglottic airway devices: Classic LMA (cLMA™), LMA ProSeal™, LMA Unique™, LMA Supreme™ (all obtained from Bioser-MBA, Gijón, Spain), Ambu® Disposable Laryngeal Mask (Ambu S.L., Madrid, Spain), and i-gel supraglottic airway (i-gel; Intersurgical Spain SA, Madrid, Spain) during a magnetic resonance procedure in a 1.5-Tesla MRI scanner (Philips Intera 1.5 T; MRI Medical System, Best, the Netherlands).

We placed the different devices on top and inside a phantom simulator with the pilot balloon taped at a distance similar to how each device would be positioned in vivo. (Fig. 1). Radiologists use phantom simulators to check the MRI machine for compatibility with material, implants and devices. The phantom, with the supraglottic airway in situ, was centred in the magnetic field as the 'head' of a hypothetical patient would be. To assess any variation in artefacts, we repeated the study with three different examples of each supraglottic device. In addition, to verify that the metal spring in the pilot balloon was responsible of the artefacts, we severed it in one cLMA and repeated the scan.

We used a standard, validated cylindrical water phantom made of polymethylmethacrylate plastic with dimensions of 15 cm × 15 cm × 35 cm (width × height × length), filled with a copper sulphate solution (770 $mg.l^{-1}$).

The imaging planes were oriented to encompass the short and long axis of the phantom using T2-weighted gradient-echo (GE) images: repetition time 638 ms; echo time 23 ms; flip angle 18°; field of view 230; Matrix 512 × 512. Gradient-echo images were used because artefacts due to ferromagnetic objects are more prominent in GE sequences than spin-echo (SE) ones. Although GE images have more artefacts, it is required in some cases,

Figure 1 Photograph of the supraglottic airway devices placed on top and inside a phantom simulator. (a) lateral view of the Classic LMA; (b) frontal view of the i-gel supraglottic airway; (c) Classic LMA positioned in the interior of the phantom.

e.g. when cerebral haemorrhage must be ruled out. In most of these cases, T2-weighted GE images cannot be replaced by SE sequences. In the clinical setting, the need for T2-weighted GE sequences could be considered as the 'worse case scenario'.

The artefacts of the MR images were subjectively evaluated by an expert neuroradiologist.

Results

The images of the different supraglottic airways with the T2-weighted GE sequences are shown in Figs 2 and 3. We chose the image in which maximal size of the artefact was shown. The artefacts of the cLMA, LMA Unique and LMA Supreme were similar and related to the ferromagnetic material in the pilot balloon valve. The magnetic susceptibility artefact was much more prominent with the LMA ProSeal (Figs 2 and 3). When we repeated the MRI of the cLMA after severing the pilot balloon, the artefacts disappeared (Fig. 4). There were no artefacts with the Ambu Disposable Laryngeal Mask nor with the i-gel (Figs 2 and 3).

Discussion

Radiologists are accustomed to artefacts in image interpretation; however the similarity of silicone to human tissue under imaging may make the LMA unsuitable for use with MRI [3–5]. Manufacturers of the LMA-Flexible™, LMA-ProSeal, and LMA-Fastrach™ tracheal tube all highlight the potential of these devices to create image distortion (and they also warn that the device could become warm) [6]. Añez et al. [7] reported that the LMA ProSeal distorted MRI images (1-Tesla scan) but the

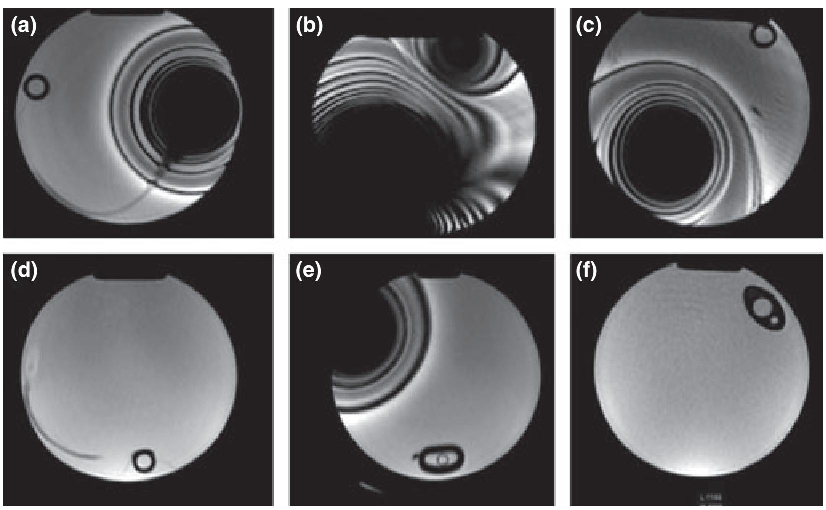

Figure 2 Axial magnetic resonance image showing artefacts as concentric circles produced by the metal spring of the pilot balloon in (a), (c) and (e) (corresponding to the Classic LMA, LMA Unique, and LMA Supreme); in (b), the two groups of concentric circles correspond to the metal in the pilot balloon and in the airway tube of the LMA ProSeal. In (d) (Ambu Disposable Laryngeal Mask) and (f) (i-gel supraglottic airway) there were no artefacts.

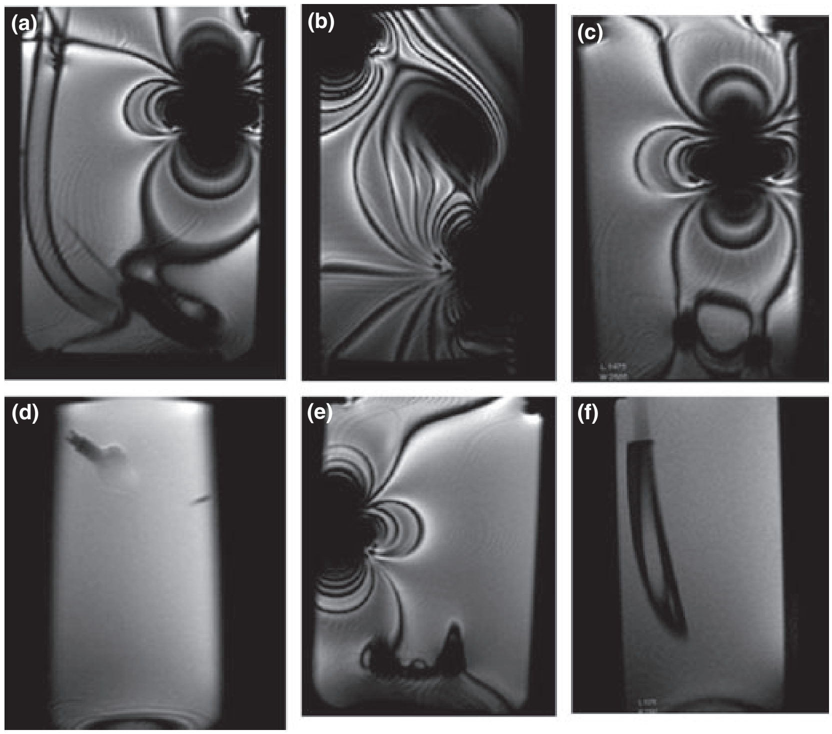

Figure 3 Sagittal magnetic resonance image showing the artefacts produced by the spring contained in the pilot balloon in (a), (c) and (e) (corresponding to the Classic LMA, LMA Unique, and LMA Supreme). In (b) (LMA ProSeal) the artefact is larger, produced by the summation of the metal in the pilot balloon and in the airway tube. In (d) (Ambu Disposable Laryngeal Mask) and (f) (i-gel supraglottic airway) there were no artefacts.

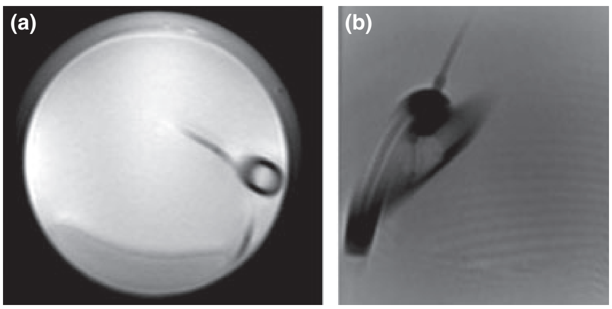

Figure 4 Axial and sagittal magnetic resonance images of the Classic LMA with the pilot balloon cut off; the artefacts have disappeared. (compare with images in Figs 2a and 3a).

cLMA yielded acceptable images in a 4-year-old patient scheduled for a brain MRI. Steven and Burden [8] found that the force exerted by the MRI magnet on an LMA-Flexible device was modest and that the cuff remained in place during the procedure (although the LMA-Flexible caused an artifact by producing a black hole around the tube).

Our data for the two devices that yielded few or no artefacts is consistent with previous reports. The Ambu Disposable Laryngeal Mask appears suitable for use with MRI [9, 10]. There appears to be only one case report on the uneventful use of the LMA Supreme for a cranial MRI exploration in a patient with cranio-cervical dystonia [11]. There are no data available on the use of the i-gel during MRI, so our data are novel in this regard.

We infer that the concentric circles of artefact in the short- and long-axis sections in Figs 2 (a), (c) and (e) and 3 (a), (c) and (e) were caused by the spring contained in the pilot balloon of the cLMA, LMA Unique and LMA Supreme, since this was the only metal part of those devices. This notion is supported by the fact that, when we severed the pilot balloon in a cLMA, the artefacts vanished (Fig. 4). The outsized artefact of the LMA ProSeal was caused by the summation of the metal in the pilot balloon and in the airway tube. The Ambu® Disposable Laryngeal Mask and the i-gel supraglottic airway do not contain any metal parts, and thus did not cause any artefacts, so these may be the most appropriate for use during MRI.

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