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Original Article

In vitro study of Magnetic Resonance Imaging artifacts of anesthetic devices

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Abstract

Background: Deep sedation or general anesthesia is usually required for Magnetic Resonance Imaging when patients cannot remain motionless in the suite. Various anesthetic devices have been used to maintain the airway and ventilate the lungs during this period. Some of them produce artifacts that pose difficulties in the interpretation of images. The aim of this study was to identify the devices that produced artifacts during Magnetic Resonance Imaging.

Methods: Twelve anesthetic devices were considered: oro-pharyngeal airway, naso-pharygeal airway, face mask with reservoir bag, nasal cannula, endotracheal tube, disposable Ambu Laryngeal Mask Airway, Laryngeal Mask Airway Unique, Disposable Laryngeal Tube Sonda, i-gel, Ambu bag, Bain Circuit, Jackson Rees Circuit. Magnetic Resonance Imaging was performed with each device placed on the top of a phantom simulator respectively to resemble the position in vivo.

Results: The artifacts with Disposable Laryngeal Tube Sonda, Laryngeal Mask Airway Unique and endotracheal tube were related to ferromagnetic material in the pilot valve and were similar. No artifacts were found with oro-pharyngeal airway, naso-pharygeal airway, nasal cannula, endo-tracheal tube with pilot valve detached, face masks with reservoir bag (metal removed), Ambu bag (without Adjustable Pressure Limiting valve), i-gel , disposable Ambu Laryngeal Mask Airway, Bain Circuit and Jackson Rees Circuit.

Conclusion: Anesthetic devices that produce Magnetic Resonance Imaging artifacts are disposable Laryngeal Tube Sonda, Laryngeal Mask Airway Unique and Endotracheal Tube.

Key words: Anesthesia; artifacts; Magnetic Resonance Imaging

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Introduction

Deep sedation or generation anesthesia is usually required for Magnetic Resonance Imaging (MRI) when patients cannot remain motionless in the suite.[1,2,3] During such conditions, the patient's airway is often maintained using airway adjuncts like Oropharyngeal Airway (OPA), Nasopharyngeal Airway (NPA), advanced airway devices like Endotracheal Tubes (ETT) and Laryngeal mask airway (LMA) and ventilation is managed using Bain circuit (BC) and Jackson Rees Circuit (JRC). Various artifacts are produced by these equipment during MRI scanning.[4] OPA, NPA, face mask, BC, and JRC have no ferro-magnetic material in them but ETT, LMA and Disposable Laryngeal Tube Sonda (LTS-D) contain variable amount of ferromagnetic material that may reduce image quality. LMA ProSeal, LMA Flexible, LMA Fastrach and Flexible ETT have visible metal parts and certainly cause artifacts.[5] There is little information available about the anesthetic equipment used during MRI scanning. Therefore, in vitro study of these devices would be useful to identify such artifacts as they pose a lot of difficulties in the interpretation of Magnetic Resonance (MR) images. The aim of this study was to identify the anesthetic devices that produced artifacts during Magnetic Resonance Imaging.

Methods

The study was approved by the Local Authority and Ethics Committee of the Institution. Twelve anesthetic devices were included. They were oropharyngeal airway (Guedel airway, Romsons™), nasopharygeal airway (Romsons™), oxygen face mask with reservoir bag (Hi mask, Romsons™), nasal prongs (Oxyset, Romsons™), endotracheal tube (Tyco™), Laryngeal Mask Airways (Disposable Ambu LMA, LMA Unique™), i-gel, Disposable Laryngeal tube Sonda™ (BVM) (LTS-D), Ambu Bag without Adjustible Pressure Limiting (APL) valve (Laederal™), Bain circuit (Romsons™) and Jackson Rees Circuit (Romsons™). They were evaluated during an MRI procedure in a 0.35-Tesla MRI scanner (Airis Elite Hitachi™).

Radiologists often use a Phantom Simulator (PS) to check the MRI machine for compatibility with implants and devices. A standard cylindrical water phantom made of polymethyl methacrylate plastic with dimensions of 12 cm x 24 cm (diameter x height), filled with a nickel solution was placed in the center of the magnetic field where the head of a hypothetical patient would be positioned (Figure 0).The imaging planes were oriented in a standard way to encompass the short and long axis of the phantom using T-2 gradient-echo (GE) images: repetition time 1000 ms; echo time 50 ms; flip angle 20^0, field of view 220^0; Matrix 256 x 256. GE images were used because artifacts due to ferromagnetic objects are more prominent in GE sequences than spin-echo (SE) ones.

The anesthetic devices were placed on the top of the PS one at a time (Figures 1,2,3,4,5,6a,6b,7,8,9,10,11) such that the pilot balloon (if present) was positioned at a distance that simulated its actual position in vivo. The scans were repeated with each device to identify the presence of artifacts. The MRI scans were repeated with ETT, LMA Unique and LTS-D respectively, after removal of the pilot valve containing the metal spring. The artifacts of the MR images were subjectively evaluated by expert radiologists of different institutes.

The photographs of anesthetic devices on the Phantom Simulator (PS) are shown in the following figures (Fig):

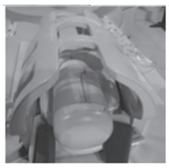
Fig.0


Fig.1


Fig.2


Fig.3

Fig 0. PS without anesthetic equipment

Fig 1. PS with Oropharyngeal Airway

Fig 2. PS with Nasopharyngeal airway

Fig 3. PS with Face mask with reservoir bag

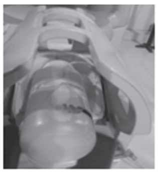
Fig.4


Fig.5

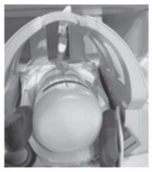
Fig.6a


Fig.6b

Fig 4. PS with Nasal cannula

Fig 5. PS with Endotracheal Tube

Fig 6a. PS with Ambu LMA

Fig 6b. PS with LMA unique

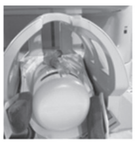
Fig.7

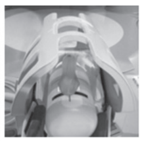
Fig.8

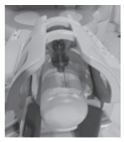
Fig.9


Fig.10


Fig.11

Fig 7. PS with Laryngeal Tube Sonda -D

Fig 8. PS with i-gel

Fig 9. PS with Ambu bag

Fig 10. PS with Bain circuit

Fig 11. PS with Jackson Rees circuit

Results

The images of the different anesthesia equipment with T-2 GE sequences were obtained as shown in the figures below with the abbreviations of the names on them.



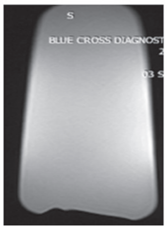


Fig.12 Fig.13 Fig.14 Fig.15

Fig 12. Control: no equipment

Fig 13. OPA

Fig 14. NPA

Fig 15. Face mask with reservoir bag




Fig.16 Fig.17 Fig.18 Fig.19

Fig 16. Nasal cannula

Fig 17. ETT with pilot valve (PV) with artifact

Fig 18. ETT without PV

Fig 19. Ambu LMA

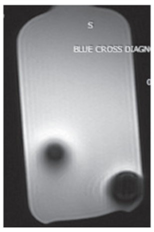
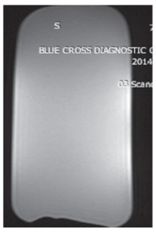
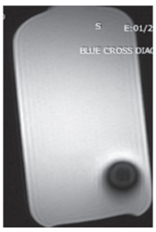


Fig.20 Fig.21 Fig.22 Fig.23

Fig 20. LMA unique with artifact

Fig 21. LMA Unique without PV

Fig 22. LTS- D with artifact

Fig 23. LTS-D without Pilot valve (PV)




Fig.24 Fig.25 Fig.26 Fig.27

Fig 24. i-gel

Fig 25. Ambu bag (without APL valve)

Fig 26. Bain Circuit

Fig 27. Jackson Rees circuit JRC

The images were studied for artifacts and they were observed with LTS-D, LMA Unique and ETT (with pilot valve). No artifacts were found with OPA, NPA, nasal cannula, face masks with reservoir bag (metal removed), Ambu bag (without Adjustable Pressure Limiting valve), i-gel, disposable Ambu LMA, Bain circuit and Jackson Rees circuit. No artifacts were noticed when the pilot valve was detached from ETT, LTS-D and LMA.

Discussion

Artifacts pose a lot of difficulties in image interpretation to the radiologists. Disposable LMA and other devices were used in this study. Reusable LMA and other equipment made of silicon are unsuitable for use in MRI because silicon being similar to human tissue can cause distortion of MR images and can also get heated up.[6] However, Anez et al[7] reported that the LMA ProSeal distorted MRI images (1-Tesla scan) but the classic LMA yielded acceptable images in a 4-year-old patient scheduled for a brain MRI. Steben 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). Its metallic spiral is an essential design that makes it flexible and is made up of a small mass of lightweight metal. This possibly explains the modest amount of magnetic force exerted on it such that it remains undisplaced from the magnetic field.

Our data for the twelve devices that yielded the artifacts is consistent with previous reports. The Ambu LMA disposable appears suitable for use during MRI.[9] There are also data available on the use of the i-gel during MRI.[10] The disposable circuits, face mask and airways also appear suitable for use during MRI. The magnetic susceptibility artifact is certainly more prominent with LMA ProSeal, Flexible LMA and LMA Fastrach.[11,12] These devices were not evaluated for artifacts because they contain visible metal in them.

The artifacts of the ETT, LMA Unique and LTS-D were similar and were by virtue of ferromagnetic material in the pilot balloon valve. Artifact may be seen in the case of Ambu bag due to the ferromagnetic material present in the spring of the Adjustable Pressure Limiting (APL) valve but there were no artifacts when used without APL valve in the Ambu bag. MRI of ETT, LMA Unique and LTS-D were repeated after cutting away the pilot valve and the artifacts disappeared. There were no artifacts seen with OPA, NPA, face mask with the reservoir bag disposable Ambu LMA, i-gel and breathing circuits (BC, JRC).

Therefore, the artifacts were caused by the spring contained in the pilot balloon of the ETT, LMA Unique, and LTS-D, as this was the only metal part of those devices.[13,14] This is supported by the fact that when the pilot balloon in those devices were removed, the artifacts disappeared. The OPA, NPA, face mask (externally seen metal removed), nasal cannula, Ambu LMA, i-gel, Bain circuit and Jackson Rees circuit do not contain any metal parts, so these airway devices may be more appropriate for use during MRI.

Conclusion

Anesthetic devices containing ferromagnetic material produce artifacts during Magnetic Resonance Imaging.

Conflicts of interest: None

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