Original Article

In vitro study of Magnetic Resonance Imaging artifacts of anesthetic devices

Uday Bajracharya*, Prabhat Rawal**

*Shree Birendra Hospital, Chhauni and National Academy of Medical Sciences, Mahabaudha, Kathmandu, Nepal
**Nepal Armed Police Force Hospital, Balkambe, Kathmandu, Nepal

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-pharyngeal 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-pharyngeal 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

How to cite this article: Bajracharya U, Rawal P. In vitro study of Magnetic Resonance Imaging artifacts of anesthetic devices. JSAN 2015;2:13-16.

Corresponding author:
Uday Bajracharya, MD
Senior Consultant Anesthesiologist, Department of Anesthesiology,
Shree Birendra Hospital, Chhauni, Kathmandu.
Associate Professor of Anesthesiology and Critical Care
National Academy of Medical Sciences, Mahabaudha, Kathmandu, Nepal
Telephone: +977 9851070188, Email: udayabjrabajracharya@gmail.com
Introduction

Deep sedation or generation anesthesia is usually required for Magnetic Resonance Imaging (MRI) when patients cannot remain motionless in the suite.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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\textsuperscript{TM}), nasopharyngeal airway (Romsons\textsuperscript{TM}), oxygen face mask with reservoir bag (Hi mask, Romsons\textsuperscript{TM}), nasal prongs (Oxyset, Romsons\textsuperscript{TM}), endotracheal tube (Tyco\textsuperscript{TM}), Laryngeal Mask Airways (Disposable Ambu LMA, LMA Unique\textsuperscript{TM}), i-gel, Disposable Laryngeal tube Sonda\textsuperscript{TM} (BVM) (LTS-D), Ambu Bag without Adjustable Pressure Limiting (APL) valve (Laederal\textsuperscript{TM}), Bain circuit (Romsons\textsuperscript{TM}) and Jackson Rees Circuit (Romsons\textsuperscript{TM}). They were evaluated during an MRI procedure in a 0.35-Tesla MRI scanner (Airis Elite Hitachi\textsuperscript{TM}).

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°, field of view 220°; 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. 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. PS with Nasal cannula
- Fig 5. PS with Endotracheal Tube
- Fig 6a. PS with Ambu LMA
- Fig 6b. PS with LMA unique
- 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 Control: no equipment
Fig.13 OPA
Fig.14 NPA
Fig.15 Face mask with reservoir bag

Fig.16 Nasal cannula
Fig.17 ETT with pilot valve (PV) with artifact
Fig.18 ETT without PV
Fig.19 Ambu LMA

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)

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 al7 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 Burden8 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. 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

Acknowledgements: We acknowledge the Department of Radiology, Shree Birendra Hospital, Blue Cross Diagnostic Centre, MRI Centre and Kathmandu Imaging, Mr DS Pujari, MRI center Naxal, Mr A Khadka, BCDC Bagbagar, Bishnu Tha Ma SBH Chhauni and H Yadav, KI, Maitighar, the technical staffs of Radiological department. Special thanks: Prof. RK Ghimire, HOD, Dept of Radiology, IOM; Dr D Shrestha, KMC; Dr KB Rawal and Prof Dr SB Basnet, SBH, Chhauni.

References