Magnetic resonance imaging artifacts: how they obscure or shape the image

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Introduction

Artifacts are an inherent part of MRI. They may arise from system hardware or software, tissue properties or patient-related factors. Understanding these artifacts is essential for accurate image interpretation and prevention of diagnostic errors.

Motion artifact

Among the most important MRI artifacts are motion artifacts, which result in image blurring or duplication of structures. They arise from periodic movements, such as cardiac pulsation or respiration, or non-periodic ones, such as peristalsis or voluntary limb motion. Periodic motion often produces "ghost" images, whereas non-periodic motion typically causes image blurring.

Methods for reducing motion artifacts include good communication with the patient and if needed fixation and sedation. To reduce the effects of peristalsis we can use pharmacological agents.

Other ways to minimize are changing the phase encoding direction, using gating techniques, applying saturation bands, using fast imaging sequences and radial sampling.

Chemical shift artifact

It occurs at the interface between water and fat due to differences in the resonance frequencies of protons in their microscopic magnetic environments. Protons in fat resonate at a slightly lower frequency than protons in water.

As a result, the signal from fat is spatially shifted relative to the signal from water, producing a displaced signal or bright/dark edge at fat–water boundaries. The magnitude of this artifact increases with higher magnetic field strengths.

The presence of this artifact can be diagnostically useful because it helps identify fat components in tissues. It is used, for example, to distinguish benign adrenal adenomas from other adrenal gland lesions.

Ways to correct it are switching phase encoding direction, increasing receiver bandwidth and using fat-supression techniques.

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Image 1: Motion artifact (respiration) (Source: archive SBMS)

Image 2: Magnetic susceptibility artifact (Source: archive SBMS)

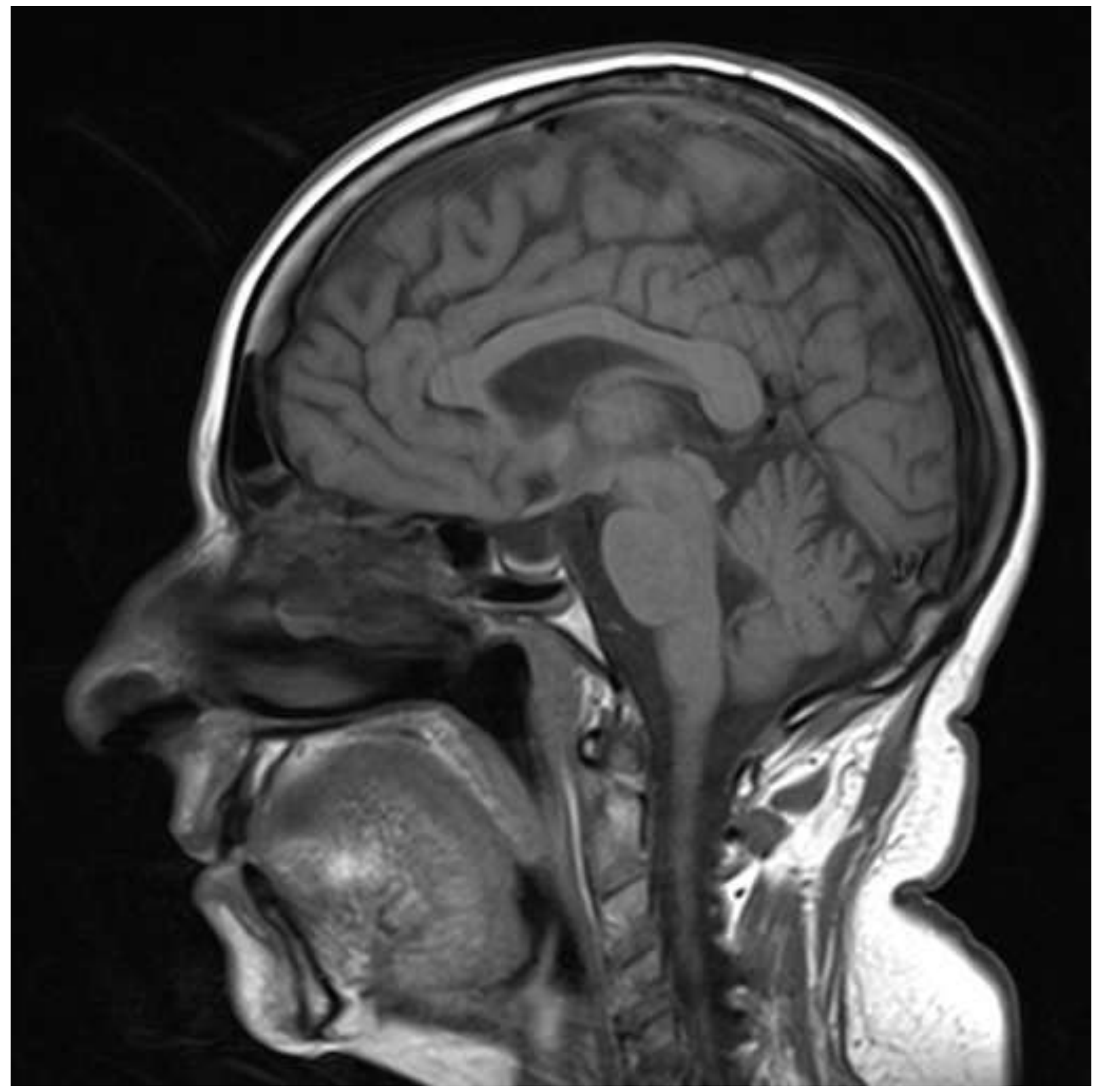

Image 3: Chemical shift artifact (Source: archive SBMS)

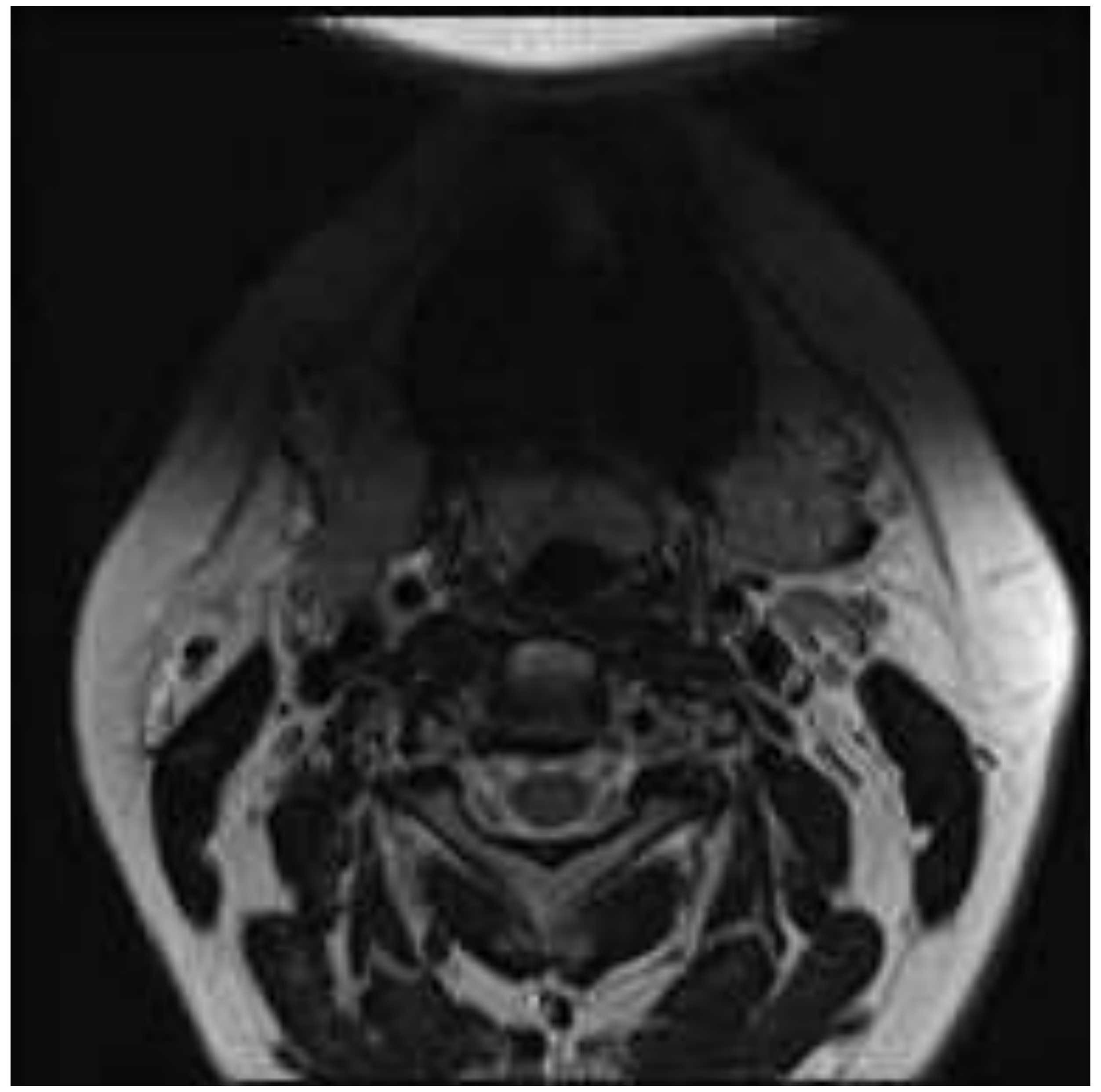

Image 4: Aliasing artifact (Source: archive SBMS)

Magnetic susceptibility artifact

This artifact occurs at the interface between tissues or materials with different magnetic susceptibilities. Magnetic susceptibility is a property that describes how strongly a material becomes magnetized when exposed to an external magnetic field.

Metal or other materials with magnetic susceptibility different from that of the surrounding tissue create local inhomogeneities in the main magnetic field (B_0). These inhomogeneities lead to frequency shifts and errors in spatial signal encoding, resulting in geometric distortions, signal loss, and signal "pile-up" artifacts.

To decrease the impact of metal, optimization of sequences can be made including the use of a lower magnetic field strength, increasing the receiver bandwidth, reducing slice thickness and using shorter echo times. Aligning an implanted device parallel to the main magnetic field (B_0) can also help to reduce the artifact. In addition, spin-echo sequences should be used when possible, instead of gradient-echo sequences, as the latter are more sensitive to magnetic field inhomogeneities.

Advanced metal artifact reduction techniques have also been developed such as View Angle Tilting (VAT), Slice Encoding for Metal Artifact Correction (SEMAC) and Multi-Acquisition Variable-Resonance Image Combination (MAVRIC).

Aliasing (Wrap-Around) artifact

Aliasing, also known as the wrap-around artifact, occurs when anatomical structures located outside the field of view (FOV) are incorrectly mapped onto the opposite side of the image.

During image acquisition, tissues outside the FOV also generate MR signals. When the FOV is smaller than the imaged anatomy, signals originating outside the FOV may be incorrectly mapped into the image due to insufficient sampling. As a result, structures located outside the FOV are displayed on the opposite side of the image, producing the aliasing artifact.

According to the Nyquist theorem, the sampling frequency must be at least twice the highest frequency present in the signal to avoid aliasing.

Methods for reducing or eliminating aliasing artifacts include increasing the FOV, using surface coils, applying presaturation bands for structures outside the FOV and using vendor-specific software options such as "No Phase Wrap" or "Phase Oversampling".

Other artifacts

Other common artifacts include the Gibbs artifact (truncation artifact), radiofrequency interference (the zipper artifact), spike artifact, and others.

References

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