College of Health and Medical Technologies
Department of Radiology Technologies
Computed Tomography

CT ARTIFACTS

4 th stage

LECTUER 8

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MSc Radiographic Imaging

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CT artifacts can be classified according to the underlying cause of the artifact.

Patient-based artifacts

motion artifact

transient interruption of contrast

clothing artifact

jewelry artifact

Physics-based artifacts

beam hardening

cupping artifact

streak and dark bands

metal artifact/high-density foreign material artifact

partial volume averaging

quantum mottle (noise)

aliasing in CT

truncation artifact

Hardware-based artifacts

ring artifact

tube arcing

out of field artifact

air bubble artifact

Helical and multichannel artifact

windmill artifact

cone beam effect

multiplanar reconstruction (MPR) artifact

zebra artifact

stair step artifact

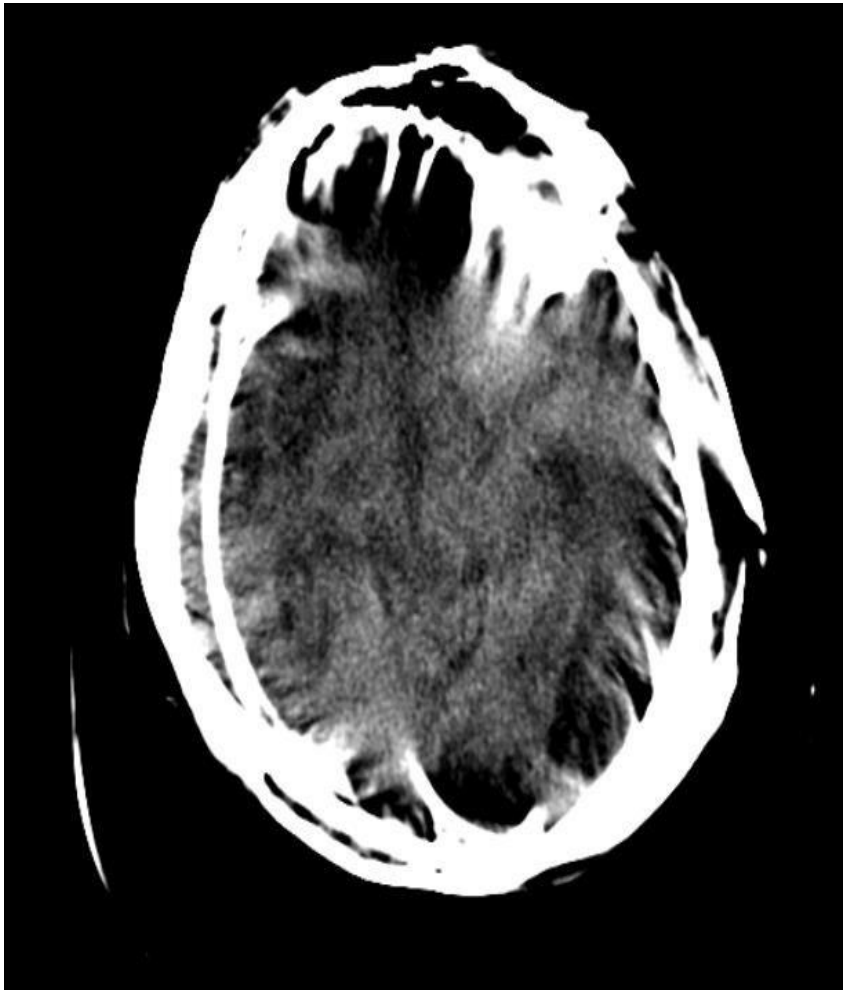
Motion artifact

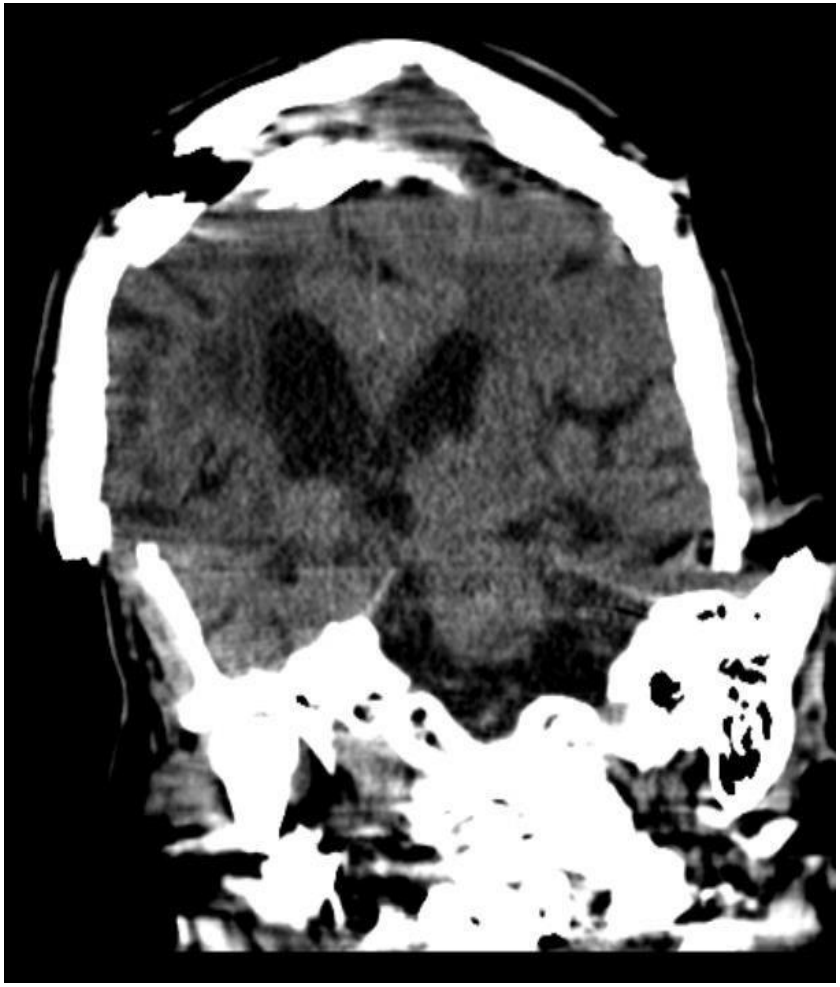
Motion artifact is a patient-based artifact that occurs with voluntary or involuntary patient movement during image acquisition.

Misregistration artifacts, which appear as blurring, streaking, or shading, are caused by patient movement during a CT scan. Blurring also occurs with patient movement during radiographic examinations.

If patient movement is voluntary, patients may require immobilization or sedation to prevent this.

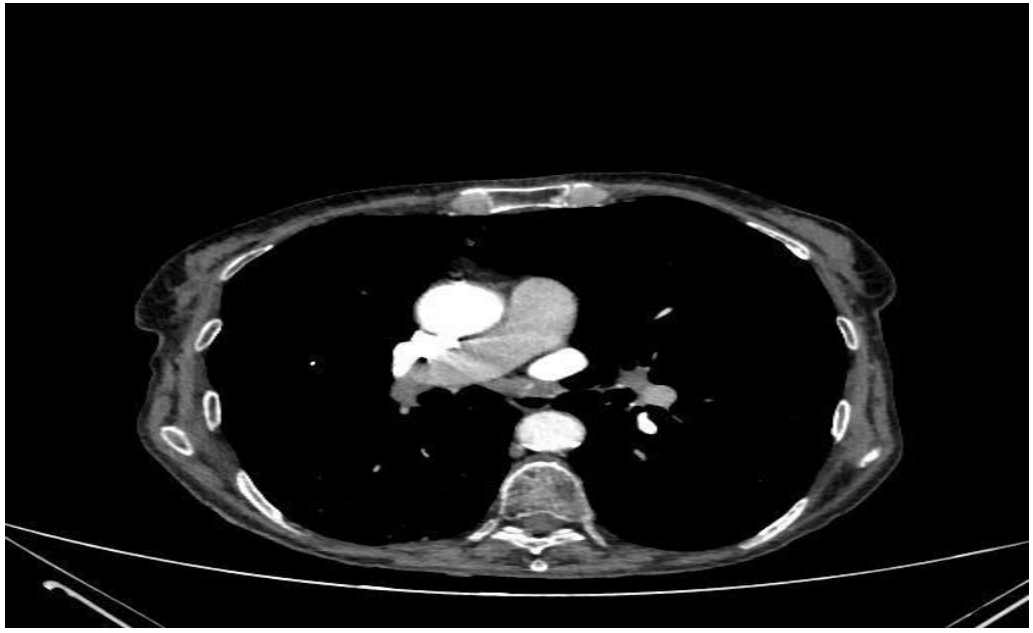
Involuntary motion, such as respiration or cardiac motion, may cause artifacts that mimic pathology in surrounding structures. Techniques, such as cardiac gating, may be used for examinations that concern the mediastinum





Transient interruption of contrast

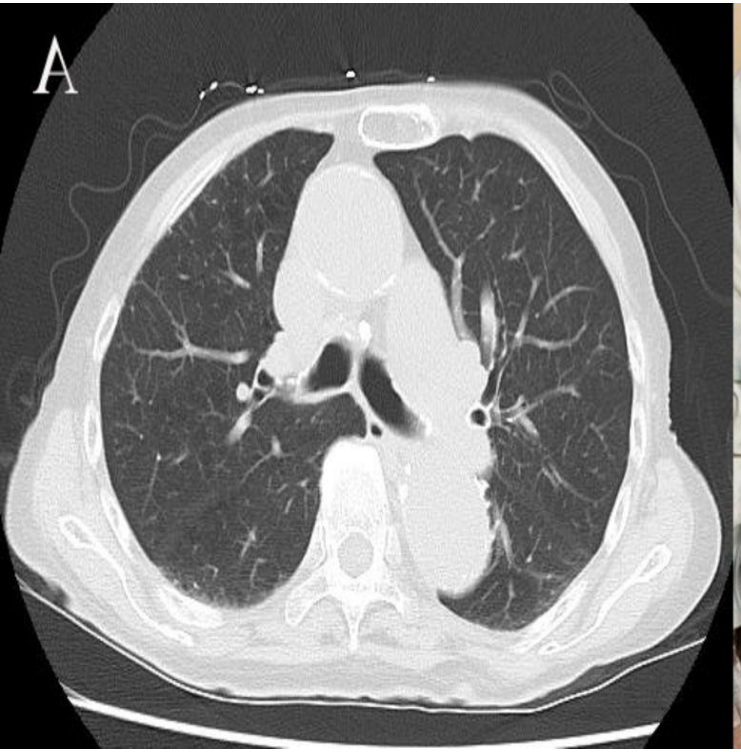
Transient interruption of contrast (TIC) is a common flow artifact seen in CT pulmonary angiography (CTPA) studies. The contrast opacification of the pulmonary arteries is suboptimal due to an increase in the flow of unopacified blood from the inferior vena cava (IVC) to the right side of the heart, often during deep inspiration



Clothing artifacts

Clothing artifacts, like jewelry artifacts, are a regular feature on imaging examinations, especially plain radiographs, but in general are recognized for what they are, either at the time the image is taken by the radiographer, or later by the reporting radiologist. The radiographer will often either retake the image or more commonly they will label the image with a warning that clothing artifact is present to avoid any misinterpretation taking place.

Removing clothing that corresponds to the area of interest is important


A

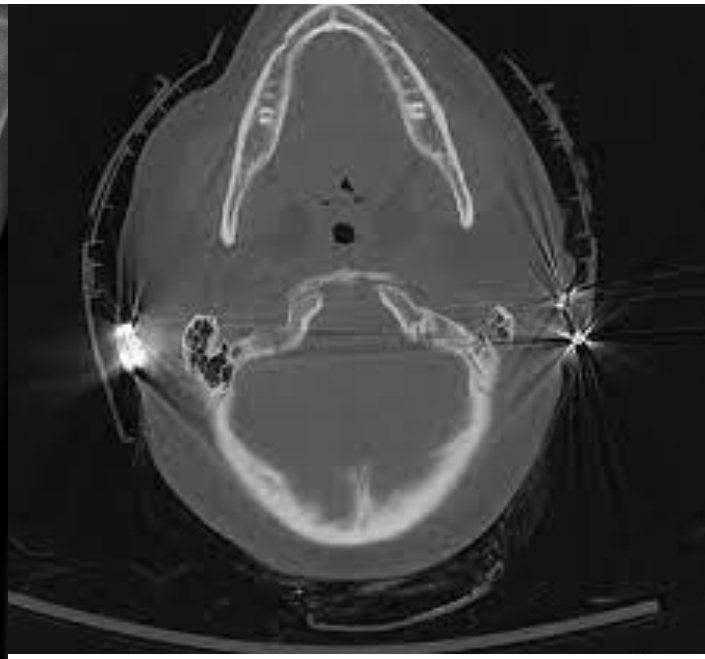

B
Always
Special Mind
Greatest Times
Beside
DELUXE

jewelry artifacts

It is common to see **jewelry artifacts** on imaging examinations, most commonly plain radiographs, although also on other modalities, where they can produce unhelpful artifacts that may obscure important structures and preclude confident diagnostic evaluation

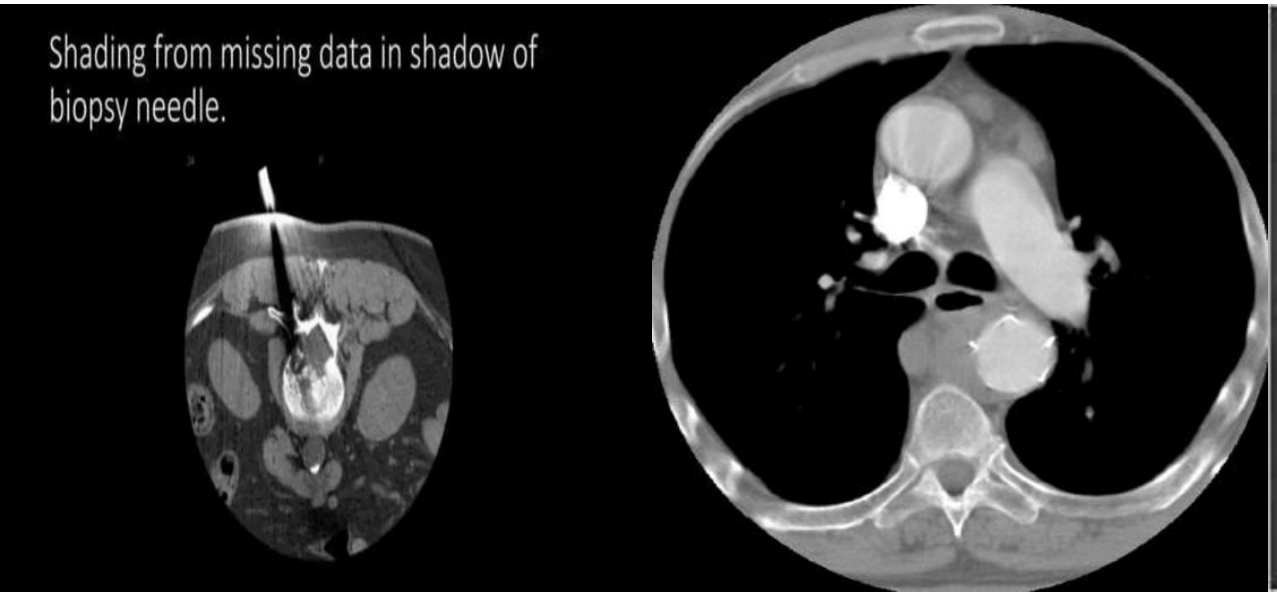
It is therefore incumbent upon the patient to remove jewelry before an imaging examination if it is likely to create diagnostic confusion. Usually, the radiographer will request that a patient removes all jewelry before imaging is performed.


R
red dot



Streaking artifact

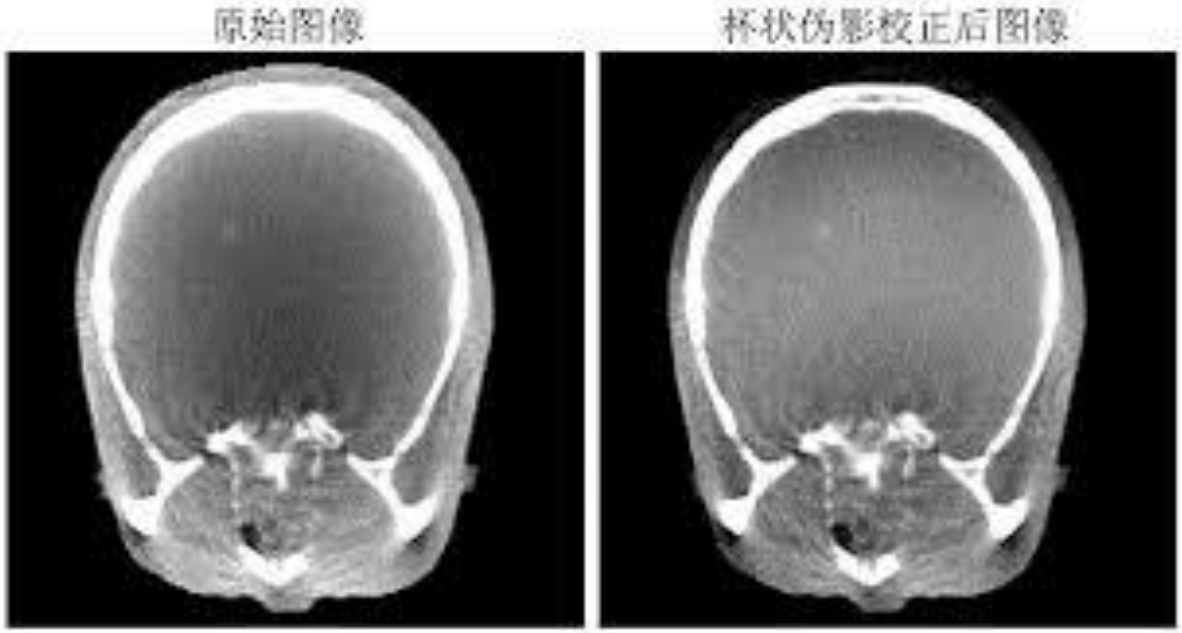
Streaking artifact appears as multiple dark streaking bands positioned between two dense objects, for example at the posterior fossa. Streaking may also occur along the long axis of a single high attenuation object. It is the result of the polychromatic x-ray being 'hardened' at different rates according to rotational position of the tube/detector.



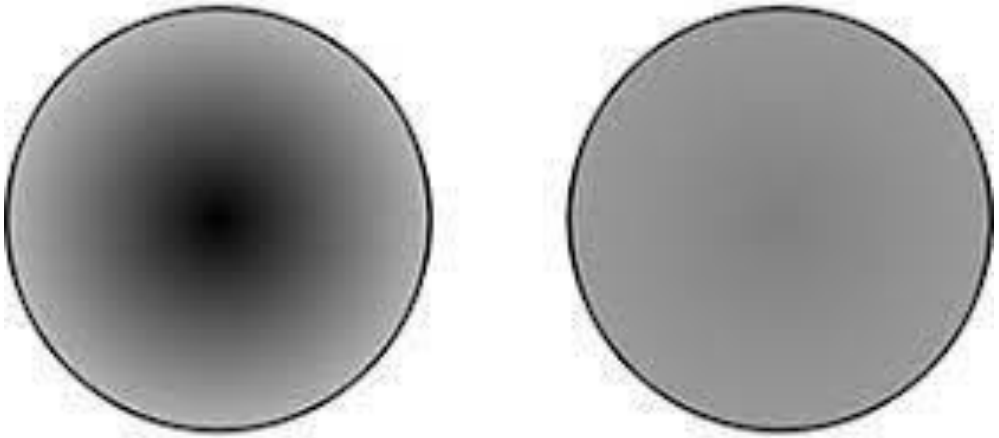
Cupping artifact

Beam hardening will cause the middle of the image to decrease in value, not increase edge value, as the lower energy photons preferentially get attenuated over longer path lengths. As the beam becomes harder and passes a higher mean beam energy, the lower attenuation coefficient means the CT number goes down for longer paths.

Since simple beam hardening correction is built into modern scanners, cupping artifact is not usually encountered during clinical imaging. The characteristic "cupped shaped profile" of the CT numbers is best demonstrated when scanning phantoms



Cupping artefact



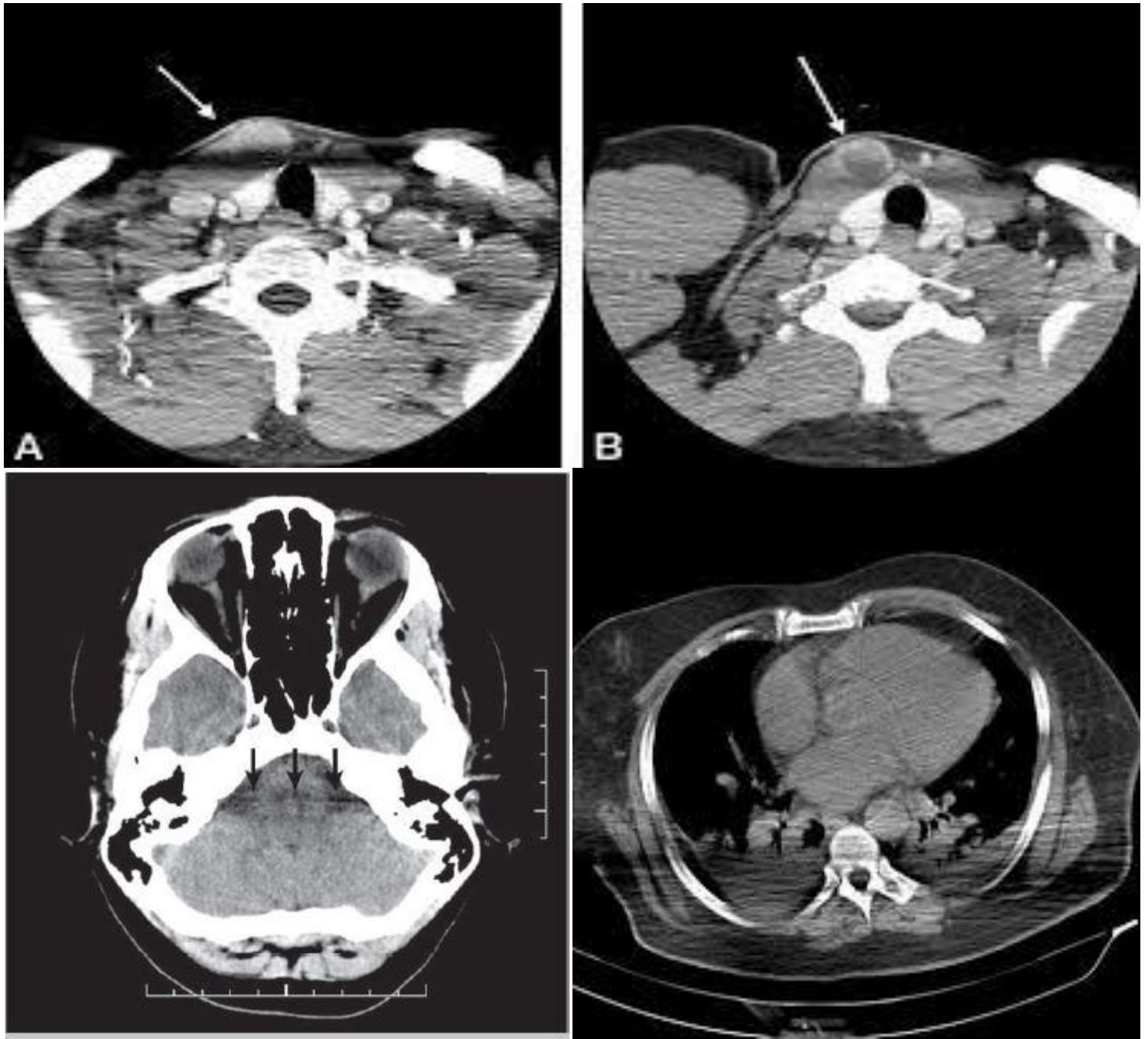
Uncorrected

Corrected

Beam hardening

is the phenomenon that occurs when an x-ray beam comprised of polychromatic energies passes through an object, resulting in selective attenuation of lower energy photons. The effect is conceptually similar to a high-pass filter, in that only higher energy photons are left to contribute to the beam and thus the mean beam energy is increased ("hardened")

CT beam hardening artifact has two distinct manifestations, streaking (dark bands) and cupping artifacts.


A
B

Beam hardening reduction

Most modern CT scanners utilize filters in an attempt to overcome beam hardening. Often an attenuating substance (usually metallic) is appropriated to harden the beam before it reaches the patient.

Streak artifacts can sometimes effectively be reduced by increasing tube voltage (better penetration of high-density objects), or by using a dual-energy imaging approach

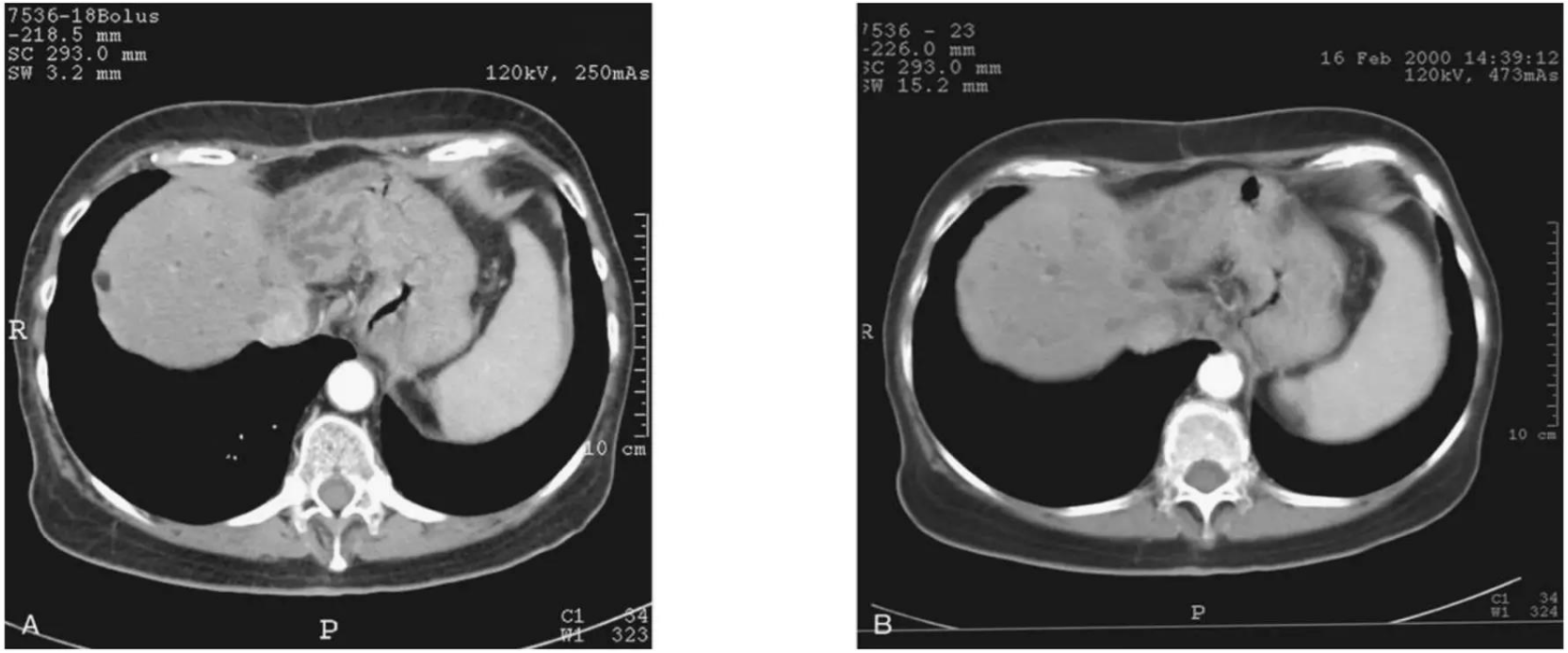
Partial volume artifact

occurs when tissues of widely different absorption are encompassed on the same CT voxel producing a beam attenuation proportional to the average value of these tissues.

The latest generation of CT scanners with an associated reduction in the volume of a voxel has substantially reduced the occurrence of this artifact.

Partial volume averaging is particularly problematic in CT angiography (e.g. misdiagnosis of an apparent contrast filling defect caused by the artifact as pulmonary embolism PE). Therefore the use of thin section reconstructions (1-1.5 mm) are recommended where the impact of this artifact is negligible

PARTIAL VOLUME ARTEFACT



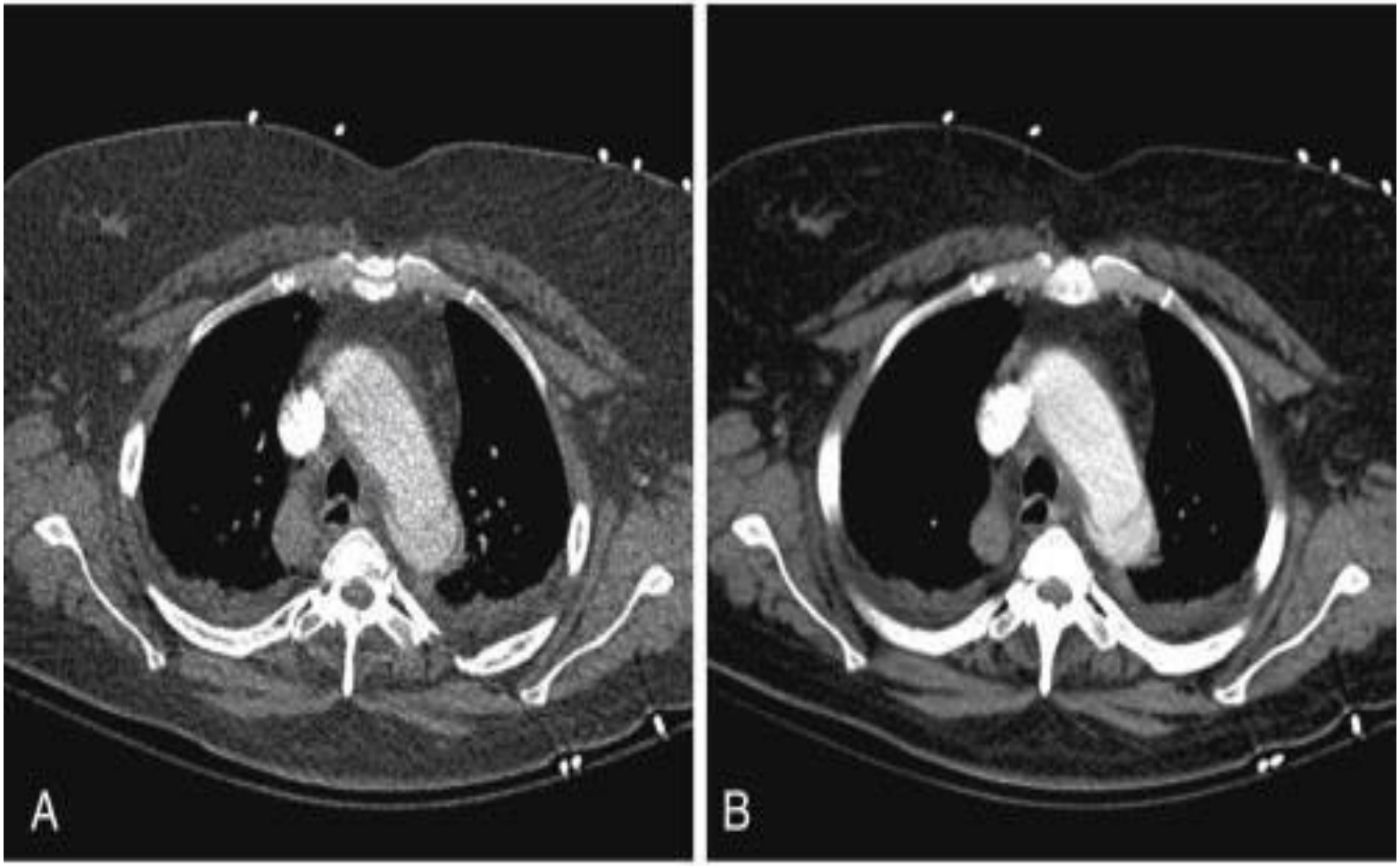
Liver scan showing partial-volume artifact. A, A 2.5-mm slice thickness shows good visibility of small liver lesions. B, A 10-mm slice thickness shows reduced lesion detectability with partial-volume averaging. (Images courtesy Dr. John Haaga.)

Noise (CT)

Noise in computed tomography is an unwanted change in pixel values in an otherwise homogeneous image. Often noise is defined loosely as the grainy appearance on cross-sectional imaging.

Noise in CT is measured via the signal to noise ratio (SNR); comparing the level of desired signal (photons) to the level of background noise (pixels deviating from normal). The higher the ratio, the less noise is present in the image.

Noise in a cross-sectional image will equal a decrease in the picture quality and inadvertently will hinder the contrast resolution.


A
B

Factors affecting noise

1 mAs:

Increasing the dose of the scan will decrease the amount of noise and hence improve the contrast resolution of the image.

2 Slice thickness:

The thicker the slice, the more photons available; and the more photons available, the better the SNR

3 Patient size:

Larger patients will absorb more radiation than smaller ones, meaning fewer photons will reach the detector hence reducing the signal to noise ratio.

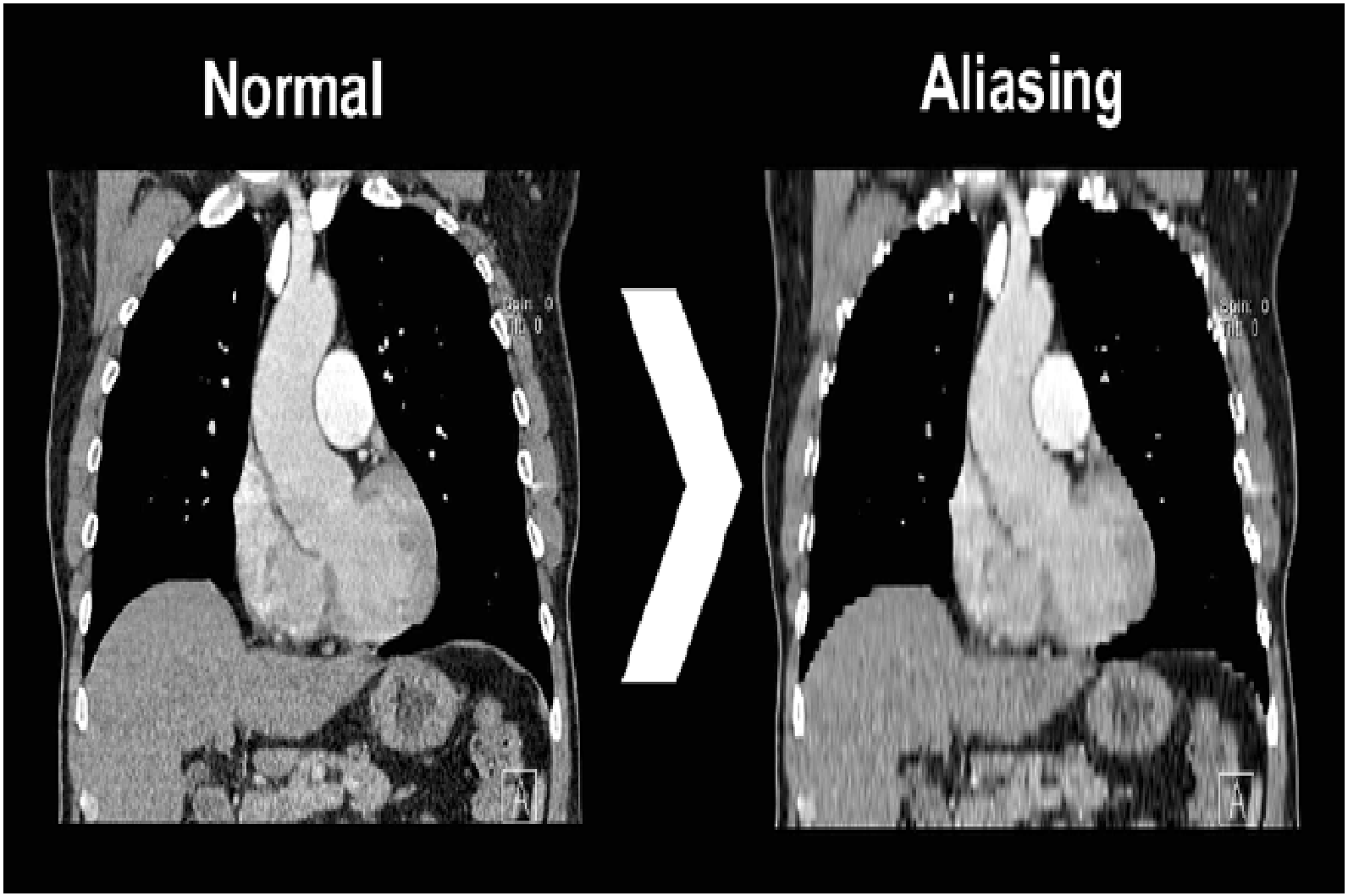
Aliasing artifact

Aliasing artifact, known as **undersampling**, in CT refers to an error in the accuracy proponent of analog to digital converter (ADC) during image digitization.

Image digitization has three distinct steps: scanning, sampling, and quantization.

When sampling, the brightness of each pixel in the image is measured, and via a photomultiplier, creates an output analog signal that is then due to undergo quantization.

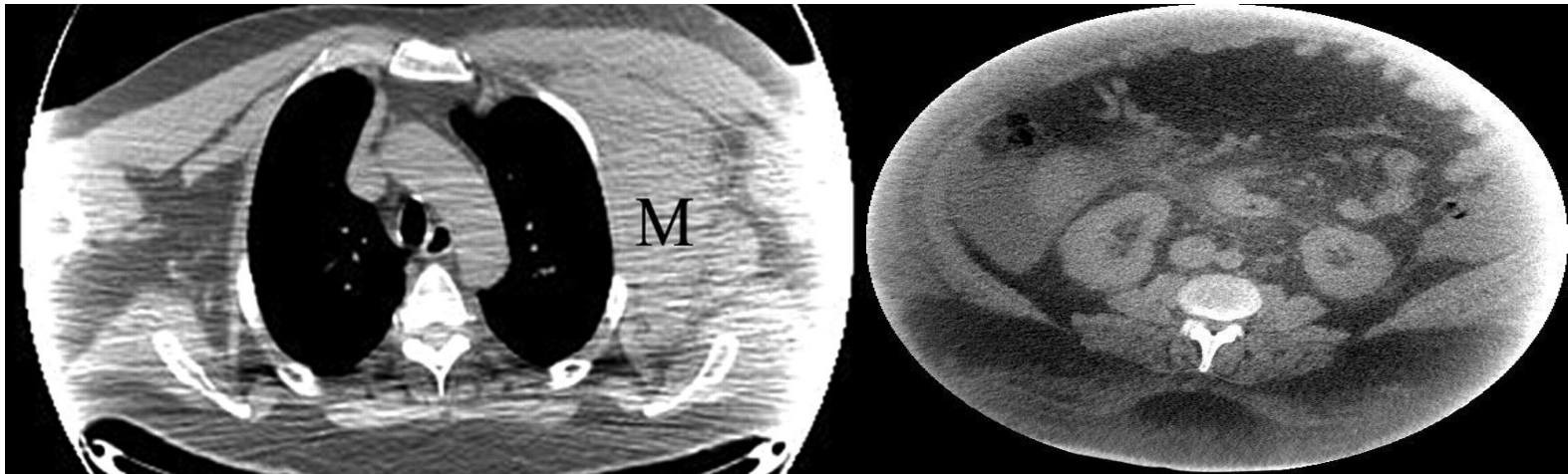
The more samples that are taken the more accurate the representation of the signal will be, hence if a lack of sampling has occurred the computer will process an inaccurate image resulting in an aliasing artifact.


Normal
Aliasing

Truncation artifact

Truncation artifact in CT is an apparently increased curvilinear band of attenuation along the edge of the image.

This artifact is encountered when parts of the imaged body part remain outside the field of view (e.g. due to patient body habitus), which results in inaccurate measurement of attenuation along the edge of the image. The artifact can be reduced - if possible - by using an extended FOV reconstruction of the affected region

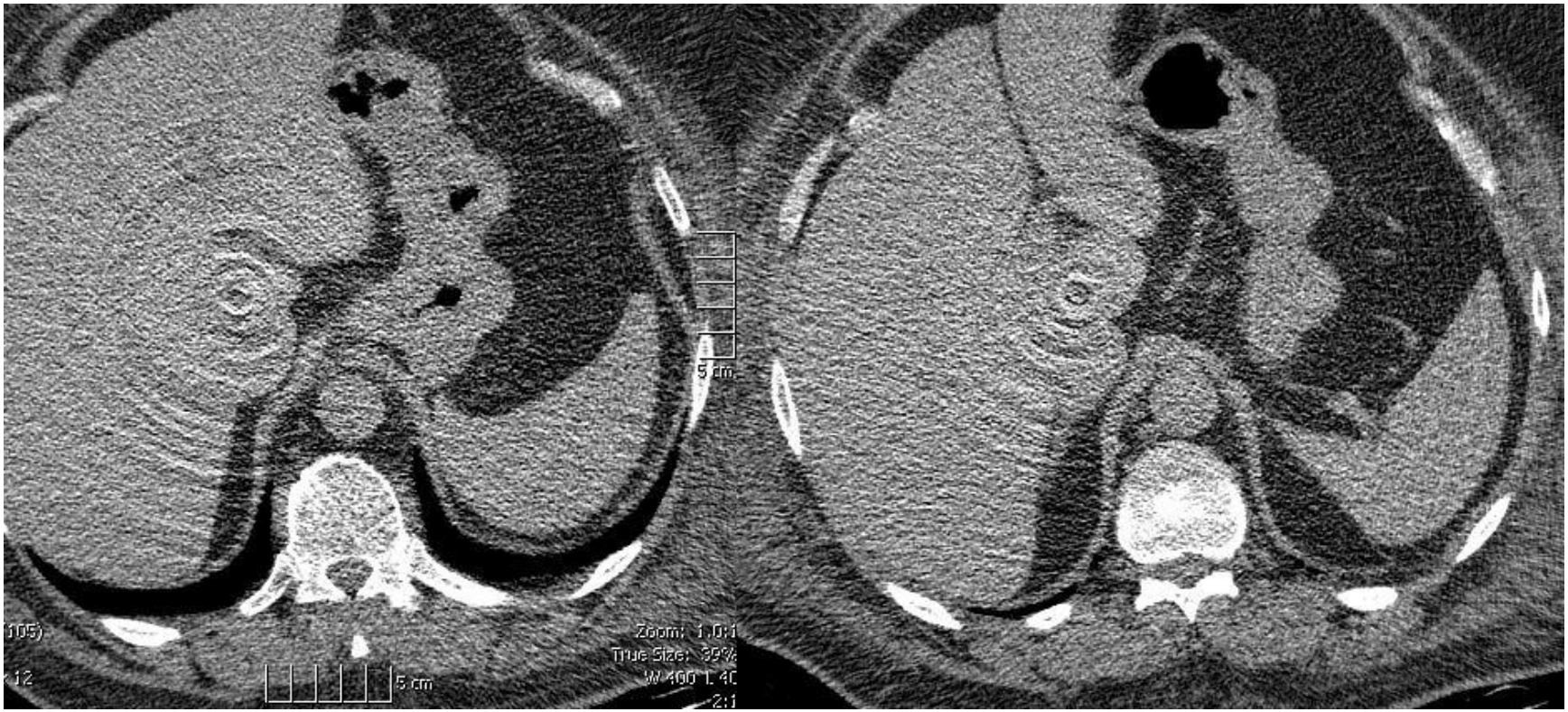


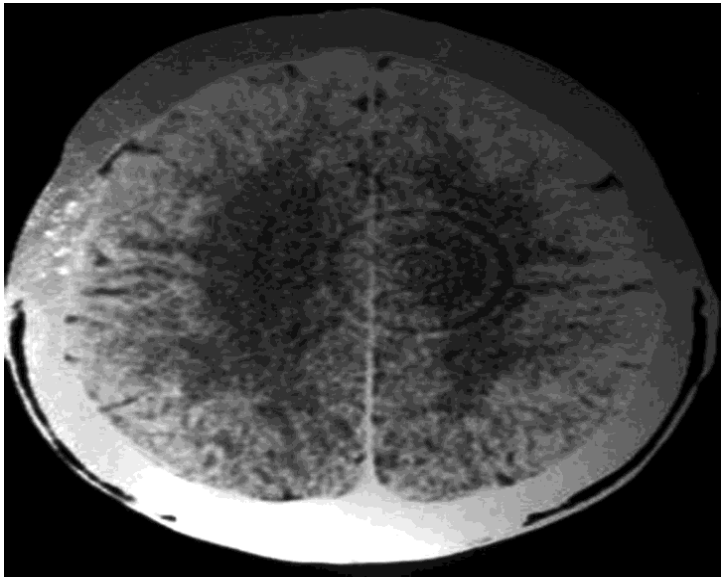
Ring artifact

Ring artifacts are a CT phenomenon that occurs due to miscalibration or failure of one or more detector elements in a CT scanner

They occur close to the isocenter of the scan and are usually visible on multiple slices at the same location. They are a common problem in cranial CT.

Recalibration of the scanner will usually rectify the artifact. Occasionally detector elements need replacing which can be costly.


5 cm
5 cm
Zoom: 1.0:1
True Size: 39%
W:400 L:40
2:1



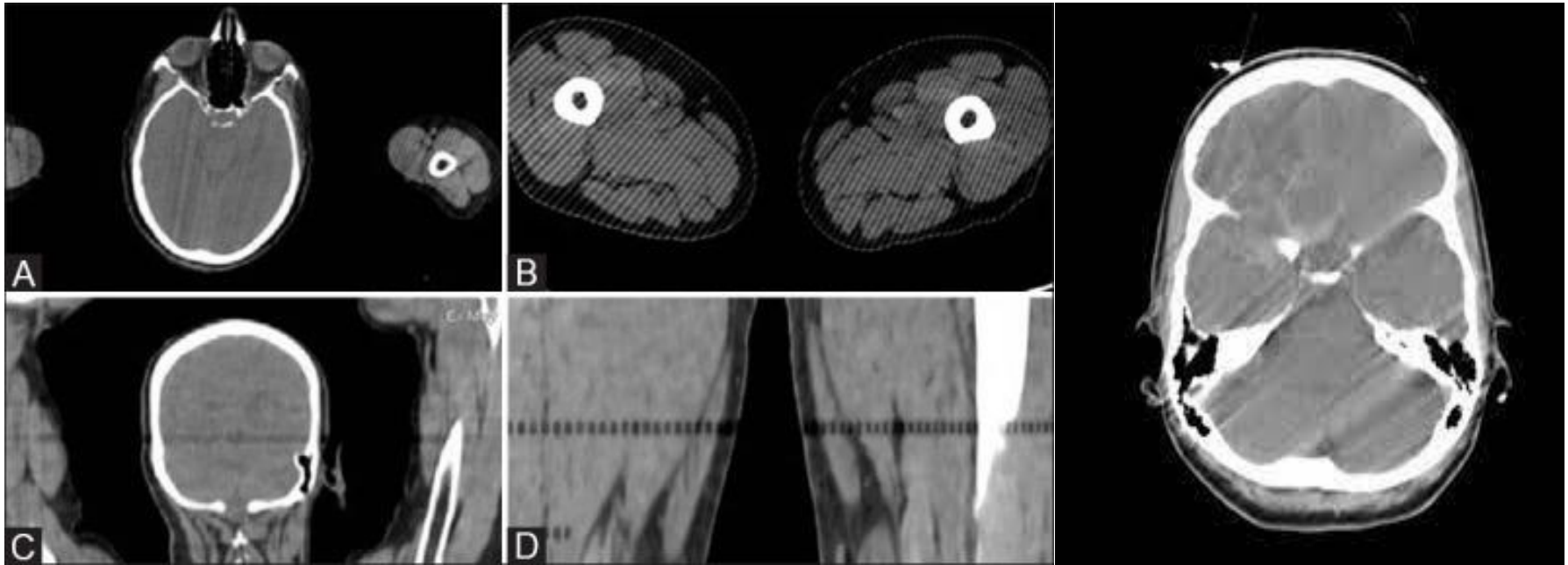
Tube arcing

Tube arcing occurs when there is a short-circuit within the tube, typically from the cathode to the tube envelope. The result is a temporary loss of x-ray output and a localized artifact.

most common due to particulate impurities or gas within the tube

new tubes are more prone to this problem due to residual gas

A small amount of tube arching is not uncommon and modern scanners have automated processes to remove the artifact from the final images



Out of field artifact

Out of field artifact (also known as **incomplete projection artifact**) is due to part of the patient existing peripheral to the field of view of the CT scanner. This can be a particular issue in obese patients who only just fit within the scanner bore.

The lack of data from these out of field tissue/objects interferes with the ability of the software to generate a correct image leading to streaking, and areas of unusual increased or decreased density.

Preventing this artifact relies on the CT operator ensuring that the body of the patient lies wholly within the scan field or - in the case of the arms - place them up or down depending upon whether the head and neck or chest and body are being scanned.

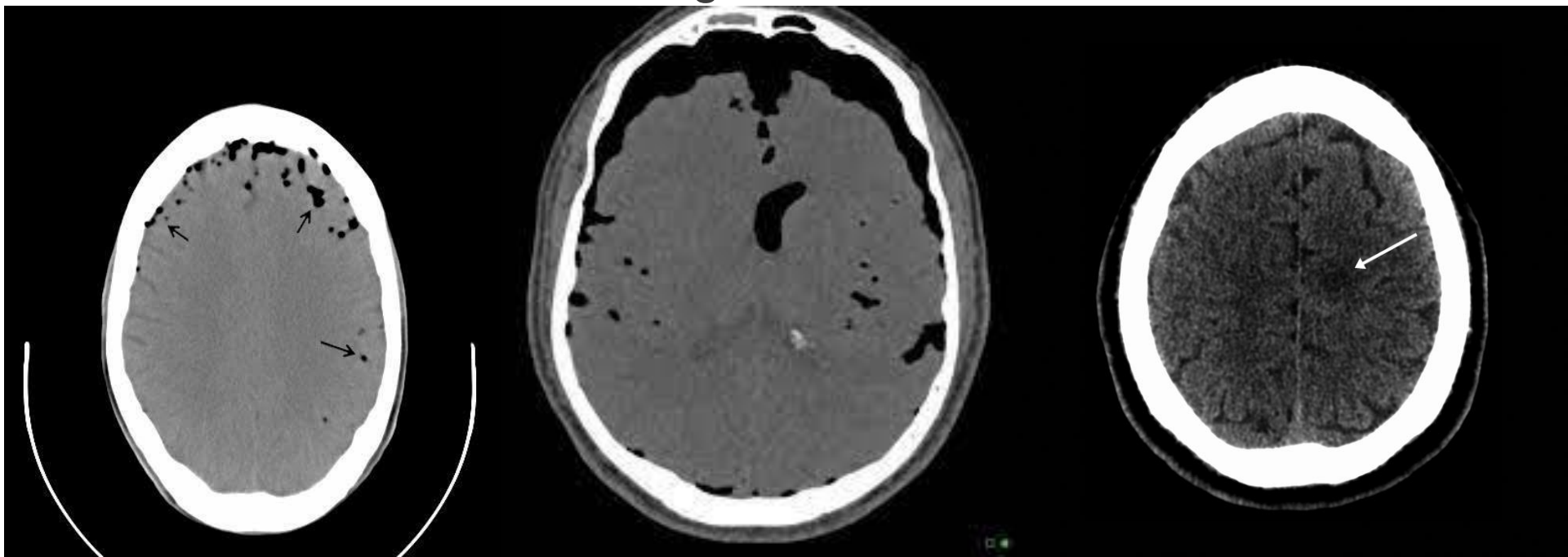
OUT-OF-FIELD ARTIFACT

- *Caused by parts of patient outside of SFOV*
- *Appears bright areas on the edges of the images*

air bubble artifact

The **air bubble artifact** on CT is due to the presence of abnormal gas in the oil coolant which surrounds the x-ray tube. The artifact manifests as subtle low density, which has only been described on brain scans.

Resolving the artifact requires an engineer to replace the oil and treat any underlying defect in the system e.g. a leak in the tube housing.



Zebra stripes/artifacts

Zebra stripes/artifacts appear as alternating bright and dark bands in a MRI image.

In CT there is also a zebra artifact from 3D reconstructions and a zebra sign from hemorrhage in the cerebellar sulci .

It therefore seems prudent to use "zebra" with a term like "stripes" rather than "artifacts"

CT stair-step artifact

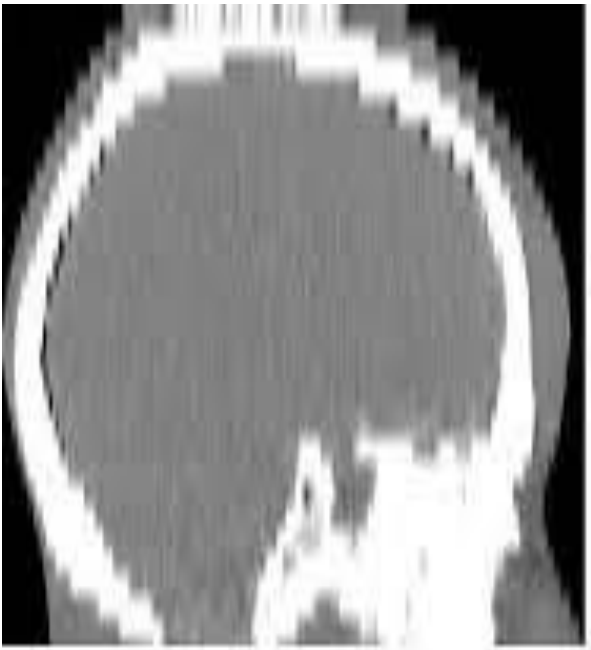
The **CT stair-step artifact** is found in straight structures which are oriented obliquely with respect to movement of the table and appear around the edges of sagittal and coronal reformatted images when wide collimations and non-overlapping reconstruction intervals are used.

It is also seen in coronary CT angiography when step-wise reconstructions are from different cardiac phases. This is associated with heart rate variability and irregular heart rates.

Solution

This can be minimized by, using smaller collimation and overlapping reconstruction in helical imaging.

In coronary CT angiography, 256 and 320-detector CT scanners typically avoid this artifact. Some authors recommend beta-blockers to reduce stair-step artifact, others report limited results in achieving target heart rates with their use.



a.

b.

THANK YOU