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CT IMAGE QUALITY

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DEFINITION

When discussing CT image quality, we are interested in how closely the image actually matches the patient. Just as a variety of factors influence a photograph's portrayal of reality, many factors influence how well a CT image represents the actual object scanned. *Image accuracy* may also be referred to as *image fidelity*.

> *Image quality is the ability to resolve anatomy in an image.*

Image quality revolves around the ability to accurately resolve anatomy within the image. To assess how well the image represents real anatomy, we are concerned with two main features: *detail*—or high-contrast resolution—and *contrast detectability*—or low-contrast resolution. High-contrast resolution is the level of detail that is visible on the image. For example, if two thin wires lie close together in an object, will they be seen as two separate lines on the image? Low-contrast resolution is the ability of the system to differentiate between objects with similar densities. For example, consider an object that is nearly the same density as its background. Will this object be distinguishable on the CT image?

SPATIAL RESOLUTION

Yet another term used for detail resolution is *spatial resolution*. Resolution is the ability to resolve, as separate forms, small objects that are very close together. Will two small B-Bs in the object scanned be represented on the image as one large circle, or will the system succeed in resolving them so that two smaller circles are seen?

> *Spatial resolution is the ability to resolve, as separate forms, small objects that are very close together.*

Measuring Spatial Resolution. Spatial resolution can be measured using two methods. It can be measured directly, or it can be calculated from analyzing the spread of information within the system. This data analysis is known as the modulation transfer function (MTF). By quantifying spatial resolution in one of these ways, it is possible to compare a system's performance with another CT system or the same system on a different day.

To measure resolution directly, a *phantom*, or *line pair phantom*, is used. This type of phantom is made of acrylic and has closely spaced metal strips imbedded in it. The phantom is scanned, and the number of strips that are visible are counted. A line pair is *not* a set of two lines, but rather a line and the space between lines. This is the conventional definition because it would be impossible to differentiate neighboring strips if there was no space between the lines. With this in mind, if 20 lines can be seen, the spatial resolution can be reported as 20 line pairs per centimeter (lp/cm).

The number of line pairs visible per unit length may also be referred to as *spatial frequency*. If objects are large, not many will fit in a given length. If the objects are smaller, many more will fit into the same length. How *frequently* an object will fit into a *given space* is its spatial frequency. Therefore, a large object will have a low spatial frequency, and small objects will have a high spatial frequency (Figure 1).

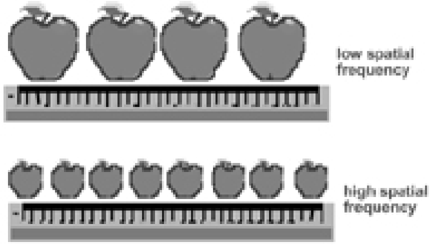

FIGURE 1. Spatial frequency is determined by object size.

> *MTF is the most commonly used method of describing spatial resolution ability.*

Spatial resolution can also be calculated using the MTF (Figure 2). The MTF is the most commonly used method of describing spatial resolution ability, not only in CT, but also in conventional radiography. It is often used to graph-

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ically represent a system's capability of passing information to the observer.

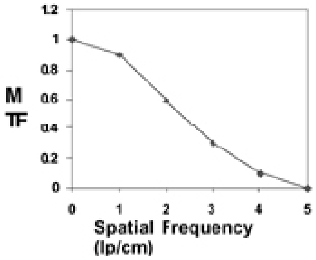

FIGURE 2. Modulation Transfer Function (MTF) Graph

The mathematical formula for calculating MTF is somewhat complex and provides little practical value for the average technologist. However, it is important to understand what MTF indicates and how it can be applied in evaluating a CT system's performance.

The ability of the system to accurately portray an object varies according to the size of the object (spatial frequency) of the object. As objects become smaller (higher spatial frequency), they will not be as accurately depicted on the CT image (ie, all other things being equal, smaller objects are harder to see). The MTF scale is from 0 to 1. If the image reproduced the object exactly, the MTF would have a value of 1. If the image were blank and contained no information about the object, the MTF would be zero. Because the actual MTF of most objects is between these two extremes, it will have a value between 0 and 1.

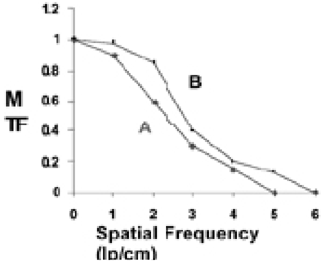

FIGURE 3. MTF Graph Comparing Scanner A to Scanner B

In graphic form, image fidelity (MTF) is charted against the spatial frequency (object size). These charts are typically referred to as MTF graphs and depict spatial frequency on the X axis and MTF along the Y axis. As expected, this graph shows that, as the size of the object increases, the MTF also increases (Figure 2). This finding correlates with the common sense observation that, as the size of the object increases, it can be more accurately portrayed on the image. The ability of a specific system to portray objects of varying sizes can be evaluated by examining a graph of its MTF. By charting the MTF of two separate CT systems, we can compare their ability to accurately resolve objects in the image (Figure 3). An MTF curve that extends farther to the right indicates higher spatial resolution, which means the imaging system is better able to reproduce small objects. In Figure 3, scanner B will produce images of higher spatial resolution than scanner A. The relationship between the size of the object and it's portrayal on the image is a complicated one. The relationship is *not* linear, meaning that an object twice the size of another object may not necessarily possess twice the image fidelity.

Limiting resolution is the spatial frequency possible on a given CT system at an MTF equal to 0.1. Figure 4 illustrates the concept of limiting resolution. First, identify the number 0.1 on the Y axis. This is considered the lowest MTF possible that will still result in a (barely) visible object. Follow this line across until it intersects the MTF curve of scanner A. We can see that at an MTF of 0.1, scanner A will have a spatial frequency of 4.3, whereas at the same MTF, scanner B will have a spatial frequency of 5.4. These numbers reflect the limiting resolutions of scanners A and B, respectively. Although CT scan resolution is often stated in these numeric terms, it is easier to think in terms of the object size that can be reproduced in the image. In our example, scanner B will be better able to reproduce small objects than will scanner A.

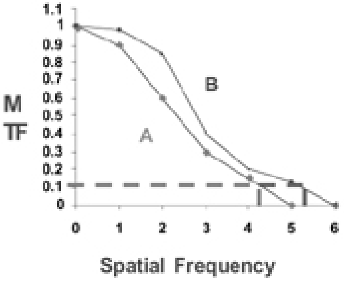

FIGURE 4. Limiting Resolution

FACTORS AFFECTING SPATIAL RESOLUTION

There are a variety of interrelated factors affecting the degree of spatial resolution in a CT image. These factors are matrix size, pixel size, field of view (FOV), voxel size, slice thickness, focal spot size, and blur.

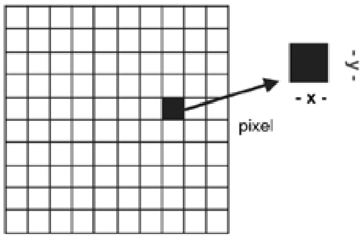

FIGURE 5. A matrix contains columns and rows of pixels.

Matrix and Pixel Size. To create an image, the system must segment raw data into tiny sections. A matrix is a grid that is used to break the data into columns and rows of tiny squares. Each square is a *picture element,* more commonly referred to as a pixel (Figure 5). The matrix size refers to how many pixels are present in the grid. A 512 matrix will have 512 pixels across the rows and 512 pixels down the columns. The most common matrix sizes used in CT are 256, 512, and 1024. Because the perimeter of the grid is held constant, a larger matrix six (ie, 1024 as opposed to 512) will contain smaller individual pixels. Therefore, matrix size is one of the factors that control pixel size.

Each pixel has a width X and a length Y. The two-dimensional pixel represents a three-dimensional portion of patient tissue. The pixel value represents the proportional amount of x-ray energy that passes through anatomy and strikes the detector. The information contained in each pixel is averaged so that one density number (or Hounsfield unit [HU]) is assigned to each pixel. If an object is smaller than a pixel, its density will be averaged with the information in the remainder of the pixel. This phenomenon is referred to as the *partial volume effect* or *volume averaging*. It results in a less accurate image.

The information contained in each pixel is averaged so that one HU is assigned to each pixel.

A large pixel size will make it more likely that multiple objects are contained within a pixel (Figure 6A). Because no object smaller than a pixel can be accurately displayed due to volume averaging, the pixel size affects the spatial resolution. When pixels are smaller, it is less likely that they will contain different densities, therefore decreasing the likelihood of volume averaging (Figure 6B). Hence, smaller pixel size will improve spatial resolution.

Because no object smaller than an pixel can be accurately displayed due to volume averaging (and the matrix size influences the size of the pixel), it follows that matrix size affects spatial resolution.

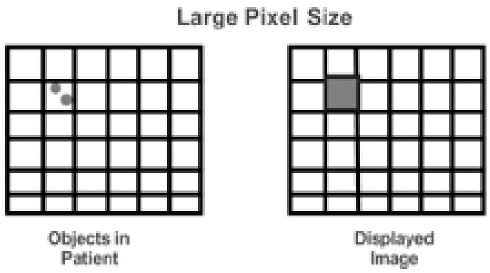

FIGURE 6A. Objects that fall within a pixel will be averaged together to appear on the image as a single, larger object.

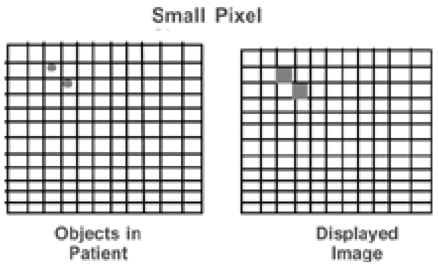

FIGURE 6B. Small pixel size reduces the likelihood that multiple objects will be averaged together. In this way, pixel size affects spatial resolution in the image.

Display Field of View (DFOV). Another factor influencing the size of the pixel is the DFOV. Selecting the DFOV determines how much of the total raw data available will be used to create an image. Decreasing the field of view will decrease the pixel size. Pixel size can be thought of as the amount of patient data each pixel contains. When we decrease the field of view, less information is contained in each pixel. As the field of view increases, the amount of data to be included in the image increases. Consequently, the pixel size increases as more patient information is crammed into each pixel. This causes the spatial resolution to decrease.

The following formula reveals the relationship between matrix size, display field of view, and pixel size:

$$\text{pixel size} = \frac{\text{field of view}}{\text{matrix size}}$$

Voxel Size. A voxel (volume element) represents a volume of patient data. Voxel size also plays a role in volume averaging. As stated earlier, in order to create an image, the system must break up the patient data into segments. We have seen how a matrix is used to divide the data into pixels with X and Y dimensions. This allows the system to create a two-dimensional image. However, it is important to keep in mind that a three-dimensional object is being represented. By accounting for the slice thickness, the voxel represents a volume of patient data. Thus, instead of a square of data-as is the case with a pixel-the voxel is a cube of data. All of the data within the voxel are averaged together to result in one HU.

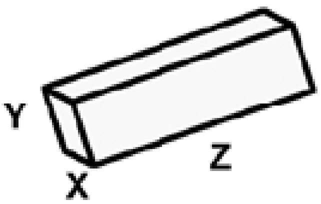

FIGURE 7. The depth of the voxel, or Z axis, correlates to the slice thickness.

The depth of the voxel correlates to the operator's selection of slice thickness. This dimension is referred to as the Z axis (Figure 7). When comparing the X, Y, and Z dimensions, even with a relatively large matrix and a small field of view, the slice thickness–or Z axis–will be longer than either the X or Y dimensions. Therefore, the slice thickness will play an even larger role in volume averaging (as well as the subsequent spatial resolution) than either display field or matrix size. In fact, slice thickness is the primary factor affecting the degree of volume averaging in the image.

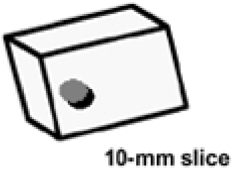

FIGURE 8A. A thicker slice will contain more volume averaging.

Decreasing the slice thickness affects the resolution in two ways. First, it reduces the amount of tissue averaged together. Second, it will increase the image noise if technique is not increased to compensate for photon absorption from increased collimation.

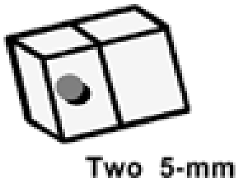

FIGURE 8B. Thin slices will reduce the amount of volume averaging and improve resolution.

Figures 8A and B illustrate how a wide slice thickness will affect the amount of volume averaging in the image. Assuming a 2-mm object is contained in a 10-mm slice (Figure 8A); 8 mm of normal tissue will be averaged to produce a less accurate image. By decreasing the slice thickness, as shown in Figure 8B, the amount of normal tissue that is averaged in with data from the abnormality is reduced. In this way, an image is created that more closely represents the actual object scanned.

Focal Spot Size. A small focal spot size will improve resolution in the image. Some scanners have only one focal spot available. Scanners with the option of higher mA stations often automatically switch to a larger focal spot size when mA is increased. This is due to the fact that although a small focal spot offers superior spatial resolution, it cannot withstand heat as well as a larger focal spot. Therefore, an increase in mAs often necessitates a larger focal spot. The effect from a change in focal spot is minimal and not readily visible in patient images. In fact, in order to assess the difference caused by a change in focal spot size, images must be taken with a phantom and then compared. Even though switching to a larger focal spot may slightly decrease the spatial resolution, it will likely be outweighed by the decrease in patient motion that is possible when switching to a shorter scan time with a higher mA.

Sharpness is the ability of a system to define an edge.

Blur. In considering the resolution of a system, we must consider an aspect known as *sharpness*. Sharpness is the ability of a system to define an edge. It is measured by the amount of blur in a system. Blur can result from factors intrinsic to radiography, such as the way a photon interacts with an object. Or blur can be caused from extrinsic factors, such as patient motion. Sources of blur in CT include geometric blur from the focal spot size, detector blur, absorption blur (patient), and motion blur (patient).

NYQUIST SAMPLING THEOREM

An element of random chance exists in the creation of a CT image. Applying the Nyquist sampling theorem helps explain this occurrence. When applied to CT imaging, the theorem can be summarized by the following statement: because an object may not lie entirely within a pixel, the pixel should be half the size of the object to increase the likelihood of being resolved.

To understand this theorem, it is again important to recall the way an object may be segmented by the system. If the object in question is the same size as a pixel, it is possible that by chance the object may fall entirely within a single pixel. Figure 9A represents this possibility. However, random chance will dictate that it is much more likely the object will straddle two different pixels. Figure 9B illustrates this possibility. It should be apparent that the image resulting from the case portrayed by Figure 9B would be inferior to that of the image resulting from Figure 9A. A third possibility could also arise. In Figure 9C, the object falls at the junction of four separate pixels. Therefore, only a fourth of the object will be averaged in with three fourths of a pixel of normal tissue. This would be the worst case scenario and would result in an image with the worst spatial resolution.

Because an object may not lay entirely within a pixel, the pixel should be half the size of the object to increase the likelihood of being resolved.

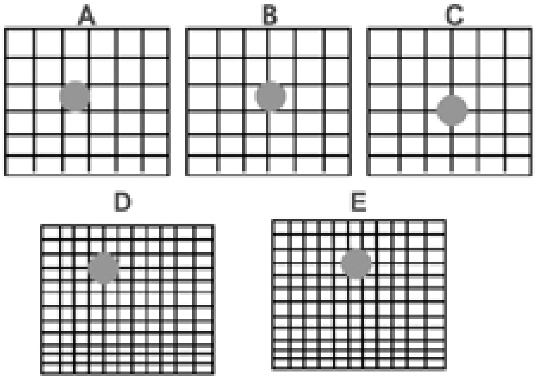

FIGURE 9. The Nyquist sampling theorem explains why a small pixel will increase resolution.

Furthermore, the Nyquist sampling theorem states that we can reduce the likelihood of our worst case scenario occurring by reducing the size of the pixel. We can see that in Figure 9D, the smaller pixel size will improve spatial resolution by allowing four pixels to represent the object, with no normal tissue enclosed in the pixel. However, even with the smaller pixel size, cases such as Figure 9E will still arise. In this case, the object will fall so that only two of the pixels accurately represent the object, whereas the four surrounding will have some degree of volume averaging. However, we can see from our illustrations that the situation depicted by Figure 9E would be preferable to that of Figure 9C. To review, by reducing the size of the pixel, we can increase our chance of accurately representing a small object. The theorem further states that in order to best increase our chances, the pixel size should be half the size of the object.

LOW-CONTRAST RESOLUTION

Low-contrast resolution is the ability to differentiate objects with slightly different densities. This factor is the second major aspect of image quality. In order to discern an object on an image, there must be a density difference between the object and its background. This is the type of contrast we are concerned with in the case of a liver lesion that is nearly the same density as normal liver tissue. The term *low-contrast detectability* is used when discussing the ability to see an object that is nearly the same density as its background. Often, intravascular or oral contrast agents are used to create or increase a density difference, thereby increasing an image's low-contrast resolution. Low-contrast resolution may also be referred to as the *sensitivity of the system*; hence, the term *low-contrast sensitivity* is also used.

The size of the object that is visible depends on three factors. The first is the level of contrast in the object. For example, consider a calcified nodule. It will be much easier to see if the nodule is in the lung, where the air within the lung will provide a substantial amount of contrast. On the other hand, imagine the difficulty in differentiating the nodule if it were to lie next to the iliac crest. The level of contrast that is related to the density of the objects being scanned is often called *subject contrast* (or sometimes *inherent contrast*).

The size of the object that is visible depends on the level of contrast in the object, image noise, and the window setting at which the image is displayed.

The second factor that influences the size of the object that is visible is *image noise*. We can recognize noise as the grainy appearance-or salt-and-pepper look-on an underexposed image.

The third factor is the window setting used to display an image. Narrow window widths will improve low-contrast discrimination in the image.

CT is superior to conventional film/screen radiography in its ability to resolve small differences in tissue densities. In fact, low-contrast resolution is where CT excels. Although the spatial resolution of a CT scanner is inferior to that of standard radiography its low-contrast resolution is much better. For example, in order for an object to be resolved with standard radiography, there must be a 10% difference in object density. But CT can resolve a density difference of as little as 0.1%.

FACTORS RELATING TO LOW-CONTRAST RESOLUTION

Common terms used when discussing low-contrast resolution are *contrast scale, contrast-detail response, receiver operator characteristics (ROC), quantum noise,* and *dose.*

Contrast scale is affected by the *window width* and *window level*. As a general rule, to enhance contrast between two tissues, narrow the window to just include both tissues, and set the level centered between them.

Contrast-detail response (sometimes referred to as the *contrast-detail curve*) shows us that for a given technique, the level of contrast that is visible will decrease as the object size decreases. To greatly simplify the concept, all other factors staying the same, smaller objects are harder to see than larger objects.

ROC describes the fact that different observers will look at the same image and evaluate it differently. A common method of evaluating an image is to scan a phantom. A series of progressively smaller low-contrast circles will appear on the resulting image. Counting the number of circles clearly visible will determine the level of low-contrast resolution on the image. However, different observers may look at the same image and evaluate it differently. Some individuals may say they see six circles clearly, whereas other persons evaluating the same image may feel they can only see four circles. Therefore, the degree of contrast measured on an image is somewhat subjective.

Quantum noise produces visible fluctuations in the image (ie, a salt-and-pepper look). This factor will degrade images, particularly their low-contrast resolution. Quantum noise is the result of too few x-ray photons reaching the detectors. Therefore, noise and radiation dose are linked; as radiation dose increases, image noise is suppressed. As the noise decreases, small low-contrast objects are more visible. Smoothing algorithms can help to reduce the visibility of noise by averaging each pixel with its neighbor. Similarly, wide window widths also help disguise noise. For this reason, it is a common practice in CT to increase the window width on images of obese patients.

EVALUATING IMAGE QUALITY USING PHANTOMS

The following aspects of image quality can be evaluated using phantoms:

- Spatial resolution–As mentioned earlier, spatial resolution is quantified using a line/pairs phantom
- Noise–This factor can be measured using a phantom that has a known uniform density, such as water. If an image is created of an object that is known to be uniform in density, then all the points within that image should be the same. Fluctuations of CT numbers at adjacent points indicate noise in the image. The standard deviation measurement offered by all CT systems is an indication of the amount of variance between pixel values in a designated area of interest. We can use the standard deviation of a known uniform phantom to indicate the degree of noise in an image.
- Cross-field uniformity–This factor can be assessed using the same phantom used to evaluate noise. Placing several regions of interest (ROI) within the phantom, it is hoped that each ROI will possess the same measurement. If fluctuations exist at different regions within the phantom (eg, if a ring around the outer perimeter measures differently from the center), then a problem with the system's cross-field uniformity can be diagnosed.
- Low-contrast resolution–Recognizing that low-contrast resolution is the ability of an imaging system to demonstrate small changes in tissue contrast, phantoms used for evaluating low-contrast resolution typically have many circles of various sizes.
- Slice-thickness accuracy–Another type of phantom allows verification of the accuracy of the selected slice thickness.
- Linearity–In CT, the system must be calibrated regularly. This will ensure that the attenuation property of water will measure zero and other densities will have the appropriate CT values.

  The relationship of a system's CT values to the object's actual density is referred to as *linearity*. This relationship can be checked by using a phantom that contains five pins, each pin of a known density. The phantom is scanned, and a region of interest is placed on each of the five pins. The reported values are then compared to the known density values of the pins. A deviation from this linearity is an indication of misalignment or malfunction of the CT system.

CONCLUSION

Ideally, CT images should replicate exactly the objects scanned. Unfortunately, even though image quality has improved dramatically over the years, CT images often do not result in perfect representations of patient anatomy. Understanding the factors affecting the quality of the CT image, the limitations of the CT system, and the various methods of evaluating quality can go a long way in ensuring that the operator optimizes the image quality on a specific CT system.

SUGGESTED READING

- Bushong S. *Radiologic Science for Technologists: Physics, Biology, and Protection.* 5th Ed. St. Louis, Missouri: Mosby; 1993.
- Huda W, Slone W. *Review of Radiologic Physics.* Baltimore, Maryland: Williams & Wilkins; 1992.
- Romans L. *Introduction to Computed Tomography.* Baltimore, Maryland: Williams & Wilkins; 1995.
- Seeram E. *Computed Tomography: Physical Principles, Clinical Applications & Quality Control.* Philadelphia, Penn: WB Saunders Co.; 1994.

CT IMAGE QUALITY POST TEST

Expires: July 15, 2011 Approved for 1 ARRT Category A Credit.

1. **Image accuracy can also be referred to as**
   a. image contrast.
   b. linearity.
   c. image fidelity.
   d. cross-field uniformity.
2. **The two main features used to assess how well the image represents real anatomy are**
   a. noise and dose.
   b. high-contrast resolution and contrast detectability.
   c. spatial frequency and the Laramour equation.
   d. focal spot size and window levels.
3. **Which of the following are synonyms for spatial resolution?**
   a. Detail resolution and high-contrast resolution
   b. Low-contrast resolution and contrast detectability
   c. Image fidelity and tissue resolution
   d. Matrix and pixel
4. **What type of phantom is used to measure spatial resolution?**
   a. line/pairs phantom
   b. water phantom
   c. 5-pin phantom
   d. phantom with circles of various sizes
5. **The most commonly used method of describing spatial resolution ability is the**
   a. Nyquist sampling theorem.
   b. partial volume effect.
   c. receiver operator charactersitics.
   d. MTF.
6. **A picture element may also be called a (an)**
   a. modulation transfer function curve.
   b. Algorithm.
   c. CRT monitor.
   d. pixel.
7. **The process in which different tissue attenuations are averaged to produce one less accurate pixel measurement is called**
   a. volume averaging.
   b. beam hardening.
   c. photon deprivation.
   d. ring artifacts.
8. **In CT, a matrix size of 512 refers to**
   a. 51 mA and a 2-second exposure time.
   b. 512 line/pairs visible.
   c. 512 pixels across the rows and 512 pixels down the columns.
   d. a spatial frequency of 512.
9. **A large pixel size will result in**
   a. more image noise.
   b. decreased spatial resolution.
   c. a larger matrix.
   d. increased radiation dose.
10. **The formula for calculating pixel size is**
   a. pixel size = field of view ÷ matrix size.
   b. pixel size = matrix size × detector size.
   c. pixel size = limiting resolution ÷ matrix size
   d. pixel size = attenuation coefficient × field of view
11. **When slice thickness is decreased,**
   a. spatial resolution is decreased.
   b. volume averaging is decreased.
   c. the number of detected photons increases.
   d. the voxel size increases.
12. **What defines the Z axis?**
   a. Display field of view ÷ matrix size
   b. Pixel size
   c. Tube arc
   d. Slice thickness
13. **The ability of a system to define an edge is known as**
   a. MTF.
   b. contrast detectability.
   c. sharpness.
   d. back projection.
14. **Which of the following explains the aspect of CT image creation that can be affected by random chance?**
   a. Nyquist sampling theorem
   b. Receiver operator characteristics
   c. Contrast-detail response
   d. Compton scatter
15. **Low-contrast resolution is defined as**
   a. whether two small B-Bs in the object scanned will be represented on the image as one large circle.
   b. the ability of the system to differentiate objects with similar densities.
   c. reduced spatial resolution.
   d. measurement of spatial resolution with a line/pairs phantom.
16. **The size of the object that is visible depends on**
   1. the level of contrast inherent in the object.
   2. the degree of image noise present in the image.
   3. the window setting used to display the image.
      a. 1 only
      b. 2 only
      c. 1 and 3
      d. 1, 2, and 3
17. **Which is a TRUE statement when comparing the spatial resolution of CT to other modalities?**
   a. CT is superior to general radiography, MRI, and ultrasound.
   b. CT is superior to general radiography but is inferior to MRI.
   c. CT is comparable to all other modalities.
   d. CT is inferior to general radiography.
18. **Concerning low-contrast resolution, what is the smallest density difference required in order for an object to be resolved on a CT image?**
   a. 0.1%
   b. 1.0%

c. 5.0%
d. 10%

19. The fact that different observers evaluate the same image differently is referred to as

a. contrast-detail response.
b. receiver operator characteristics.
c. CT number subjectivity .
d. Nyquist sampling theorem.

20. If measurements taken around the perimeter of a water phantom are different from those taken at the center of the phantom, then there is a problem with the system's

a. linearity.
b. slice-thickness accuracy.
c. photon absorption.
d. cross-field uniformity.

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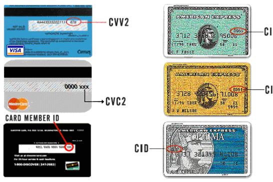

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