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CHEST Postgraduate Education Corner
MEDICAL WRITING TIP OF THE MONTH

When a Picture Needs 1,000 Words*

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Biomedical images (diagnostic images in clinical medicine and analytical images in the basic sciences) differ from other figures in scientific publications because they do not summarize or organize data. Rather, they are the data. For this reason alone, they need to be documented well. In addition, because interpretations of these images can vary widely (sometimes notoriously so), accurate and complete documentation should be provided to support each interpretation. If key information is missing, interpretations may be incomplete, inaccurate, or simply wrong.

However, there appear to be no comprehensive, widely available guidelines for documenting or reporting these images. Although the procedures for acquiring and interpreting some of these images are standardized and can be referenced, and individual journals have proposed some reporting conventions for specific types of images, the information that should accompany them in a scientific article remains to be specified. Without such guidelines, reporting is almost certainly inconsistent and probably inadequate.

For a forthcoming book on preparing scientific communications (*How To Write, Publish, and Present in the Health Sciences: A Guide for Clinicians and Laboratory Researchers*[1]), I attempted to develop reporting guidelines for several of the more common biomedical images. However, because these images are so seldom reported completely, I was not able to find or to develop model examples for many images. Among the images that need to be addressed are several of special importance to readers of *CHEST:* spirograms; flow-volume loops; polysomnograms; and recordings of flow, volume, and pressure from mechanical ventilators. I outline here the information that should at least be considered in such guidelines and propose reporting guidelines for the following three types of images: plain radiographs, ECGs, and MRI scans. I emphasize that these guidelines may be incomplete and are not yet satisfactory.

Components of Documentation and Interpretation

The guiding principle of reporting biomedical images (or anything else in science, for that matter) is to provide readers with the information they need to assess the accuracy, validity, and credibility of the claims made on the basis of the image. The goal is to prevent missing or misleading information from reducing or distorting the accuracy of its interpretation. Thus you need to identify the relevant characteristics of the subject of the image, how the image was acquired, the image itself, and the interpretation of the image (Table 1). Much of this information may be given in the caption so that the image and caption will be self-explanatory and not rely too heavily on information in the text of the article.

Image Enhancement and Modification

Image enhancement and modification, with settings on acquisition equipment or with image-editing software (*eg*, Photoshop; Adobe Systems Inc; San Jose, CA), is the process of changing all or parts of an image, usually to improve its appearance. However, enhancement has also occasionally led to careless or inadvertent changes that affect the accuracy of original images and, sometimes, to outright falsification of the data on the image. For this reason, any and all enhancements made to images should be disclosed in the article. Full reporting of the details and the reasons for such enhancements should resolve concerns about their use.[2]

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Table 1—*Characteristics To Consider When Reporting Biomedical Images in Scientific Publications*

Characteristics	Description
Subject of the image	Identify the tissue, organ, body part, region, signs, condition, or diagnosis shown in the image Report the relevant demographic (*eg*, age, sex, socioeconomic status, and living conditions), clinical (*eg*, diagnosis, vital signs, and pertinent positive and negative findings), and lifestyle (*eg*, smoking status, fitness level, and occupational or environmental exposures) characteristics of the patient State the reason for acquiring the image (*eg*, to establish or confirm a diagnosis, stage a disease, guide or assess treatment)
Image acquisition	Describe or reference any procedures undertaken to prepare the patient for imaging If applicable, specify any contrast media used, including the dose, route, and timing of its administration relative to the acquisition of the image, or any fasting, voiding, or dietary preparations Describe any settings, optical or band-pass filters, sampling algorithms, amplification, or other technical information necessary to understand how the image was acquired and that could affect the interpretation of the image Describe or reference any standard procedures or protocols used to acquire the image If applicable, state the conditions under which the image was taken (*eg*, in the emergency department, operating room, ambulatory care center, or during a stress test) and any evocative techniques used to increase the diagnostic value of the image Identify the model and manufacturer of the hardware and software used to acquire the image Describe the condition of the patient during imaging; if applicable, specify the patient's position or posture (seated or supine), state of consciousness (asleep or anesthetized), and any medications in the patient's system during imaging
The image	Indicate what the image shows (*eg*, the presenting feature) and where it shows it; use circles, arrows, or other marks on the image to highlight areas of interest; subtle findings that help point toward the diagnosis should be emphasized[2] Indicate the orientation of the subject in the image: identify the patient's left and right sides, the angle from which the image was taken, or the plane or level of any sections (*eg*, a cross-section at the level of the third thoracic vertebra) Describe any enhancements to the image If applicable, indicate whether the appearance of the image is typical (and similar images are therefore more likely to be seen by other investigators) or whether it is particularly anomalous or illustrative (and is thus less likely to be seen by other investigators)
Interpretation of the image	If applicable, identify the evaluators who interpreted the image and under what circumstances; if applicable, report the credentials of each evaluator (*eg*, whether they were board certified or how many years they have worked in the field) Diagnostic images are often read by evaluators who are blinded to some or all of the patient's characteristics to prevent bias; if so, the information provided to, and perhaps withheld from, the evaluator should be specified; if two or more evaluators interpreted the image, it may be appropriate to report a measure of interrater agreement, such as the κ statistic or the percentage of concordant interpretations Explain the implications of the image; support the interpretation with references to the features of the image (or lack thereof) and to other evidence from the patient; for diagnostic images, specify the criteria for the diagnosis, the meaning of a positive or a negative result, and the presence and explanation for any equivocal results Address possible confounding of the interpretation by artifacts

Guidelines for Reporting Selected Biomedical Images

Plain Radiographs

Radiography is the process of using x-rays to obtain images of the inside of the body. Projection or plain radiographs (the term *radiograph* should be used instead of *radiogram* or *roentgenogram*) are photographs of the images created when x-rays strike a fluorescent plate after passing through the body. The "shadows" on the radiograph reflect differences in the radiopacity of the structures through which the x-rays have passed.

- Explain any details of the original radiograph that are missing from the published image. The ratio of black to white on a radiograph is called the *contrast ratio*. Some radiographs can have black areas that are more than 500 times darker than the brightest areas, although the typical range in the tissues of interest is about 32:1. Even a good-quality photograph of a radiograph does not have a contrast ratio higher than about 63:1, and the contrast in a published radiograph is even lower. This loss of contrast means that a radiograph reproduced to show good detail in the lighter areas, such as bones, will render darker areas, such as tissues, as all black. If the gray levels are adjusted in the printing process so that both the brightest and the darkest areas reproduce, detail is lost in the middle gray levels. Radiographs that have been digitally processed to fit the areas of interest into a more readable range of values are called *enhanced radiographs*. A radiologist needs to see the full range of densities (that is, the most contrast) to make a proper diagnosis. Because this range cannot be duplicated in print, missing details need to be indicated in the text or in supplemental enhanced images taken from the original radiograph.

- Taking digital photographs of plain chest radiographs and CT scans that have been placed on a wall viewer is strongly discouraged.[3]
- Consider describing factors that may pertain to the part or region of the body being imaged. Such information might include the smoking history of a patient undergoing chest radiography; the presence of prosthetic joints, stents, and pacemakers; and previous fractures, resections, or injuries in the area covered by the image.
- If applicable, indicate the point in the respiratory cycle at which the image was taken and the patient's position during imaging.
- Identify the left and right sides of the patient on the image. Patients face the radiograph source in anteroposterior views and face away from it in posteroanterior views.
- Report the angle of exposure, or "view," from which the image was taken. The Waters view is used to image the maxillary sinuses, and the gravity sag view is used to determine posterior laxity of the knee, for example.
- If patients can be identified from the image or associated information, confirm that they gave consent to publish the information. Patient confidentiality must be preserved in scientific publications. Unless identifying information is removed completely from the image and associated commentary, to the point where neither the patient nor those who know the patient can determine the patient's identity, you should obtain consent before publishing the information.

ECGs

Electrocardiography involves recording the electrical activity of the heart over time. The output is an ECG, a continuous recording of voltage fluctuations that are printed on a long paper strip or are shown on a computer screen.

- Identify how and by whom the ECG was acquired. An ECG can be acquired when the patient is resting, ambulatory (Holter monitoring), on a treadmill completing a stress test, being monitored during surgery or recovery, or by telemetry. In addition, ECGs can also be acquired by any of the following providers: ambulance-based paramedics; emergency department personnel; operating room personnel; and office-based cardiologists. Both the type of ECG and who recorded it may need to be identified. Although the number and placement of the leads is standard (a 12-lead ECG is typical), other numbers and placements are possible and should be reported if necessary.
- Report any patient characteristics relevant to heart rate. Such characteristics may include whether the patient has a history of heart disease or is taking any cardiotropic or other cardiac medications, for example.
- Include a calibration signal on the tracing. The standard recording speed is 25 mm/s (0.2 s between the heavy vertical lines on the tracing), and a standard signal is calibrated at 10 mm/mV. Thus each 1-mm square in the light lines on standard recording paper represents 0.04 s (40 ms) in time and 0.1 mV in voltage. The standard signal can be varied, however, which changes the displacement of the wave and may need to be reported. The recording speed remains the same. Areas of interest on the tracing can be indicated by underlining or circling the segment, spike, or waveform.
- If patients can be identified from the image or associated information, confirm that they gave consent to publish the information.

MRI

MRI uses magnetic fields and radio waves to produce high-quality images of internal structures without the use of ionizing radiation (x-rays) or radioactive tracers. A strong magnetic field aligns the hydrogen atoms in the body, and then radio waves systematically alter the alignment of this magnetization, causing the hydrogen atoms to produce a magnetic field that is detectable by the scanner. The signal can be manipulated by additional magnetic fields to provide additional signals, which can then be used to construct transverse images for any plane through the body.

In functional MRI, changes in brain structures are imaged as patients are presented with different visual, auditory, or tactile stimuli, or perform an action, such as moving a joystick. In this way, changes in perception, thoughts, and action can be associated with physiologic changes in the brain.

Magnetic resonance spectroscopy is used to measure the levels of different metabolites in body tissues.

The following technical information may need to be included with the MRI image.

- The strength of the magnetic field, in Teslas or Tesla units. Magnetic field strength is an important factor in determining image quality. Stronger fields increase the signal-to-noise ratio, permitting higher resolution or faster scanning. For example, "All images were acquired with a 1.5-T magnetic resonance imager (Signa; GE; Milwaukee, WI)."
- The pulse sequence. Examples include the 90 free-induction-decay (or FID) pulse sequence, spin-echo sequence, inversion-recovery sequence, and gradient-recalled echo images.
- Whether the image is a T1- or a T2-weighted image. The return of the hydrogen atoms to their initial state is governed by the following two physical processes: the return to equilibrium of the magnetization component that is parallel to the magnetic field (T1); and the return to equilibrium of the component that is perpendicular to the magnetic field (T2). Images can be reconstructed from each of these components.
- The T1 and T2 exposure times.
- Whether the image was gated. Gating refers to taking a sequence of images at the same time during the respiration or cardiac cycle to minimize the blurring caused by the movement of the body or blood.
- Decimation of the image. Decimation is the elimination of data points from a data set. A decimation ratio of 4:5 means that four of every five data points are deleted, or every fifth data point is saved.
- The gradient echo, or flip angle. The entry, "GE (30°)" refers to a gradient echo of 30°.
- The repetition and echo times. For example, the entry "TR/TE = 11/2 ms" means repetition time/echo time = 11 ms divided by 2 ms.
- The axis of the scan with respect to the body.
- The depth or area of coverage and the slice thickness of the image. Slice thickness is often abbreviated as Thk; thus, "2.5 mm Thk" refers to a slice 2.5 mm thick.
- Number of excitations (or number of averages or number of acquisitions). Measurements of the signal can be averaged to improve the signal-to-noise ratio of the image. The number of acquisitions is averaged in the number of excitations.
- The field of view. The distance across an image, typically in centimeters.
- The resolution of the scan in pixels (*eg*, "256 × 192 matrix").
- If the patient can be identified from the image or associated information, confirm that he or she gave consent to publish the information.

Conclusions

Although it is true that a picture is worth 1,000 words, a biomedical image may still require several dozen words to put it into context. The information needed for each image is waiting to be specified, but now that the issue has been raised, I believe the necessary words will appear in time.

References

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