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Guidelines for Submission of Graphics in Manuscripts

During the manuscript submission process, *Anesthesiology* employs an automated manuscript tracking system called Editorial Manager® (EM). EM compiles all the manuscript pieces into a single Adobe® Portable Document File (PDF) for distribution to reviewers. When building the PDF, images can sometimes be problematic, and these guidelines are provided to minimize the difficulties you may encounter with graphics in manuscripts.

First and foremost, if you cannot generate acceptable graphics no matter how you try, contact the Editorial Office for assistance. This must be done in lieu of approving the PDF, for once approved, the manuscript begins the automated submission process and cannot be retrieved. Provide the Editorial Office with as much detail as possible about the manuscript and the problematic graphic so that we may locate and correct it properly.

To generate high-quality graphics within PDFs, you must start with high-quality graphics during their initial creation. Graphics files will not improve when PDFed, and they may even substantially degrade. Since PDFs are more akin to printed documents than they are to screen images, printing your graphic on paper will give you a rough idea of what to expect once it is PDFed. If you own a full copy of Acrobat (not just the reader) and can generate your own PDFs, you are encouraged to practice with your graphics prior to submission and learn how the PDF process can be optimized. Physically small, low-resolution images generally make worse PDFs than physically large, high-resolution images, so always err on the side of "too much" over "too little."

> *Your graphic should be no smaller than 4 X 6 inches (10 X 15 cm) and preferably closer to 8 X 10 inches (16 X 25 cm). Graphics larger than 8 X 10 inches are discouraged.*

Besides the physical size of an image, three other factors affect the quality of an image during the PDFing process: resolution, color depth, and compression algorithm. We will look at each of these three factors in-depth to see how they impact PDF quality.

Resolution

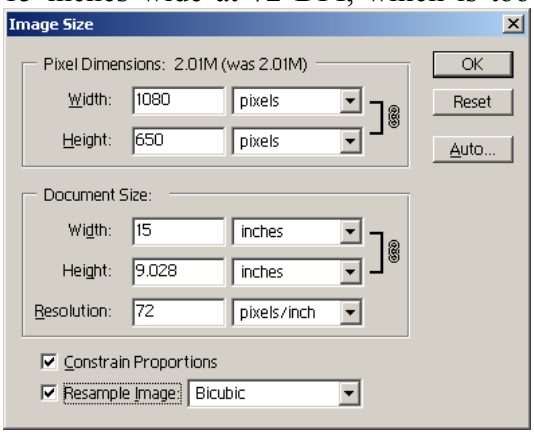
Images are not like text on a typewriter or old-time printing press. Whether you view them on paper or on your monitor, images are made up of tiny dots. The image itself comes into focus only when the dots are viewed as a whole. The number of these dots within any given image is defined as the image's resolution. Resolution is typically specified as the number of dots in a single row of dots that occupies one inch of space within the image and is measured as dots per inch (DPI). Our sample image to the left has been stored at 16 DPI to emphasize

the pixelation. Resolution can be easily imagined if you take a photograph and draw a one-inch line on it with a sharp pencil. Using a magnifying glass or microscope, count all the dots that lie along one side of your pencil line and you'll know the image's resolution. If you were

to view our example sailboat image to the left at high magnification, you could count 96 dots alongside the white line in the water. This means the image is stored at 96 DPI. Low-resolution images such as this one look great on a computer monitor because monitors typically display only 72-96 DPI (or more accurately, pixels per inch—PPI). However, a low-resolution image that looks great on your monitor may look terrible when printed or PDFed. Images like this often get pixelated (dotty-looking, as in our 16 DPI sample) due to the printer's attempt to rebuild the image at a higher resolution, generally 300-600 DPI. The cardinal rule is that you cannot add dots (or pixels) to an image without degradation. You can remove dots, but you cannot add new dots where they don't already exist. The printer can only stretch the size of each dot to retain the original dimensions of the picture while printing at the higher resolution. To clarify this a little further, an image 100 pixels wide saved at 100 DPI should be one inch. When printed at 300 DPI, however, the image would be only 1/3 inch, clearly not what was intended. Thus, the printer has to spread each pixel out over three dots to print a one inch image at 300 DPI from the original 100 DPI image.

> *For the highest quality PDFs, store your images at 300 DPI or higher. This allows a printer to print the image at its native resolution without having to interpolate it, thereby keeping the dots small and unnoticeable. Adobe Acrobat works very much like a printer, so this applies equally here as well.*

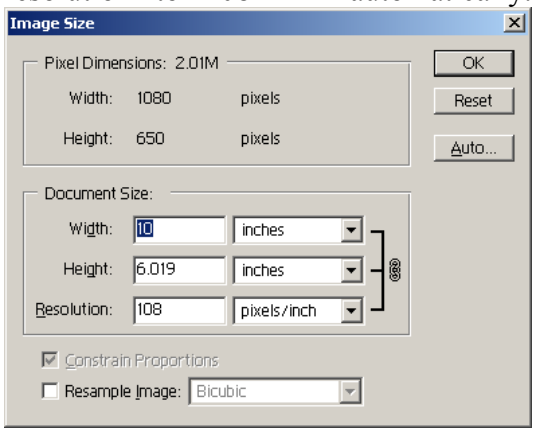
If the starting image is physically large, we can generate a high-resolution image from a low-resolution image. For this example, we are using an image that is 15 inches wide at 72 DPI, which is too



large to fit on a page. In landscape mode, where everything is rotated ninety degrees, the maximum width is about ten inches, so we will reformat the graphic to fit a ten-inch page.

Using PhotoShop, the easy way to shrink the image to ten inches is to throw out 1/3 of the pixels. As with most things, the easy way yields the worst results. A much better way is to retain all the information while resizing, and that means changing the resolution (DPI). Changing the resolution is also easy in PhotoShop, but you must remember to **un**check the "Resample Image" box (it's on by default) to change resolutions. With resampling turned off, you can

now change the size of the image to ten inches and PhotoShop increases the resolution to 108 DPI automatically.



What this does is allow us to print a physically smaller image using the same information as the larger one (notice how the number of pixels remains constant at 1080 X 650—no information has been discarded). If we shrink the image even further, down to six inches wide, PhotoShop boosts the resolution to 180 DPI and at four inches to 270 DPI. This graphic will print at very high resolution at the four-inch size, despite being created at a very low 72 DPI.

> *Reduce physical dimensions of a graphic destined for printing by increasing resolution rather than throwing out pixels.*

Color Depth

The third parameter affecting image quality is color depth. At its simplest, imagine a purely black and white image. There is no gray here. This might be line art or a fax. Every dot on the image is either black or white, and the image of our sailboat is barely discernible. This is a monochrome image, and every dot on it can be described with a single bit of information, black or white. If we wish to define a gray level or two, we need to store more information, more bits.

Two bits of information per dot will allow us to record both black and white, plus light gray and dark gray. However, even with the four shades, we still can barely discern the sailboat. To render this image at an acceptable view, we need even more bits of storage.

Four bits of information per dot gets us an additional 12 shades of gray for a total of 16 distinct shades, with much better results. Now we can easily determine what we are looking at. The only serious artifacts left are in the shading of the sails.

As we have seen, the number of bits per dot can have a dramatic impact on image quality. With line art, such as a chart, color depth may have little effect, but it does impact the crispness of text. With only two shades, black and white, text outlines take on that jagged appearance we all have been subjected to. Photographs need even more depth than line art. Images recorded at low bit depth suffer from degradation, making fine details difficult to see.

In the left image, 256 colors renders a picture almost as well as the original 16 million color image on the right.

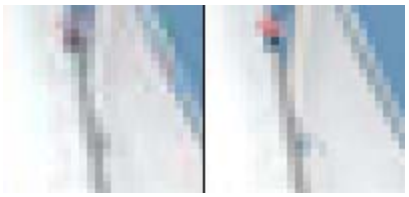
Create images with enough color depth to portray them accurately. Monochrome images are rarely acceptable, even with black and white images. Grayscale images should contain 256 shades (8 bits) and color photographs should be rendered at 16 million colors (24 bits).

The unnecessary use of color in tables and figures is discouraged. As with most publications, grayscale images in manuscripts are published at the journal's expense, but color images are usually published at the author's expense. The costs involved in reproducing a color image can even reach into the four figure range, so seriously consider whether color is essential to convey the meaning of your graphic.

Compression Algorithm

How an image is saved can have a dramatic impact on the quality of that image. Some file formats use compression to achieve small file sizes, which is particularly useful for web pages. For our purposes though, we want as little compression as possible to keep the quality of the image high.

File formats such as TIFF do not compress the image much at all, and this makes them perfect for our purposes. JPG files are often used with photography so that a large number of images can be stored in a small amount of memory. The compression used by JPG can be very good, however, it suffers from one noteworthy drawback. During compression, some of the information within the photograph is discarded to make the file size smaller. This is often referred to as a "lossy" compression algorithm, meaning information is lost. The more times the image is saved, the more information is lost. Artifacts begin to creep into the image, and major degradation can result. This is compounded by the fact that the compression is tunable. Rather than settling for a small amount of compression, you can tune the algorithm to throw out massive amounts of information simply by adjusting the settings to "smallest file size" or "lowest image quality" every time you save it. You cannot resave the image at the highest quality setting later on and return to a good image. Once it goes bad, it stays bad. You can see this effect for yourself quite easily. Open a TIFF image and save it as a JPG. Close the image. Now, repeat the following steps a few times. Open up the JPG image and save it overtop the starting JPG. Close the image and repeat. After doing this a few times, open the JPG and zoom in on it to about 400%. Compare this to the original TIFF also zoomed 400% and you'll see how artifacts have begun to creep into the JPG image. With each save, it gets worse and it cannot be



repaired. The sample comparison above shows the original on the right. Note the flag color upper middle on the two images, as well as the spurious color artifacts on the left image's sails. This is similar to the effect you see when you go to a copy machine and make a copy of a copy.

The Graphics Interchange Format (GIF) is often called lossless compression, meaning that no information is lost during compression. This is a bit misleading, though. It is true that you may

save a GIF image repeatedly without further degradation, hence the lossless designation. What it does not mention, however, is that information is most definitely thrown out when creating the GIF initially. In particular, the GIF format can accommodate only 256 colors. A 16 million-color image must be "color-reduced" (called color-mapping or color-indexing) to fit into a 256-color space. That means that the three colors orangish-yellow, yellow, and greenish-yellow may all display as yellow once saved as a GIF image. Where GIF really fails though, is images with smooth gradations. These will usually come out choppy, and sometimes they may even take on completely foreign colors in parts of the gradation depending on how the colors get mapped. There is a degree of control to the user when indexing color images, but that is beyond the scope of these guidelines. If you choose to use GIF compression and would like to learn more about color-reduction processes, the documentation that came with your graphics editing software is a good place to start.

You should always work in your application's native file format and only do conversions as the very last step prior to submission. With PhotoShop, keep all images as PSDs and then save the image as a TIFF only after you have finished with it. If you need to make changes later on, go back to the original PSD file and work from there, rather than from the submitted TIFF file. **Conversions are bad, so minimize them.**

Do not compress images to make the file sizes smaller. TIFF files generally do the least amount of damage to photographs, but file sizes are also the biggest. Keep images in your application's native file format until the final step. Do not convert between file formats needlessly, and save any such conversions for last.

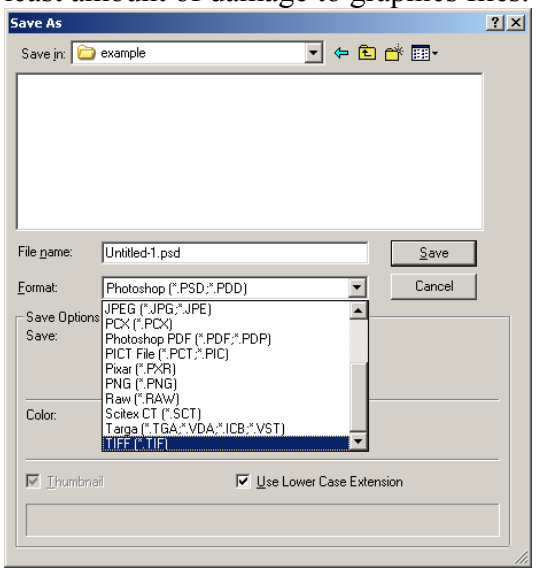
Working with Excel Graphs

Our final guideline concerns applications that provide no means of exporting images to one of our preferred formats, as with Excel. Excel is an application with fine charting capabilities but zero exporting options.

Before you begin, you should maximize the size of the spreadsheet so that it occupies the full screen. Taking an existing chart, single click anywhere inside the chart to make it active. You will now see resizing buttons around the chart. Click and drag the upper left button to the upper left of your spreadsheet and the bottom right button to the bottom right of your spreadsheet. This will maximize the size of your chart. In Windows, hold down "Ctrl" and press "C" to copy the chart to your clipboard. (On a Macintosh, use "Cmd" and "C" instead.) Now, open PhotoShop or any other graphics editing application and paste the chart *via* the Edit menu. (Windows users may also use Kodak Imaging, which comes free on your Windows CD-ROM. Likewise, Macintosh users may use any of the imaging utilities that come with the Macintosh OS.)

Saving the file is a simply a matter of choosing a file format compatible with Editorial Manager. We recommend that

you use the TIFF format as it does the least amount of damage to graphics files.



From the "Save As" dialog box, select TIFF from the pull-down menu of file types, click "Save" and you are done. If you wish to make changes to this image at a later time, we still recommend that you do as many of those changes as possible in your starting application (Excel in this case) and then repeat the steps outlined above. This will insure that the final graphic is as good as it can be, rather than a copy of a copy.

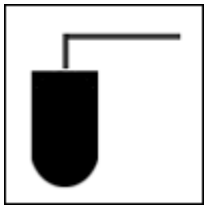
In summary then, the best starting graphics make the best PDFs. The accompanying chart highlights those points that have the greatest impact on your manuscript's graphics.

Graphics Guidelines Summary

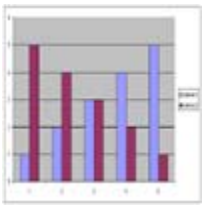
1) Create your graphics at a minimum physical size of four inches by six inches and a maximum size of eight inches by ten inches. Larger image sizes should be reduced *via* point number three below.
2) Aim for resolutions of 300 DPI. Resolutions higher than about 300-600 DPI accomplish little additional beyond bloating file sizes.
3) To reduce an image's physical size, do so by increasing the resolution rather than by throwing away pixels. An image destined for a printer should almost never be reduced in size by throwing away information, and only then when the resolution is already exceedingly high. A 12 X 16 inch image at 72 DPI can be reduced to 7.5 X 10 at 115 DPI or 4.5 X 6 at 192 DPI.
4) Use sufficient color depth to portray images accurately, 8 bit for grayscale and 24 bit for color. Almost never create monochrome graphics, even with black and white images. Use grayscale instead. Do not use color needlessly. Most times, color images are published at the author's expense, which can exceed $1000 US.
5) Do not compress images to reduce file sizes. Avoid compression schemes like JPG and GIF when possible. Do not ZIP images or otherwise compress them using a compression utility such as Winzip® or Stuffit®, either.
6) Keep images in your application's native file format as long as possible.
7) If your graphics application's native file format is not supported by EM (most proprietary formats are not), a conversion will be necessary. Keep conversions between formats at a minimum, and save them for last. Save converted files as TIFF images when possible. Be careful with JPG and GIF as they throw out information, either when saved (JPG) or when initially created (GIF).

Recommendations for Specific Types of Artwork in Manuscripts

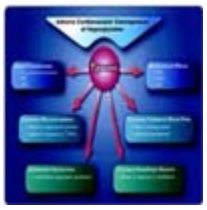
Images saved as TIFFs work well with all of these types of artwork, although they are far from the best at delivering small file sizes. If TIFF is not available to you, GIF and JPG can be used judiciously. Save JPGs with as little compression as possible ("best image" or "largest file size" setting) and GIFs with 256 colors.



Monochrome Line Art— This type excludes photographs of any kind and is the only kind of artwork that looks good when photocopied on an old-style copier. Consists of one color only (usually black) and comprises only lines or solid blocks of color. Monochrome line art can be saved as a one-bit monochrome image, but only when the resolution is high (like 300 DPI). Usually looks better as grayscale, though the differences may be subtle. GIF compression works well with this type of art, as does JPG.



Color Line Art—This artwork is similar to the monochrome version, but appearing as a grayscale or color image instead. This is the same type of art generated by Excel's graphing functions. With a limited range of colors, it can be saved as a grayscale image and still retain meaning. With histograms and similar charts, colors close in luminance may appear to be the same shade. Confusion can be eliminated with the use of cross-hatching or fill patterns. GIF and JPG compressions work well with this art.



Vector Art—This is the type of artwork that comes from a vector-based application like Freehand or Illustrator and is used widely in the USA Today® newspaper. Often, gradations and shadows will be used to simulate a 3D effect. These images are best treated as photographs. GIF compression works poorly with this type of artwork, but JPG is okay. Images are best saved as postscript files (EPS) or TIFFs.

Black and White Photographs—Probably the best medium for showing ultra-fine detail. Higher resolving power than color at the same resolution, and the medium of choice for many professional photographers even today. Always treat B/W as grayscale. GIF compression will usually yield a file larger than the uncompressed file, but JPG will still work okay. TIFF is the format of choice for grayscale images.

Color Photographs—Grayscale images rendered with pseudo-color, or true color photographs. If your image requires color to convey meaning and you are prepared to spend the money to deliver it, color can be a very compelling medium. Color can show relationships better than other media. Save your photographs as 24 bit color TIFFs. Do not use GIF compression as this is the worst medium for it. JPG will still yield a nice result, though, provided the compression is kept low.