Image management systems

The American Society for Gastrointestinal Endoscopy (ASGE) Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methodology is used, with a MEDLINE literature search to identify pertinent clinical studies on the topic, and a MAUDE (U.S. Food and Drug Administration Center for Devices and Radiological Health) database search to identify the reported adverse events of a given technology. Both are supplemented by accessing the "related articles" feature of PubMed and by scrutinizing pertinent references cited by the identified studies. Controlled clinical trials are emphasized, but, in many cases, data from randomized controlled trials are lacking. In such cases, large case series, preliminary clinical studies, and expert opinions are used. Technical data are gathered from traditional and Web-based publications, proprietary publications, and informal communications with pertinent vendors.

Technology Status Evaluation Reports are drafted by 1 or 2 members of the ASGE Technology Committee, reviewed and edited by the committee as a whole, and approved by the governing board of the ASGE. When financial guidance is indicated, the most recent coding data and list prices at the time of publication are provided. For this review the MEDLINE database was searched through February 2013 for relevant articles by using the key words endoscopy, video recording, digital capture device, tele-endoscopy, quality, and endoscopic imaging.

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BACKGROUND

Endoscopic procedures are traditionally documented with a written report and variable use of still images (eg, photographs or diagrams). Endoscopic documentation may be supplemented with video recording of part or all of the procedure. Potential applications of videos include documentation of procedures (eg, cecal intubation during colonoscopy), the ability to provide assistance to others (tele-endoscopy), sharing new techniques with a wider audience during presentations or via the Internet, monitoring of quality of endoscopic examinations, providing second opinions, training, and patient education. Image management systems enable capture, storage, and labeling of digital still images and videos. This review summarizes the features of image management systems.

TECHNOLOGY UNDER REVIEW

Image management systems are digital capture devices (DCDs) that store and encode endoscopic images and video. Options for still photograph capture and storage include comprehensive software systems that generate an endoscopy report and capture and save still images and videos as well as external DCDs. External DCDs plug into the endoscopic processor or are routed through an integration system.

Equipment necessary for recording video during endoscopy includes a video recorder and a method of storage. There are a few options for video recorders. Some endoscopic software has built-in video recording capabilities (Table 1). The videos are saved on a central server and can be exported to other media (eg, flash drive, disk).

External video recorders designed specifically for medical use are commercially available from a number of sources (Table 2). Care must be taken when purchasing an external video recorder to ensure that the device connection will be compatible with the endoscopy processor being used. To ensure recording in high definition (HD) to an HD DCD, an HD-compatible cable must be used for the connection.

Standard commercially available digital video disk (DVD) recorders can be used for recording endoscopy. Laptop computers can be connected to the endoscopy processor (or monitor) and special software purchased to record and store video.

Capturing a still image is accomplished by depressing a button on the endoscope or using capture controls on the image storage software. The system can be arranged so that the image can be frozen with 1 button and captured with another button. In systems with fully integrated software, the system saves the image digitally and incorporates it into the endoscopy report. Images can be retrieved and viewed later. Thermal printers allow for printing a hard copy of the picture frame that is frozen, but once the image is unfrozen, the image is not digitally retrievable unless it was saved by integrated software or to an external

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TABLE 1. Software with integrated image management systems

	Web site	Image management	Video clip management	Remote Internet access	Software and installation (cost/room)
gCare EMR (gMed, Inc, Weston, Fla)	www.gmed.com	Yes	No	Yes	$15,000-$45,000
EndoWorks 7 (Olympus America, Inc, Center Valley, Pa)	www.endoworks.com	Yes	No	Yes	$5,000-$15,000
endoPROiQ (Pentax Research Montvale, NJ)	www.pentaxmedical.com	Yes	Yes	Yes	$15,000-$40,000
Provation MD (ProVation Medical, Inc, Minneapolis, Minn)	www.provationmedical.com	Yes	Yes	Yes	$10,000-$25,000
Endoprose (Summit Imaging, Inc, Lee's Summit, Mo)	www.summitimaging.net	Yes	Yes	Yes	$15,000-$20,000
Endosoft (UTECH Products, Inc, Schenectady, NY)	www.endosoft.com	Yes	Yes	Yes	$10,000-$20,000
Studio3 (Stryker Communications, Flower Mound, TX)	www.stryker.com/mediamanagement/	Yes	Yes	Yes	$12,500-$20,000

storage device. Depending on the device, video recording can be initiated and paused via touch screen and/or mouse click, depressing a foot pedal, or pressing a button on the endoscope. Some devices have dual-channel recording so that video can be captured from 2 inputs simultaneously (eg, video endoscopy and US). Images and video from a variety of sources can be recorded (endoscopic, fluoroscopic, US) and stored by a DCD.

Image quality

Image and video quality are determined by a number of factors, including the resolution of the output (eg, standard definition [SD] vs HD), the data transfer rate, and the method of compression.[1]

SD versus HD. All DCDs are capable of SD image and video capture, whereas some of them are capable of HD recording. SD handles resolution up to 640 × 480 pixels. HD cameras and monitors can handle video at resolutions of 1280 × 720 pixels, and some have higher available resolutions (1920 × 1080 pixels). SD-compatible signals include separate video (S-video) and composite. HD-compatible signals include digital visual interface (DVI) and HD-serial digital interface (HD-SDI).

HD video uses either progressive or interlaced scanning. Progressive scanning renders each frame of video as a series of horizontal lines drawn from left to right and then top to bottom. The process then repeats to display the next frame. Interlaced scans are different in that the rendering happens every odd-numbered horizontal line of the frame until the bottom of the page is reached, and then it fills in the even numbered lines.[2] A field is a set of even or odd lines. As long as the fields are drawn in rapid succession, the viewer perceives them as one complete moving image. The type of scan used is indicated along with the image resolution: 720p (p for progressive) video contains 720 lines drawn in sequence by using a progressive scan to complete the frame, whereas 1080i (i for interlaced) video contains 2 fields of 540 lines each, drawn in succession by using an interlaced scan. Video is captured in either progressive or interlaced scans and requires playback in the same format.

Data transfer rate. The data transfer rate (DTR) is commonly used to measure how quickly data are transferred from one location to another. In telecommunications, data transfer usually is measured in bits per second. In computers, data transfer is often measured in bytes per second. The DTR is important in HD because a higher DTR will be required for clean video streaming.

Compression. Compression reduces file sizes by eliminating all nonessential data. Uncompressed HD video uses a significant amount of storage space. For example, 1 hour of HD video requires 500 GB of space. Because of the large volume of memory required for HD video, compression is almost always used during recording. The codec is a program used to compress and decompress images and video into a variety of image formats.

Image format. Images and videos can be captured in various formats. Image format types include bitmap (BMP), Joint Photographic Experts Group (JPEG), JPEG 2000, Truvision Graphics Adapter (TGA), Tagged Image File Format (TIFF), and others. These formats vary in image quality, file size, and compatibility with software programs. When images are converted between formats, image quality may deteriorate because of loss of data.

Video formats include Moving Picture Experts Group (MPEG) MPEG1, MPEG2, MPEG4, movie, Audio Video Interleave (AVI), and Windows Media Video (WMV). MPEG-4 is a new standard for interactive multimedia creation, delivery, and playback for the Internet. The Moving Picture Experts Group committee designed MPEG-4 to be a single standard covering the entire digital media workflow (eg, editing, storage, playback, transfer). MPEG-4 provides scalable, high-quality audio and video and is currently the most widely used format. It supports recording in resolution up to 1080p. The quality of MPEG-4 and movie formats can vary by device. AVI is an older format that may contain both audio and video data. One limitation of AVI files is the lack of standardization to encode aspect ratio. The other major limitation of AVI files is that they were not intended to contain video in a compressed file. This may cause problems with playback software. A WMV file was developed by Microsoft (Redmond, Wash) as a video compression format. This can pose a problem for Macintosh (Mac; Apple Inc, Cupertino, Calif) users if a Mac tries to open a WMV file in QuickTime (Apple Inc). WMV files use Microsoft proprietary codecs that are not compatible with operating system X. A program called Flip4Mac Plugin (Telestream Inc, Nevada City, Calif) can be used to open WMV files by using a Mac computer.

Image storage and retrieval

Options for image and video storage include computer hard drives, Universal Serial Bus (USB) storage devices ("memory stick"), conventional digital video disk, external hard drives, or offsite servers ("cloud"). Patient demographics can be entered into most DCDs. Newer functions of some image management systems allow for integration with electronic medical record (EMR) systems. This feature links the captured video or images to the patient's medical record. The ability to view images or videos in the patient's medical record enables physicians in multiple disciplines to have access to the recorded content, and the ability to remotely access recorded video and images may be useful for later viewing for teaching, research, and presentation purposes. By using a secure log-in, cases can be retrieved, viewed, and edited. If integration into an EMR is desired, the images should be Digital Imaging and Communication in Medicine (National Electrical Manufacturers Association, Rosslyn, Va) compatible.

HD video editing

Video editing usually requires the use of editing software. There are a number of excellent programs on the market that are compatible with use on a personal computer (PC) or a Mac. Editing HD requires at least 2 GB of random access memory and at least 100 GB of available disk space, along with a capable internal video card. Less memory and space will make the editing process slower and more cumbersome. The first choice of editing software depends on whether a PC or Mac computer will be used. PC computers have a larger variety of choices when it comes to editing software. Users of Mac computers have two choices: iMovie (Apple Inc), which comes with each computer, and Final Cut X (Apple Inc), which is professional editing software for purchase. Once a video has been edited, it needs to be saved and exported. The formats to which the edited video is exported vary (eg, MPEG-4). A primer on endoscopic video editing has been published.[3] Courses in endoscopy video editing are available.

Features of available external DCDs for medical use

The SDC3 (Stryker, Kalamazoo, Mich) captures images and video in HD. The recorder is capable of dual channel HD recording in native resolution (the actual video resolution from the source). The recordings are in 1080p in MPEG-4/H.264. The system allows for picture-in-picture or picture-by-picture recording. The dual-channel capability allows for simultaneous viewing of different video inputs (eg, US, fluoroscopy, endoscopic image). The SDC3 has a 1-terabyte hard drive and stores up to 500 cases in the internal archive. The option to use Studio3 (Stryker) integration provides the ability to share, edit, and archive while maintaining Health Insurance Portability and Accountability Act (HIPAA) compliance. The system also can wirelessly integrate with hospital networks, such as Studio3, picture archiving and communication systems [PACS], and EMRs.

Olympus (Center Valley, Pa) offers 2 new HD-DCDs. The IMH-10 has a generous hard drive with a 320-GB capacity but can record only 1 input. It does not have a touch screen but does have easy patient data input. The IMH-20 has a large 500 GB hard drive and allows for dual-channel recording. One feature of the IMH series is the ability to record voice data to the recorded images in real time. The IMH-20 links with all Olympus systems (US, endoscopes, laparoscopes, camera head), and patient information can be linked to the file recorded for easy searching and retrieval.

The HVO-1000MD (Sony, New York, NY) is an HD DCD that can record simultaneously to its internal hard drive, Blu-ray disk (Blu-ray Disc Association, Beaverton, Ore), USB thumb drive, or portable hard drive. The portable recorder also allows for connections to the hospital network for archiving to a central server. It allows for high-quality recording at 1080-line video by using MPEG-4. A 320-GB internal hard drive stores more than 30 hours of HD video, and the Blu-ray disc can store more than 9 hours of HD video per standard disc. It accepts a wide range of video interfaces and signal types, including HD-SDI, DVI-D, SD-SDI, composite, and S-video. This DCD can link to Sony's OPSIGATE Content Management and Delivery System, a comprehensive Web-based software preloaded on a professional server. This system allows the user to gain remote access of the recorded material through a secure network and access cases and image files.

TABLE 2. External digital capture devices and/or video recorders for medical use

	Stryker*	Olympus†	Olympus†
Product name	SDC3	IMH-20	IMH-10
Web site (www)	stryker.com	olympusamerica.com	olympusamerica.com
Supported resolutions	1080p 720p 1280×1024 1024×768 NTSC (SD) PAL (SD)	1080i	1080i
Image formats	Bitmap, JPEG, JPEG 2K, TIFF, TGA, PNG, JPG	BMP, TIFF, JPEG	BMP, TIFF, JPEG
Recording formats	MPEG2-SD MPEG4 (H.264)-HD	MPEG4 (H.264)	MPEG4 (H.264)
HD video inputs/outputs	DVI	HD/SD-DVI, DVI	HD/SD-SDI
SD video inputs	RGB horizontal and vertical (VGA), S-video, composite	Y/C, composite	Y/C, composite
Dual channel	Yes	Yes	No
Internal hard drive capacity	1 TB	500 GB	320 GB
Removable media	CD/DVD, USB, iPad||	USB, HDD, DVD, Blu-ray¶	HDD, HDD, USB, Blu-ray¶
Blu-ray¶	Yes (optional)	Yes	Yes
Hospital network (file transfer protocol)	Yes	Yes	No
DICOM	Yes	No	No
DICOM video	Yes	No	No
Patient information	Yes	Yes	No
User interface	Graphical user interface touch screen	Touch screen	Buttons on front
Voice activation	SDC3	No	No
Wireless capture solution	Yes (Studio3)	No	No
Image size	1920 × 1080 pixels	1920 × 1080i 720 × 480	1920 × 1080i 720 × 480
Media	USB, Blu-ray,¶ CD/DVD, iPad	USB, Blu-ray,¶ DVD	USB, Blu-ray,¶ DVD
USB	USB 2.0 (2)	USB 2.0 (2)	USB 2.0 (2)
Network	Ethernet, Wi-Fi**	Ethernet	Ethernet
Supported video formats	MPEG4 (H.264), MPEG2	MPEG4 (H.264)	MPEG4 (H.264)
Cost, $	17,800-26,500	19,900	13,400

p, Progressive; *NTSC,* National Television System Committee; *SD,* standard definition; *PAL,* Phase Alternating Line; *i,* interlaced; *DVD,* digital video disk; *JPEG/JPG,* Joint Photographic Experts Group; *TIFF,* Tagged Image File Format; *TGA,* Truvision Graphics Adapter; *PNG,* portable network graphics; *BMP,* bitmap; *DICM,* Digital Imaging and Communication in Medicine; *MPEG,* Moving Picture Experts Group; *HD,* high definition; *DVI,* digital visual interface; *SDI,* serial digital interface; *N/A,* not applicable; *RGB,* red, blue, green; *S-video,* separate video; *VGA,* Video Graphics Array; *Y/C,* luminance/color; *BNC,* Bayonet Neill-Concelman; *TB,* terabyte; *GB,* gigabyte; *CD,* compact disc; *USB,* Universal Serial Bus; *HDD,* hard disk drive.

*Kalamazoo, Mich.

†Olympus America, Center Valley, Pa.

‡New York, NY.

§Ampronix, Irvine, Calif.

||Apple Inc, Cupertino, Calif.

¶Blu-ray Disc Association, Beaverton, Ore.

**Wi-Fi Alliance, Austin, Tex.

TABLE 2. Continued

Sony‡	MediCapture§	MediCapture§	MediCapture§
HVO-1000MD	USB 170	USB 200	USB 300
sony.com/imagecorehd	medicapture.com	medicapture.com	medicapture.com
1080-line	N/A	DVD quality	1080p/i
JPEG, TIFF, BMP	JPEG, TIFF, PNG, DICOM	JPEG, TIFF, PNG, DICOM	JPEG, TIFF, BMP, DICOM
MPEG2, MPEG4	Image only (JPEG, TIFF, PNG, DICOM)	MPEG2	MPEG4 (H.264)
DVI-digital, HD-SDI	N/A	N/A	DVI (RGB via adapter), HD-SDI, S-video, composite
S-video, RGB	PAL or NTSC format using S-video	PAL or NTSC format using S-video or composite, BNC	NTSC, PAL
No	No	No	No
320 GB	None	None	320 GB
USB, CD/DVD, Blu-ray¶	USB	USB	USB
Yes	No	No	No
Yes	No	No	No
Not listed	No	No	No
Not listed	No	No	No
Yes	Yes	Yes	Yes
Buttons on front	USB keyboard (not supplied)	USB keyboard (not supplied)	USB keyboard (not supplied)
No	No	No	No
Yes (OPSIGATE system)	No	No	No
1920 × 1080 720 × 576	1280 × 1024, 1024 × 768, 800 × 600, 640 × 480 pixels	1024 × 768, 800 × 600, 640 × 480 pixels	Not listed
USB, Blu-ray,¶ CD/DVD	USB flash drives or external USB hard drive	USB flash or external USB hard drive	USB flash or external USB hard drive
USB 2.0 (4)	2.0 (4)	2.0 (4)	2.0 (3)
RJ-45(1), 1000 base-T/100-base-TX	Ethernet T10/100 connection via network upgrade kit	Ethernet T10/100	RJ45 10/100/1000 Ethernet
BNC, composite, S-video, DVI-digital, HD-SDI	N/A	MPEG-2	MPEG4 (H.264), NTSC, PAL
9995	2500	3500	5500

MediCapture (Ampronix, Irvine, Calif) offers recording devices without internal storage capacity. The models are universally compatible with all makes and models of medical cameras and monitors. Videos or images recorded can be viewed on any Mac or PC system without special software. Only one model, USB 300, allows for HD recording. The USB 300 can be hooked to the Sony UPDR80MD medical printer for image printing, or the USB flash memory stick can be plugged into a USB port on a computer, and images can be printed on a commercial-grade printer.

Transmission of video

Videos can be shared with others by sending a hard copy (DVD) or secure e-mail, or by transmission over the Internet. E-mailing videos requires a secure system to be HIPAA compliant. Moreover, files are usually large, and some servers will not accommodate the space requirement. Video can be uploaded to a secure site and others given access to it, or video can be de-identified for widespread sharing over the Internet. Video can be transmitted live over the Internet. This generally requires some logistical support. The Digital Video Transport System (DVTS)[4] is free software that transforms digital video images directly into Internet protocol, without need for analog conversion, enabling production and transmission of uncompressed HD video in real time. This requires a fast Internet connection with broadband capabilities. Superfast broadband internets (eg, Internet 2[5] and Asia-Pacific Advanced Network, APAN[6]) have been developed as part of a nonprofit consortium dedicated to developing applications for high-speed transfer of information in the academic and research communities. These require a subscription and are often available at universities. Other broadband Internets are available commercially as well.

OUTCOMES AND COMPARATIVE DATA

Currently, there are no studies comparing image management systems. The choice of DCD depends on user preference and will likely be influenced by its intended use (eg, private practice, academic setting).

Clinical use of video

The clinical impact of video recording has been evaluated in a few studies. A prospective study of 165 patients undergoing colonoscopy aimed to evaluate whether documentation of cecal intubation could be improved by specific still photographs versus video recording. There was marked variation in the evaluation of cecal documentation among reviewers of the still photographs, and an attempt to document specific features (eg, ileocecal valve, appendiceal orifice) resulted in modest improvement. Video recordings were highly convincing of cecal intubation and were rated higher than still photographs.[7] Another study aimed to find the video technical characteristics (spatial resolution, data transfer rate, etc) that would render a video of diagnostic quality for colonoscopy documentation. This study of normal colonoscopy landmarks established that a data transfer rate of 1.0 Mb/second (Mbps), using MPEG-1 as the format, was the minimum standard for diagnostic-quality video.[8] Notably, the study did not evaluate pathologic findings, which would likely require a higher resolution. There are no other studies evaluating the minimum standard for video resolution with regard to diagnostic quality in GI endoscopy, although MPEG-4 was validated for use in echocardiography and fetal US.[9]

A study of 421 consecutive screening colonoscopies found that video recording of procedures resulted in no change in the adenoma detection rate (38.5% vs 33.7% rate before recording; $P = .31$).[10] Another study found that awareness of being video recorded increased colonoscopists' mean inspection time by 49%, but there was no change in polyp detection.[11]

Photographic documentation of landmarks and pathology are an important part of a patient's procedure report. Quality in endoscopy recommendations from national societies regarding the procedure report include photographic documentation of findings and landmarks for colonoscopy, endosonography, and ERCP.[12-14] Photographic documentation may be an important piece of evidence in cases of malpractice litigation.[15]

Studies of tele-endoscopy

Tele-endoscopy can be real-time (synchronous), in which the video being captured is streamed live and evaluated during the event by a remote observer, or store-and-forward (asynchronous), in which video is viewed after the event has taken place. Synchronous tele-endoscopy requires more technical support (eg, high bandwidth Internet, logistic support) than asynchronous tele-endoscopy.

A prospective study evaluated the effectiveness of asynchronous tele-endoscopy. Fifty upper endoscopies were performed by local endoscopists and recorded with both high-quality digital video compressed video (25 megabits/second [Mbps], 720 × 480 pixels) and highly compressed MPEG-1 video (2.0 Mbps, 352 × 240 pixels) simultaneously. Endoscopist reviewers (asynchronous endoscopists) rated the videos as diagnostic in 85% of cases, but only 18% of videos yielded the same diagnoses. There was poor concordance for both major ($\kappa = 0.38$, 95% confidence interval [CI], 0.19-0.57) and minor findings (kappa = –0.29, 95% CI, –0.43 to –0.15). An independent panel found that 90% of the lack of concordance was due to interobserver variability rather than poor image quality (4.9%).[16] Another study evaluated synchronous tele-endoscopy; this study aimed to evaluate the effectiveness and quality of video during a multicenter demonstration of endoscopic submucosal dissection and ERCP streamed in real time by using the DVTS as well as feasibility of an international remote live conference. Multiple

uncompressed HD videos were successfully transmitted in real time over multiple channels of a superfast broadband Internet to 1000 endoscopists at a site remote to the endoscopic suites. Questionnaires after the demonstration showed that 91% of reviewers were satisfied with the quality of the video.[17]

A proof-of-concept study on tele-endoscopy for teaching ("tele-teaching") evaluated endoscopy trainees' test scores on identifying neoplasia (precancerous and cancerous lesions) before and after viewing of endoscopy lectures, with video transmitted over superfast broadband Internet (100 Mbps) from 3 international endoscopy units. Transmission of uncompressed HD video by using the DVTS over the APAN was found to be feasible, and it was concluded that the infrastructure to support tele-endoscopy for teaching is attainable for most academic centers. Participants showed overall improvement from before-lecture to after-lecture test scores.[18]

EASE OF USE

Systems vary in their ease of use of information input, recording, and transfer of video. Most are user friendly. Some have automatic generation of patient information through integration with the EMR, and others require manual input. The newer DCDs allow for immediate archiving and quick transfer of data to external sources. Physician and staff training is generally required during initial use of a given image management system.

SAFETY

The biggest safety concern with image management systems is HIPAA compliance and security of information. Any system that allows remote access will need to use a secure network and other protective measures. Patient identifiers should be removed if records are to be used for teaching or presentations.

FINANCIAL CONSIDERATIONS

The cost of recording systems varies depending on available features, size of internal hard drive, ability to record HD versus SD alone, and installation and integration requirements. Costs are increased if image management systems are purchased for multiple endoscopy rooms. Service contracts will need to be considered; these are required to maintain proper upkeep and operation of the system. The costs of various image management systems are listed in Tables 1 and 2.

AREAS FOR FUTURE RESEARCH

Studies evaluating the use of video in endoscopy training of fellows would be useful. Comparative studies should be performed evaluating the ideal means of transmitting HD video for tele-endoscopy. The legal ramifications of video recording of procedures have not been studied. Unresolved issues with tele-endoscopy include medicolegal aspects (eg, providing a second opinion) and financial implications. Tele-endoscopy is not currently reimbursable, which will undoubtedly affect its use. Cost-effectiveness research might be a way to facilitate such a goal.

SUMMARY

Image management systems are becoming an integral part of endoscopy units. Systems have evolved from standard definition to HD recording. Newer features allow for integration with a hospital/ambulatory center's EMR system as well as remote access to a centralized storage and archiving system. The overall needs for a hospital or endoscopy unit need to be taken into account before purchasing an image management system.

DISCLOSURES

The following author disclosed financial relationships relevant to this publication: Dr Tokar received an honorarium from Olympus Endoscopy, Inc. All other authors disclosed no financial relationships relevant to this publication.

Abbreviations: APAN, Asia-Pacific Advanced Network; AVI, Audio Video Interleave; BMP, bitmap; BNC, Bayonet Neill-Concelman; CD, compact disc; DCD, digital capture device; DICM, Digital Imaging and Communication in Medicine; DTR, data transfer rate; DVD, digital video disk; DVI, digital visual interface; DVTS, Digital Video Transport System; EMR, electronic medical record; GB, gigabyte; HD, high definition; HDD, hard disk drive; HIPAA, Health Insurance Portability and Accountability Act; JPEG, Joint Photographic Experts Group; Mac, Macintosh; Mbps, megabits/second; MPEG, Moving Picture Experts Group; NTSC, National Television System Committee; PAL, Phase Alternating Line; PC, personal computer; PNG, portable network graphics; RGB, red, blue, green; SD, standard definition; SDI, serial digital interface; S-video, separate video; TB, terabyte; TGA, Truvision Graphics Adapter; TIFF, Tagged Image File Format; USB, Universal Serial Bus; VGA, Video Graphics Array; WMV, Windows Media Video; Y/C, luminance/color.

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