A Novel Approach to High Definition, High-Contrast Video Capture in Abdominal Surgery

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Objective: The aim of this study was to define the best available option for video capture of surgical procedures for educational and archival purposes, with a view to identifying methods of capturing high-quality footage and identifying common pitfalls.

Summary Background Data: Several options exist for those who wish to record operative surgical techniques on video. While high-end equipment is an unnecessary expense for most surgical units, several techniques are readily available that do not require industrial-grade audiovisual recording facilities, but not all are suited to every surgical application.

Methods: We surveyed and evaluated the available technology for video capture in surgery. Our evaluation included analyses of video resolution, depth of field, contrast, exposure, image stability, and frame composition, as well as considerations of cost, accessibility, utility, feasibility, and economies of scale.

Results: Several video capture options were identified, and the strengths and shortcomings of each were catalogued. None of the commercially available options was deemed suitable for high-quality video capture of abdominal surgical procedures. A novel application of off-the-shelf technology was devised to address these issues.

Conclusions: Excellent quality video capture of surgical procedures within deep body cavities is feasible using commonly available equipment and technology, with minimal technical difficulty.

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Video recordings are frequently used as teaching aids in operative surgery. Indeed, a surgical meeting that does not contain a session devoted to video presentations of surgical technique is a rare event these days. Unfortunately, many video recordings are of poor quality, and often, because of the constraints of the equipment and the operating environments, do not demonstrate the principles of the technique as well as the presenter intended. The intention of this paper is to outline some of the readily available equipment for recording operative video, to highlight their relative strengths and shortcomings, and to describe a high-quality video recording technique developed at upper gastrointestinal surgical units at Bankstown and Royal North Shore Hospitals in Sydney.

There are many options for avoiding poor quality video capture in surgical procedures on the body surface. The simplest and most cost-effective method in this setting is to employ a video camera mounted on a tripod. These are available from any number of consumer electronics outlets and in a variety of formats. Although it is possible to obtain reasonable quality video recordings by using the automatic exposure settings on most cameras, this often requires diversion of the operating light away from the operative field to avoid overexposure of the image. Almost all cameras, however, will have a predefined setting for bright environments, and this is an ideal alternative to use in this situation.

The resolution of standard definition digital video is 480 lines, whereas that of high definition digital video is up to 1080 lines. If a high definition camera is selected, it is imperative to invest in computer hardware and software capable of editing and outputting high definition video. While several software developers provide software capable of editing high definition video, two problems arise when considering high definition recording equipment. First, there are no consumer options currently available to create high definition video on DVD; this can only be done with high-end professional equipment. To further compound the issue, there are two mutually exclusive formats currently competing for market share, in much the same way that Vertical Helical Scan (VHS) and Betamax fought it out for the video cassette recorder (VCR) market in the 1980s: HD-DVD and Blu-Ray DVD. The first HD-DVD players were released in the United States in April 2006, and the first Blu-Ray players in June 2006. Neither format currently has a recording device on the consumer electronics market; and when they eventually are released in 2007, they will not be cross-compatible. At this stage, it is probably safest to eschew the problems with high definition video altogether.

Many operating rooms are equipped with video cameras mounted in the handle of the operating light. Although

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these may also be suitable for recording surgical procedures on the body surface, they are of variable quality and do not usually have a digital interface. Those without a digital interface can be connected to a standard VHS or super-VHS (S-VHS or s-video) VCR. Although analogue video is acceptable for most uses, it is rapidly approaching obsolescence, and is more difficult to edit effectively than digital video.

When performing laparoscopic or other minimally invasive surgery, video capture is not usually an issue. A signal can be taken directly from the line out plug of the camera-processing unit and inputted directly into an analogue or digital VCR using an s-video connection. Some laparoscopic and endoscopic video processors come equipped with digital video (DV) outputs, also known as FireWire or IEEE 1394 interface. This can also be used with a digital video camera or digital VCR. The resolution of most modern laparoscopic equipment approaches, or is equivalent to, high definition video.

It is when video capture is considered during operations deep in body cavities that a greater challenge arises. Operating light-mounted cameras, head-mounted cameras, and consumer video cameras cannot capture high contrast video in the depths of the thorax, abdomen, or pelvis due to insufficient lighting. Even those consumer cameras with low-light recording capabilities cannot record in low-light conditions without loss of contrast and loss of resolution. In addition, head-mounted and hand-held cameras suffer from unsteady images, light-mounted cameras are difficult to train on some parts of the body cavities, and hand-held or tripod-mounted cameras often suffer from obstruction of the scene by members of the surgical team. Lack of sterility limits the utility of these methods of video capture, but a novel solution to this problem is already available in every operating suite.

A 10-mm 0° viewing angle laparoscope with an attached laparoscopic camera head is used as an image-sensing device. A digital VCR is connected to the line out plug of the camera-processing unit of the laparoscopic tower using an s-video cable or a FireWire cable if available. High definition video is thus captured through the laparoscope, processed, and recorded on Mini-DV tape for future editing. The long depth of field inherent to laparoscopic video equipment is advantageous for capturing images from the depths of body cavities, as it improves the quality of low-light capture. In addition, the laparoscopic halogen light source may be used to supplement the operating light if needed, although this may

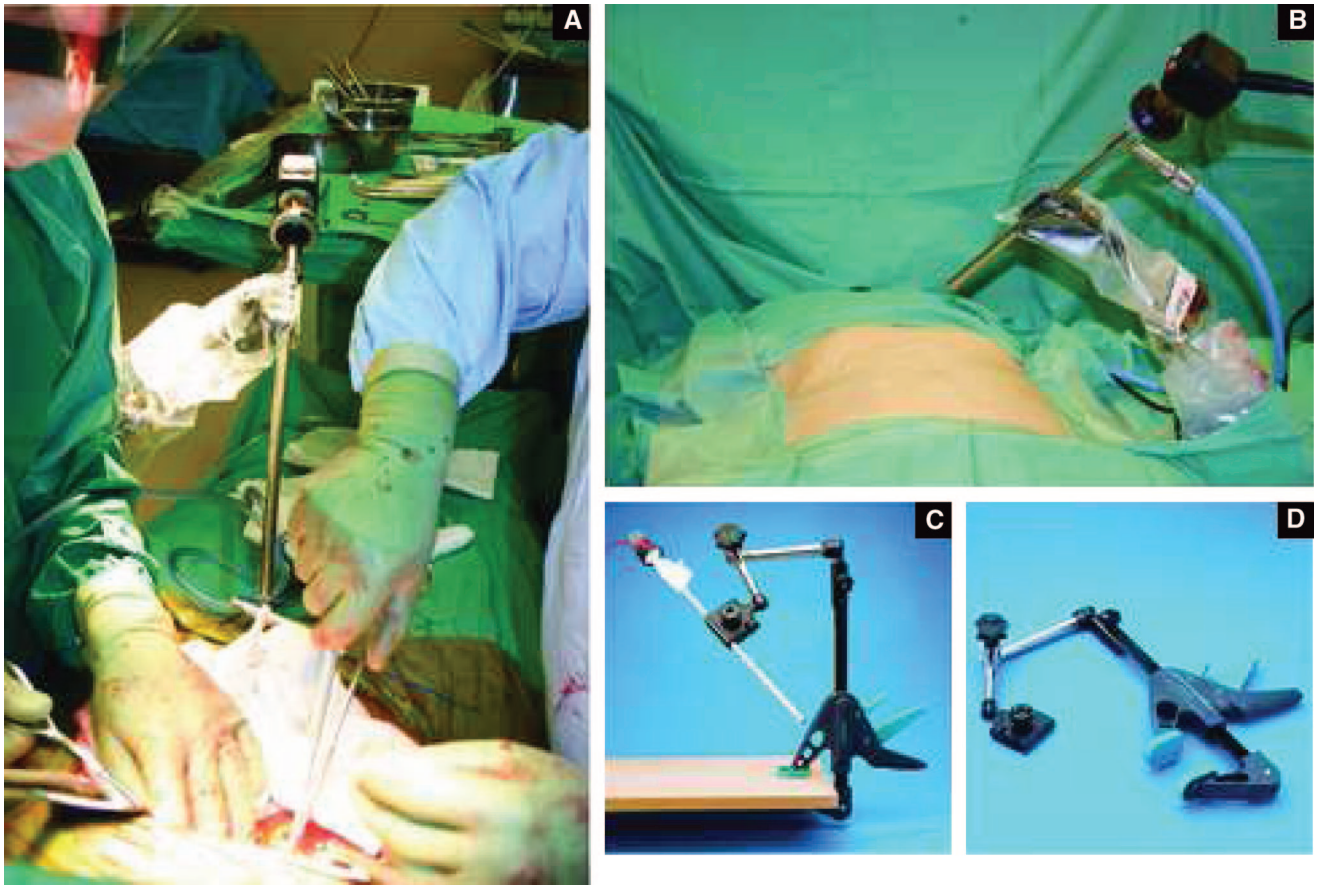

FIGURE 1. A, The laparoscope is sturdily attached to the operating table opposite the surgeon. B, The arrangement for video capture in upper abdominal surgery, after preparing and draping the operative field. C, The laparoscopic arm securely holds the laparoscope in place and is mounted on the operating table. D, The knob in the middle of the arm simultaneously tightens or releases all articulations for rapid and easy manipulation into position.

result in overexposure of the image if used injudiciously. The exposure can, of course, be adjusted by manipulating the shutter controls on the camera-processing unit.

To avoid camera shake, a Laparoscopic Arm (Limbs & Things Ltd, Bristol, U.K.; http://www.limbsandthings.com) is affixed to the side of the operating table opposite the surgeon, as demonstrated in Figure 1A. A sterile camera sleeve is used to sheathe the arm, and sterile drapes are placed normally around it, after the manner illustrated in Figure 1B. The laparoscope is mounted between the jaws of the device, which holds it steady, as shown in Figure 1C. A tightening knob at the joint in the middle of the arm (Fig. 1D) can be used to loosen all the joints simultaneously and so facilitate positioning of the laparoscope, which may be moved toward or away from the operating field, or to a different angle to obtain an unobstructed view, simply by manipulating a single control. Adjustment is also occasionally required to facilitate the first assistant's access to the operative field, particularly if the patient is moderately obese, or if the ipsilateral arm is extended on an armrest during the procedure. Because the entire setup is sterile, it can be manipulated by an assistant or the instrument nurse, either of whom may keep an eye on the monitor. Should further access to the operative field be required, the entire device may be rapidly dismantled using a quick-release mechanism.

A short, illustrative segment of video captured using this technique may be viewed by accessing the Sydney Skills Network website (http://www.surgical-skills.net).

This arrangement has been used extensively in open abdominal surgery, with resultant high-quality video recordings being presented at a number of national surgical meetings. In addition to being used for recording video, members of the operating theater staff can refer to the video display to monitor the progress of the operation, and it can be used to teach medical students and junior doctors present in the operating room about the procedure.

This system was assembled from commercially available, off-the-shelf components for rapid deployment; improvement in its ergonomic characteristics should emerge with fabrication of a specially designed apparatus for securing the laparoscope unobtrusively to the operating table while maintaining an unencumbered view of the operative field.

This technique is recommended to any surgeon who wishes to capture video for teaching operative surgery or for archival purposes, and is well within the capabilities and budgets of most surgical units.