Emergence of three-dimensional video microsurgery for male infertility

In every surgical field, paradigm shifts occur through innovation in either surgical approach or technology, and in the most dramatic instances through a combination of the two. For male reproductive surgery, a prime example is the advent of microdissection testicular sperm extraction (microTESE), in which technology (the operative microscope) facilitated a novel approach—high-magnification search for seminiferous tubules with distinct appearance—that dramatically changed the treatment paradigm for men with nonobstructive azoospermia. Of course, not all surgical innovations lead to a paradigm shift or even a patient benefit. In both urology and gynecology, the rapid adoption of robotic surgery has been polarizing. Although the robotic approach offers clear benefits, such as improved surgeon visualization, reduced length of stay, and decreased operative blood loss, the impact of robotic surgery on oncologic outcomes and costs remains unclear.

The latest technological innovation in male reproductive medicine is video microsurgery. The operative microscope has been the cornerstone of male reproductive surgery since its introduction by Silber in the 1970s, and there have been very few refinements in the last half century. More recently, with the popularity and widespread adoption of laparoscopic surgery, microsurgeons have begun to explore new technologies that might leverage the advantages of laparoscopy and apply these principles to microsurgery in a variety of ways. One example is the use of robotic surgery, an approach that remains controversial. A second example is the concept of video microsurgery, which is not new—in fact, Gorman et al. (1) performed video microsurgery in a rat model almost 20 years ago. However, the feasibility and advantages of video microsurgery were limited by the capabilities of the existing video and optical technologies. Now, two decades later, substantial technological improvements have fostered a resurgence of this concept alongside new technology that may help surgeons to recognize its benefits.

Video microsurgery uses a three-dimensional (3D) laparoscope to project microanatomy onto a high-quality monitor. In the United States, three devices are approved by the Food and Drug Administration (FDA): ORBEYE Video Microscope (Olympus Medical Systems Corporation), VITOM (Karl Storz Endoscopy), and NGENUITY (Alcon). These devices are similar insofar as they all include a high-quality, 3D camera with the ability to articulate for optimal positioning and visualization of the target anatomy. Images are projected onto a monitor, and surgeons wearing 3D glasses can visualize the anatomy on the monitor, performing extracorporeal "heads-up" surgery similar to laparoscopy.

There are a number of theoretical advantages of video microsurgery over conventional microsurgery with regard to operative, surgeon, and educational outcomes. From an operative perspective, the video microscope offers flexibility without compromising visualization. Hayden et al. (2) conducted a head-to-head laboratory comparison of the standard operating and video microscopes, finding that the video microscope offered a wider field of view and better depth of field with equivalent image resolution, particularly at lower magnification. The small footprint of the camera itself allows the surgeon to make direct eye contact with the assistant and enables both to easily look outside of the microsurgical field, which can be very useful during knot tying or other operative maneuvers. The articulating camera arm also allows for an angled view of the anatomy, whereas the conventional operative microscope must be positioned at a 90° angle.

In a randomized animal trial, Hayden et al. (3) performed vasal reconstruction in 23 rats, demonstrating equivalent patency, granuloma formation, and operative times between the conventional and video microsurgery groups. Not only do these data suggest noninferiority of the video microsurgical approach, but they also indicate a very short learning curve for well-trained microsurgeons to adapt this new technology. Conversely, these data also demonstrate that surgical outcomes are not clearly improved by this technology, which prompts the question of what other potential advantages may make its adoption worthwhile.

Perhaps the greatest potential benefits of video microsurgery pertain to surgeon ergonomics. There is robust evidence to suggest that surgery, and microsurgery in particular, can place a great physical strain on surgeons. Surgeons are at high risk for musculoskeletal disorders, with an estimated 17% prevalence of cervical spine disease, 18% prevalence of rotator cuff pathology, and 19% prevalence of degenerative lumbar spine disease (4). Moreover, in a survey of 339 surgeons, Capone et al. (5) found that microsurgeons who operated more than 3 hours per week had higher rates of cervical and thoracic pain. The opportunity to perform heads-up surgery with the video microscope could alleviate some of this surgeon morbidity, though other studies have shown that surgeons who perform minimally invasive surgery are also at increased risk for musculoskeletal symptoms. Certainly, prospective studies are needed to determine whether surgeon morbidity is truly improved with the use of video microsurgery. But given the high rates of physician and surgeon burnout, any technology that can reduce surgeon discomfort and morbidity should be worthy of consideration.

Another feature of the video microscope is the ability for all members of the operative team to visualize the operative field simultaneously and with the same image quality. The conventional operative microscope only allows for two, at most three, surgeons to visualize the anatomy in 3D. Even when the image is projected onto a monitor, the image is converted to two-dimensions, and resolution is lost. With the video microscope, all team members can function with the same working image, which may increase operative efficiency and quality of care. Furthermore, this serves as an excellent teaching platform for surgical trainees and medical students: they can follow along throughout the operation even when they are not directly assisting. There may even be opportunities to establish low-cost, scalable video microsurgery simulations.

As with any new technology, costs must be considered in addition to efficacy. Both conventional and video microscopes require high-cost initial capital investments and ongoing service contracts. Both require few, low-cost disposables, and operative time (and therefore cost) appears similar between the two approaches. Ultimately, cost comparisons will likely be driven by the pricing of the initial capital purchase and the life span of the equipment; the former is likely to change, while the latter remains unknown. Of course, if video microsurgery can truly reduce surgeon morbidity and burnout, the cost benefit of healthier, happier surgeons with longer careers would be substantial.

As a field, we must be deliberate in our approach to the evaluation and adoption of this new technology. How should we integrate video microscopy into clinical practice, if at all? What are the criteria for demonstration of safety, efficacy, and cost-effectiveness? Hayden et al. (2, 3) should be commended for their initial laboratory studies in this space. Cautionary tales from robotic surgery, morcellation, and many other innovations should inform our collective approach toward these difficult questions: adoption of technology simply because we can is not a good enough reason to do so. We maintain cautious optimism regarding the potential of video microsurgery to improve upon our surgical subspecialty, and we look forward to future collaborative efforts to determine the appropriateness of use.

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