

Video transmission of urology surgeries: proof of concept in a resource-constrained environment

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Introduction

Video capture is widely used to transmit, record and archive, open and minimal access procedures across a variety of interventional disciplines.¹⁻⁴ It is used as an educational tool for operators, trainees, and observers, for audit and monitoring of performance indicators and for medicolegal purposes.⁵⁻⁹

Recording procedures pose challenges as the integration and manipulation of a variety of video sources (external cameras, views from flexible and rigid endoscopes, fluoroscopy, ultrasound, etc.) are required to ensure consistent and optimal image quality, particularly during live transmission to large audiences and for telementoring.

There are a variety of commercial devices that have been developed for specific purposes and companies that offer a specific software/hardware integration with or without virtual tools that can improve the educational aspects, particularly for telementoring. These include GoPro, Proximie, SWIS Surgical Video and SurgiCams.⁹⁻¹² These commercial entities are costly, as are AV production companies to manage live events and deter from their use on a regular basis in resource-restricted healthcare systems.

There is a paucity of systems developed by innovative surgeons using standard low-cost hardware and open-source software.⁹ This study describes and illustrates the components of such a low-cost system and their successful integration for live transmission of urology procedures.

Methodology

Figure 1 gives a schematic overview of the components required for two-way audio-visual (AV) transmission used in this low-cost and open-source software setup. This setup has been used on two occasions when our division hosted a minimal access surgery workshop.

Technical aspects

Hardware: Any modern laptop can handle multiple AV inputs. Figure 2 illustrates commonly used outputs from the laparoscopic stack, for example, DVI/Composite out to HDMI/Composite to HDMI/USB capture card to allow input into the laptop.

For a camera showing the surgeon or open operative field, any webcam on a tripod/pivot head (with auto focus and zoom)

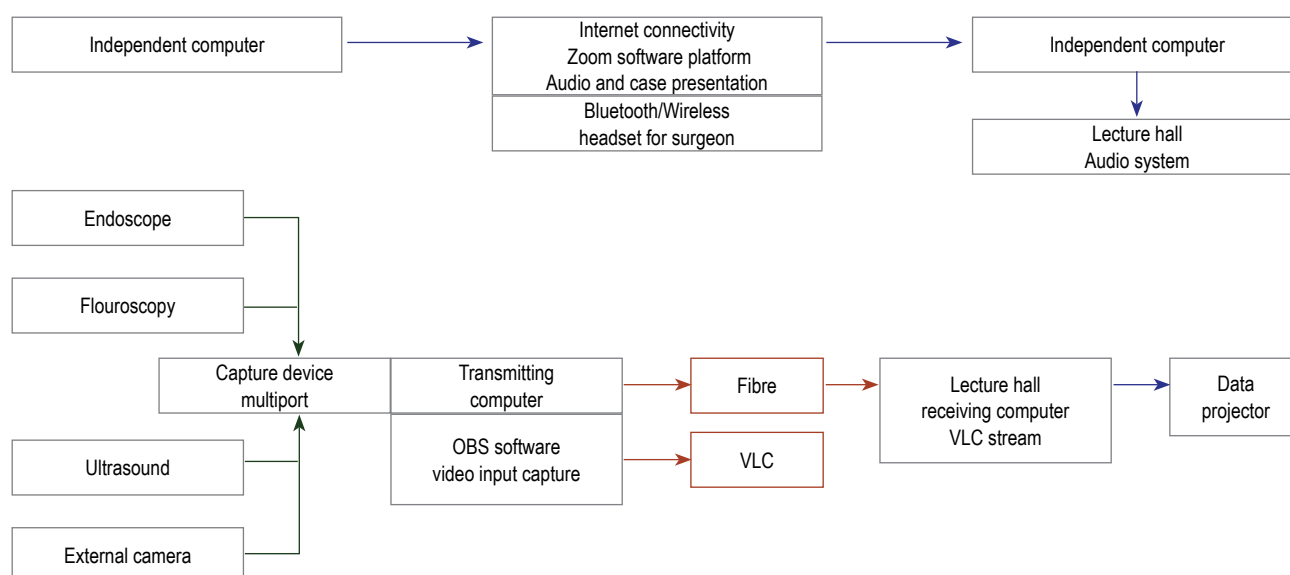


Figure 1: Schematic overview of two-way audio-visual transmission

Commonly used video output connectors for endoscopy, ultrasound and fluoroscopy

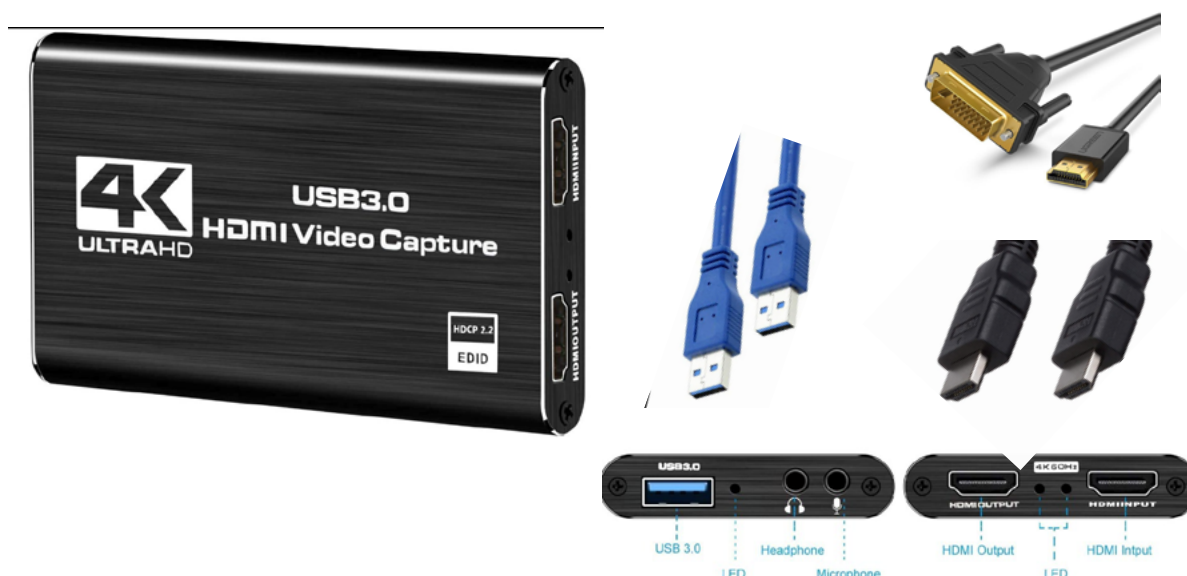
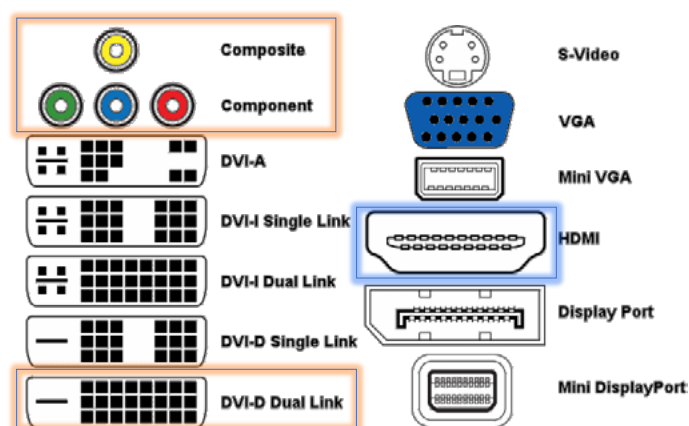


Figure 2: a) Commonly used video output connectors for endoscopy, ultrasound and fluoroscopy, and b) an HDMI input capture card with USB output to a PC or laptop



Figure 3: An affordable USB webcam and tripod to film the surgeon or operative field in open surgery



Figure 4: OBS Studio is a free open-source computer program which allows mixing of video and audio to be streamed to a remote location over a local network or internet

is adequate (Figure 3). Sound capture is best handled by an inexpensive Bluetooth/Wireless headset.

Software: To live stream the video signal over the internet or an internal hospital network is a software function. While several proprietary programs exist, the open source and free program OBS Studio (Open Broadcaster Software – <https://obsproject.com>) is

ideal. OBS Studio mixes the various video inputs and the sound and sets up the live feed for network transmission (Figure 4). Software setup is comprehensively described here: <https://obsproject.com/wiki/OBS-Studio-Quickstart> (Last accessed 23 January 2022). We transmitted from two theatres simultaneously using two dedicated computers running OBS Studio.



Figure 5: In the remote auditorium, we make use of two further laptops running a media player which can output to the data projector for the audience with the Zoom link shown in the top screen for audio communication

In the remote auditorium, on another two computers, we used the free media player VLC player to receive the streaming signal from OBS Studio (<https://www.videolan.org>) (Figure 5).

Network: Network connectivity was via a dedicated permanent fibre optic cable between the theatre and auditorium. Again, the components of this installation are comparatively inexpensive. A long fibre cable and a network switch are required. The ability to see and control the desktop of the remote machine was enabled using TightVNC (<https://www.tightvnc.com>).

Audio: Two-way audio was established using the popular teleconferencing software Zoom (<https://zoom.us/>). This allowed seamless communication between the surgeon using a wireless microphone and headset and the moderator/audience in the auditorium using a roving wireless microphone. This was on a standard university LAN connection.

Personnel: Medical personnel in theatre and the auditorium used WhatsApp text messenger to communicate and coordinate the smooth sequencing of the live surgery and adjustment of the external camera. In the auditorium a senior moderator coordinated participant interaction and directed minimally disruptive questions to the expert surgeons.

The focus of this workshop was to demonstrate minimally invasive uro-oncology and advanced endourology procedures.

Discussion

Estimates by leaders in global surgery suggest that low- and middle-income countries have a disproportionately rising clinical burden, with limited access to safe, timely, and affordable surgical care.¹³

COVID-19 has ushered in an accelerated transition to remote and virtual teaching techniques and fostered the growth in surgical teaching methods and surgical simulation.¹⁴ Worldwide attention to ensuring patient safety, concerns about trainees' exposure and increased surgical specialisation have all coincided to promote alternative teaching for the technical aspects of surgery for both trainees and trained surgeons embarking on new techniques.¹⁵

Multiple studies support the idea that surgical simulation in wet, dry and virtual reality labs fosters surgical skills and translates into improved psychomotor performance metrics in the clinical setting.¹⁶ Likewise, the live surgical broadcast (LSB) is an efficient way to demonstrate surgical techniques and real-time surgical decision-making to a wider audience. Routine recording of live surgery also offers the opportunity of visual reinforcement for self-reflective and constructive feedback between the trainee and trainer.¹⁷ Similarly small group training workshops using live broadcasts are excellent vehicles for "train the trainer" interactions.¹⁸

Traditionally the most common means for trainee surgeons to be taught surgery or trained surgeons to gain exposure to new techniques, is a one "expert" on one "trainee" preceptorship. COVID-19 and other training paradigm shifts have led to the realisation that providing distance learning to participants in the hands-on course like its in-person version is a much-needed supplemental educational technique that requires a remote

mentoring platform capable of allowing meaningful one-on-one interaction with the learner.

The concept of telementoring in surgery is best defined as real-time guidance and instruction during an operation to a surgeon in a remote location using audio, video, and other telecommunications technologies.¹⁹ The first application of telementoring in-house occurred in 1996 using a dedicated T1 line for signal transmission, and in 1998, ophthalmologists telementored endoscopic laser-assisted dacryocystorhinostomy from Hawaii to the Philippines using ISDN transmission rates of 128 kilobytes per second.^{20,21} Since these pioneering days, the technology has moved forward with the use of high bandwidth videoconferencing, satellite and, particularly now, internet transmission and more recently with moderate bandwidth with improved signal compression encoding and decoding.

Telementoring systems provide reliable, high-quality video and audio transmission. The system we describe here used 100 megabytes/sec transmission rate providing high image and audio quality using standard computers and audio-visual accessories.

With the improvement in transmission quality has come further software and platform innovation to enhance levels of instruction. One such platform is Ohana One (<https://ohanaone.one/>) a medical NGO promoting telementoring. They have international surgical experts who can remotely mentor surgeons using VUZIX smart glass technology (<https://www.vuzix.com>). The line-of-sight software allows the mentor to superimpose pointers to indicate and direct dissection (<https://www.helplightning.com>).

This is the first report in a South African resource-limited hospital setting utilising in-house high-quality transmission of live surgery via low-cost technology. We believe that this and similar technologies can be adapted for local settings and that, as well as being used for LSB, it is adaptable to a variety of applications for the training of surgeons in resource-limited settings that exist in most healthcare systems in African countries. The further and more complex educational extension of LSB is that of telementoring that has been shown to have similar safety and efficacy profiles as on-site mentoring.

Conclusion

This proof-of-concept paper has laid out the steps required for low-cost video broadcast for live surgery workshops or telementoring. The more widespread adoption of these novel teaching techniques should foster surgical skills training in resource-constrained environments. Wider adoption would also promote the goals of the global surgery movement.

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