

Videoconferencing for Large Animal Trauma Experiments During COVID-19: A Cross-Continent Experience

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ABSTRACT

Introduction:

COVID-19 shutdowns in many research facilities across North America impacted preclinical trauma-related research and development. Shutdown limited the speed and resources available for large animal experiments necessary for advancing medical devices and technologies. However, the pandemic led to the rapid adoption and expansion of videoconferencing in social circles, workplaces, and primary care health settings. Here, we describe the use of simple videoconferencing equipment to plan and carry out 3 total weeks of large animal experiments with a large, cross-continent, interdisciplinary team testing a novel technology in swine models of noncompressible intraabdominal hemorrhage and junctional hemorrhage.

Materials and Methods:

Animal experiments using swine were scheduled over 3 weeks in February and March 2021 to take place in Toronto, Canada. All relevant animal protocols and COVID-19 site-specific risk assessments were completed and approved by the responsible institutional committees. Experiments were conducted by connecting 12 total research personnel from 3 sites by a simple video conferencing setup which included low-cost, high-definition webcams and standard smartphones streaming to Zoom.

Results:

Video conferencing allowed for 3 weeks of trauma experiments to take place at the height of Toronto's third peak of COVID-19 cases. Up to 3 experiments were completed for models requiring 6 hours of monitoring, and up to 5 experiments were completed for models requiring 3 hours of monitoring. The large amount of digital data collected during these experiments was rapidly shared with our network of collaborators, who analyzed results and interpreted findings in real time.

Conclusions:

The system described in this paper has the potential to reduce costs of trauma animal model development and allow for rapid testing and implementation of life-saving devices in settings with limited onsite personnel as experienced during the COVID-19 pandemic.

INTRODUCTION

Advancements in medical devices and technologies for managing trauma have rapidly advanced in the last decade, with many new systems now available to both military and civilian hospital care teams. However, COVID-19 shutdowns in

many research facilities across North America in the previous year have heavily impacted trauma-related research and development. Large animal hemorrhage models play a vital role in generating data for new trauma management techniques, but shutdowns have greatly limited both the speed and the resources available for these experiments to be completed.

The COVID-19 pandemic led to the rapid adoption of videoconferencing, which, within weeks of shutdowns, became the norm for most forms of face-to-face communication. Many primary care physicians integrated the use of telemedicine into their regular practice to continue to provide care to their patients.^{1,2} The wide-spread emergence and habitual use of videoconferencing create opportunities where large interdisciplinary teams of researchers, which include scientists, engineers, veterinarians, and surgeons, can continue the development and testing of novel technologies remotely. Videoconferencing allows for skeleton onsite teams to carry out animal trauma experiments with the remote support of collaborators, expert advisors, and additional research personnel in experimental planning and in collecting and tabulating data in real-time.

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The aim of this article is to describe the experience of a cross-continent, interdisciplinary team which relied heavily on videoconferencing to plan and carry out 3 total weeks of large animal experiments using swine models of non-compressible intraabdominal hemorrhage (NCIAH) and junctional hemorrhage (JH) during the COVID-19 pandemic.

APPROACH

Experiments were planned in December 2020 and occurred over a total of 3 weeks in February and March 2021, with NCIAH experiments taking up 2 weeks and the JH experiment taking 3 days. Experiments took place at the Li Ka Shing Research Institute Vivarium, associated with St. Michael’s Hospital in Toronto, ON, Canada. All animal protocols were approved by the St. Michael’s Hospital Animal Care Committee and performed according to the guidelines of the Canadian Council on Animal Care. All site-specific COVID-19 protocols were adhered to during these experiments, and risk assessments and approvals were obtained prior to the February start dates.

The interdisciplinary team of collaborators consisted of 12 total research personnel from 3 sites. One site, the onsite group, was St. Michael’s Hospital, Toronto, ON, Canada, which included a trauma surgeon and the group’s principal investigator, a research administrator, and registered veterinary technicians (RVTs). The second site was Canadian Forces Base Suffield, Ralston, AB, Canada, which included a defense veterinarian. The third site was The University of British Columbia (UBC), Vancouver, BC, Canada, which included 2 research assistants, 1 graduate student, 2 post-doctoral fellows, and the group’s principal investigator. The onsite group carrying out the experiments was comprised of 3 team members: a trauma surgeon, an RVT, and a research assistant (RA) traveling from UBC. They were responsible for all aspects of the experiment, including anesthesia, performing the experimental procedure, preparing samples for analysis, animal monitoring, and necropsy and harvest. The same onsite team members worked on the experiments throughout the week. The team was prepared to bring in another local surgeon or veterinary technician to continue the experiments if an onsite team member contracted COVID-19 prior to the week of experiments. The RA limited their movements prior to and during the week to limit exposure to the virus. The team was also prepared to reschedule experiments if necessary.

Video Conferencing Setup

Collaborators in Vancouver and CFB Suffield were connected to the operating room through audio-visual equipment and the internet, which included various nonspecialized (low to moderate cost) 1080p webcams, and previous-generation smartphones placed around the operating room with flexible-leg tripods. Zoom Cloud Meetings (Zoom; Zoom Video Communications, California) was used for the experiments. Zoom was chosen as the telecommunication method for these experiments for its ease in recording sessions, the ability to spotlight

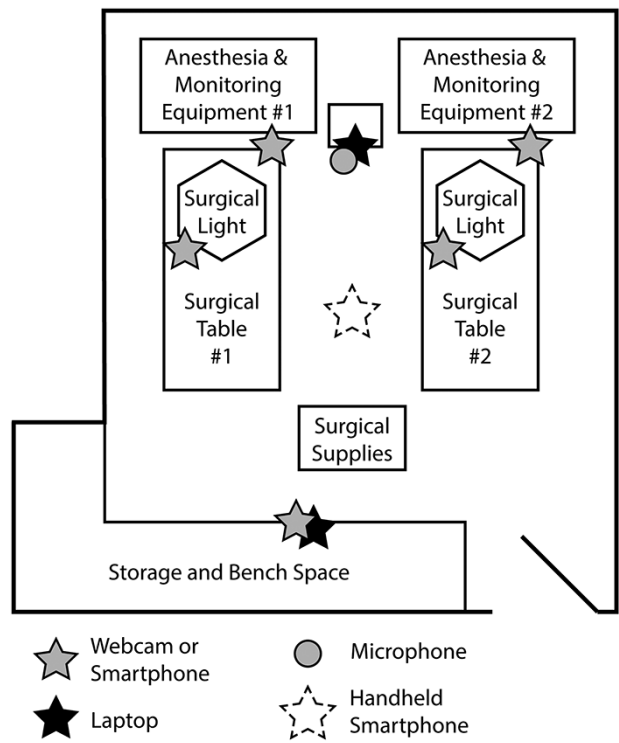


FIGURE 1. Representative schematic of operating room setup and camera placement. To prevent feedback, only one microphone was enabled in the room at one time.

specific streams in the videoconference, the gallery view capability to view multiple monitors at once, and its familiarity to all team members. The gallery view allowed for multiple animals to be monitored in parallel when necessary. Up to 4 total cameras, all connected to Zoom, were used for one animal (Fig. 1). This includes one webcam connected to a computer with its microphone enabled or a smartphone directed towards the animal’s vitals monitor, an additional webcam providing an overhead view of the procedure connected to the surgical light, a webcam-enabled laptop with active speakers at the foot of the operating table where all remote team members could be seen and heard by the surgical team and, when opportunities arose, a handheld phone camera showing close ups of procedures. This setup allowed the remote sites to communicate with the operating rooms in real time.

A Zoom link was circulated to the offsite team, prior to the week of experiments, and one offsite team member in Vancouver was always connected to the stream and acted as the Zoom administrator, a key requirement for this system. This individual was responsible for managing the Zoom recordings, monitoring vitals, recording, and analyzing data in real time and was ready to provide protocol clarifications and time point reminders when required. This remote team member was fully responsible for ensuring that the experiment occurred in the expected manner, which was a management task that could not be performed by members of the onsite team due to the large number of responsibilities and hands-on tasks at any

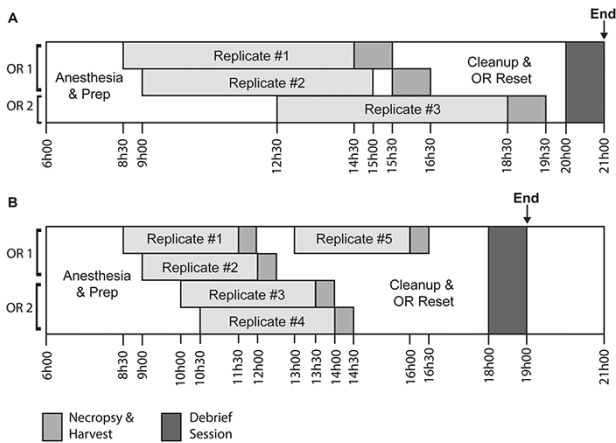


FIGURE 2. (A) Experimental timeline on a day with a maximum number of replicates for a 6-hour survivability study, assuming all animals lived 6 hours. (B) Experimental timeline for a day with a maximum number of replicates for a 3-hour survivability study, assuming all animals lived 3 hours.

given time. This individual would also message and ask other remote team members to join the call if they were required by the onsite team. Model development experiments benefited greatly from this setup as it allowed remote team members to watch the experiment and provide their real-time advice based on prior experience with similar models.

Experimental Timeline

Experiments started daily in Toronto at 8:30 am EST and Zoom meetings began up to 30 minutes before the surgical start time. Surgical preparations were started 2 hours before the surgical start time and were not streamed. Two ORs were used daily with a maximum of 2 animals set up per OR in parallel. Models of NCIAH involved monitoring survival for up to 6 hours, and a maximum of 3 NCIAH animal replicates were completed in one day (Fig. 2A). Models of JH involved monitoring for survival for up to 3 hours, and a maximum of 5 JH animal replicates were completed in one day (Fig. 2B).

To review the data that was obtained in the day and perform preliminary analyses, the research team met nightly for 1 hour for a debrief session. Debrief sessions were structured in the following manner: review of each animal and the outcomes, presentation of data analysis, consultation and hypothesis building the days results, and planning for the following day. This ensured all the team members understood the progress and could provide their expertise and insights to the studies. The plans for the following day were then promptly communicated to the RVTs at the animal facility.

DISCUSSION

The described audio-visual setup allowed for 3 weeks of trauma experiments using 2 different swine models to be carried out successfully at the Li Ka Shing Research Institute Vivarium in Toronto. The data from these experiments were

shared widely with our network of collaborators, and additional experts beyond the team described here were consulted to help analyze the results and interpret the findings. These experiments coincided with the Toronto area’s third peak of COVID-19 cases and would not have been possible without the telecommunication methods described. During the weeks of the experiments, communication between Vancouver, Suffield, and Toronto provided valuable oversight on the steps of the protocol and key experimental timepoints when all the onsite team members were occupied. The real-time advice and expertise of collaborators in hemorrhage models enabled rapid, collaborative decisions during experiments. All experiments were recorded in their entirety and are available for team members to review. The extensive AV setup also benefited RVTs, who were able to monitor the vitals of pigs in adjacent ORs via secondary laptops that were connected to Zoom.

Here we implemented aspects of telemedicine to carry out large animal research and to continue developing tools and techniques for managing trauma. COVID-19 research curtailments and social distancing prevented multiple team members from Vancouver and Suffield from attending the experiments. While operating with a team of 3 and carrying out up to 5 animals per day for model development, the team was able to successfully have additional team members and experts in animal hemorrhage models assist remotely. This enabled high-resolution data to be extracted from each experiment. The capability to record and archive all experiments, which included vitals monitors, procedures, and audio from the surgical team describing each step and their observations allows for enhanced data analysis and planning future directions.

While there have been shortages of nonhuman primates due to ongoing COVID-19 research studies,³ we had no difficulties or changes to obtaining the pigs necessary for the experiments. Swine models remain the gold standard in modeling human hemorrhage due to their similarity to humans in size and hemostatic responses. Pigs are raised globally as livestock and were sourced from a local commercial herd raised for the food industry. Shortages of pigs for research were not extensive, as they are not used much for COVID-19 research.⁴ Based on this, we expect that trauma research is more robust to potential disruptions of animal supplies.

Videoconferencing has been previously reported for mentoring physicians through emergency trauma surgery in a live porcine model.⁵ However, to our knowledge, this is the first report of videoconferencing to perform live, large animal experiments for research and development of tools and techniques in trauma. The easy-to-use methods described here mirror procedures already present in telehealth environments, described as a real-time, bidirectional audio-visual videoconferencing system.⁶⁻⁸ Ideally, although not completely necessary as shown here, this system is one where a virtual presence is established with minimal interference and does not include any setup time for the onsite team.⁶ Continued development

in this area, including in the realm of small, wearable cameras than can be readily streamed, and the wide adoption of these technologies could position animal research facilities to install similar systems for faster, less resource intensive and more transparent experiments in the future. The approach described here may also be implemented in high risk, human health situations where an imbedded videoconferencing infrastructure does not exist if there is a dire need for consultation with specialists.

The methods described here could be adapted for remote, hands-on training scenarios, testing new life-saving interventions, or be used to execute more complex models that simulate field care—all of which expand the tools for the care of severely injured trauma patients. Beyond research and development, the methods described in this report could also be adapted to rural or resource-limited settings where real-time virtual support from expert health providers could improve outcomes.^{9,10}

Future shutdowns due to pandemics should not limit trauma research and development. Furthermore, implementing systems like this could significantly reduce the costs of model development while also increasing the model's quality, allow for rapid testing and implementation of life-saving devices, streamline experimental analysis and planning by generating large stores of data that can be rapidly shared and also be used as evidence to support commercialization of new devices.

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CONFLICT OF INTEREST STATEMENT

A.B. is an active serving member of the Canadian Armed Forces. The rest of the authors have no conflicts of interest to declare for this work.

AUTHORSHIP

N.A. and M.F.C. contributed equally to this work. C.J.K. and A.B. are co-corresponding authors. N.A., M.F.C., C.J.K., and A.B. designed and performed the described procedure and wrote the manuscript. J.R.B. and H.S. designed and performed the methods and provided critical revisions.

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