Review Article Compte rendu

Teleconsulting in the time of a global pandemic: Application to anesthesia and technological considerations

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Abstract — As a result of the various restrictions associated with the current COVID-19 pandemic, the practice of veterinary telehealth is likely to grow substantially. One area in which high quality care can be maintained while respecting physical distancing is teleconsulting, which describes the relationship between an attending and off-site consulting veterinarian. This guide uses a dentistry case to illustrate the provision of real-time anesthesia consulting, with a focus on the technological considerations central to facilitating live, 2-way video-communication. Case selection, teamwork, and patient safety are also discussed.

Résumé — Téléconsultation en temps de pandémie globale : application à l'anesthésie et considérations technologiques. Comme résultats des différentes restrictions associées à la présente pandémie de COVID-19, la pratique de télésanté vétérinaire est appelée à croître considérablement. Un domaine dans lequel des soins de haute qualité peuvent être maintenus tout en respectant la distanciation physique est la téléconsultation, qui décrit la relation entre un vétérinaire traitant et un vétérinaire consultant hors-site. Ce guide utilise un cas de dentisterie pour illustrer les exigences de consultation en temps réel pour l'anesthésie, avec une emphase sur les considérations technologiques essentielles pour faciliter une communication vidéo bidirectionnelle en direct. La sélection de cas, le travail d'équipe et la sécurité du patient sont également discutés.

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Introduction

Telehealth is a rapidly emerging area of veterinary medicine, the growth of which is likely to be accelerated during the current severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the coronavirus 2019 (COVID-19) pandemic. Telehealth is an umbrella term that describes "all uses of technology to deliver health information, education or care remotely" (1). Under this umbrella, there is a host of "tele-" terms describing specific aspects of telehealth, such as telemedicine, teletriage, telemonitoring, and teleconsulting (1). The most important of these is "telemedicine," a term that is frequently misunderstood and variably defined (2,3).

Telemedicine is similarly defined by the Canadian Veterinary Medical Association (CVMA) and the American Veterinary Medical Association (AVMA) as the practice of veterinary medicine at a distance, or between sites, using telecommunication technology to exchange medical information (1,4). Critically, telemedicine must occur within a valid veterinary-client-patient-relationship (VCPR), as it relates to the practice of veterinary medicine. Within Canada, each province and territory has its own definition of a VCPR, but there is broad overlap such that core principles are shared [(5), page 11].

In contrast, teleconsulting describes the relationship between an attending veterinarian (who has a VCPR) and a consulting veterinarian who is providing advice. The attending veterinarian remains responsible for the veterinary medical care of the animal, unless the consulting veterinarian is providing medical advice or expertise directly to the animal owner, in which case the consulting veterinarian becomes the attending veterinarian and is required to meet the licensing requirements of the jurisdiction in which the animal is located and have a valid VCPR (4).

The purpose of this review and guide is to share recent experiences with providing teleconsulting services for anesthesia support, with a focus on considerations surrounding technology, case selection, communication, and teamwork.

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Dentistry case example

A 13-year-old, 9 kg, neutered male Shih Tzu cross dog was presented for general anesthesia and referral dental surgery to complete dental work that was aborted due to concerns about anesthesia. The dog had been anesthetized 3.5 mo previously for a dental procedure at the referring veterinary hospital but the anesthesia was terminated shortly after induction due to respiratory complications (increased abdominal effort associated with radiographic diagnosis of left cranial and caudal lung lobe atelectasis; cause undetermined, suspected endobronchial intubation). Atelectasis had resolved when radiographs were repeated 3 d later. The dog also had a history of dysplasia and osteoarthritis in multiple limbs and an increased respiratory effort (panting) with prolonged exertion. A complete blood cell count and serum biochemistry were completed on the morning of the aborted procedure. Abnormalities included a mild erythrocytosis [RBC: 9.3×10^{12}/L, reference range (RR): 5.83 to 9.01×10^{12}/L] and a moderate elevation in alkaline phosphatase (ALP) (401 U/L, RR: 23 to 212 U/L). The increased ALP was attributed to enzyme induction due to chronic administration of a low-dose of prednisolone for inflammatory bowel disease.

Physical examination findings and blood analysis on the morning of surgery included a moderate tachycardia (144 beats/min), erythrocytosis (packed cell volume 64%, RR: 36.6% to 54.5%), total protein within reference range (74 g/L, RR: 52 to 82 g/L), hypoglycemia (blood glucose: 3.4 mmol/L, RR: 3.89 to 7.95 mmol/L), and a nervous but calm demeanor. Heart rhythm, bilateral femoral pulses, bilateral lung field auscultation, tracheal auscultation, and respiratory rhythm and rate were normal. There was no history of coughing, cyanosis, syncope, stridor, or stertor before or after the anesthetic episode. An American Society of Anesthesiologists (ASA) physical status classification of 2/5 was assigned.

The day before the procedure, a successful trial (~20 min) of the videoconferencing equipment to be used for the procedure was performed, which also provided the opportunity to try various camera positions.

The videoconference started at 0950. A smartphone (iPhone 7; Apple, Cupertino, California, USA) was mounted on a mobile IV stand in the dental suite and the consulting anesthetist used a laptop computer (MacBook Air 11-inch; MacOS v10.15.3, Apple) with built-in camera and microphone. A free videoconferencing platform was used (Zoom; San Jose, California, USA) with a unique call-in ID, and the Wi-Fi Internet connections were password protected at both locations. During the first 10 min, the dog was visually assessed, physical examination findings were discussed, and a plan for anesthesia was reviewed with the lead animal health technologist (AHT) anesthetist. The anesthetic considerations and potential interventions for erythrocytosis, as well as the procedures for avoiding and detecting endobronchial intubation were discussed in detail. The moderate tachycardia was attributed to the patient's nervous demeanor.

A detailed procedural document was developed to help manage the case, including checklist items, to compensate for the limitations of teleconsulting (Appendix I, available from https://doi.org/10.7910/DVN/NIZ51Y).

The smartphone camera was initially positioned to provide a frontal view of the dog and 2 AHTs performing induction of general anesthesia. Salbutamol (Teva-Salbutamol HFA 100 μg/actuation; TEVA Canada, Toronto, Ontario), 200 μg, was administered *via* a pediatric aerosolizing chamber connected to a tight-fitting face mask, followed by IV fentanyl (50 μg/mL; Sandoz Canada, Boucherville, Quebec), 2 μg/kg body weight (BW), and 5 min of pre-oxygenation with 100% O_2 *via* a tight-fitting face mask. Instrumentation for an electrocardiogram (ECG) and with a pulse oximeter provided continuous monitoring and audible signals during induction with IV fentanyl (2 μg/kg BW), midazolam (5 mg/mL; Sandoz Canada Inc), 0.1 mg/kg BW, and alfaxalone (10 mg/mL; Alfaxan, Jurox Pty, Rutherford, NSW, Australia), 3 mg/kg BW, until endotracheal intubation was possible. Intubation was confirmed with bilateral thoracic auscultation during intermittent positive pressure ventilation (IPPV) and capnography.

Following intubation, the camera was positioned to provide a simultaneous view of the physiologic monitor, fluid pumps, ventilator bellows, and anesthetic machine. The lead AHT was in constant communication with the consulting anesthetist, providing feedback regarding anesthetic depth, physiologic status, and the dental procedure. The attending veterinarian (dentist) and other members of the healthcare team also provided feedback as needed (speakerphone function was used for communication). The consulting anesthetist directed several interventions during the course of the anesthesia including volume resuscitation [Lactated Ringer's Solution (Lactated Ringer's Solution USP, Baxter, Mississauga, Ontario), IV bolus of 10 mL/kg body weight (BW) and Voluven (6% hydroxyethyl starch 130/0.4 in 0.9% sodium chloride, Fresenius Kabi Canada, Toronto, Ontario), 5 mL/kg BW, in addition to a 5 to 10 mL/kg BW per hour, IV maintenance rate of Lactated Ringer's Solution], blood glucose management, adjustments of IPPV settings, and administration of analgesics both as boluses and variable rate infusions. Left and right infraorbital and inferior alveolar dental blocks were performed (1.5 mg of 0.5% bupivacaine HCl with epinephrine per site; bupivacaine 5 mg/mL + epinephrine 0.0091 mg/mL, Vivacaine, Septodont, Cambridge, Ontario).

The duration of the procedure was approximately 3 h. The lead AHT and consulting anesthetist formulated a recovery and extubation plan in advance of turning off the isoflurane vaporizer. For recovery, the camera was repositioned to face the dog, showing a view of its head (in sternal recumbency), with audible Doppler ultrasound, ECG, and pulse oximeter monitoring, along with oxygen administration by mask. The consulting anesthetist directed the recovery phase and timing of extubation, in the presence of the attending veterinarian. Remote continuous observation continued for a further 10 min post-extubation. The consulting anesthetist remained available by telephone for the remainder of the day and was notified by text message when the patient was discharged to its owner. Post-procedure follow-up was provided by the attending veterinarian, AHT, and consulting anaesthetist by telephone.

The videoconference quality was adequate for communication and visualization; however, several minor problems were encountered. There were 6 interruptions in the video feed, each

Table 1. General considerations when setting up a teleconsultation with a specific example illustrated using the Zoom videoconferencing platform.

	General considerations	Example
Device	Software (installed, upgraded)	Operating system and Zoom software up-to-date on cell phone (in operating room) and laptop (with teleconsultant)
	Power (chargers, sockets)	Confirmed available (day before during test call)
	Positioning (mounting/field of vision)	Mounting cell phone on portable IV stand tested day before (height and field of view)
	Video capture	Minimum resolution ≥ 720 p, frame rate > 30 fps
	Video viewing	Minimum 1 MP (e.g., 1334 × 750 pixels), frame rate > 30 fps
	Security (passwords, virus, etc.)	Password-protected cell phone and laptop
	Recording capability	Not performed (requires consent from participants). Paper anesthetic record maintained
	Storage memory	Not used (no recording)
	Spare device?	Smartphone [with alternative (FaceTime) videoconferencing software installed]
Network	Data transfer rate up + down to Internet	> 5 to 10 Mbps
	Security (Wi-Fi password, VPN)	Password-protected Wi-Fi network (all locations)
	Backup connectivity (mobile data/wired?)	Cell phone data (3G) available as backup
Service	Features (video, voice, screenshare, multi-participant)	Zoom: videoconferencing with option to switch to voice-only as needed to improve connectivity. Additional communication available *via* live chat function.
	Cost	Free
	Security (encryption, limiting participants)	Zoom: unique session ID, password required to join session, "waiting room" function enabled (host controls who joins the session), session "locked" by host once all participants have joined (prevents additional parties joining), screen sharing capabilities controlled by host. End-to-end encryption provided.
	Reliability	Assessed during a test call the day before
	Accounts/numbers/handles to be used	Login and connection tested during test call
Preparation tests	Dry run call (same numbers/handles, devices, networks, locations)	Performed ≥ 1 day before procedure
	Image and sound quality	Test using planned location and monitoring equipment (ability to see monitor screen)
	Instrument legibility	As above
	Check switchover to backup device/network	Check backup cell phone number is correct and signal service is good at both locations

Information provided in the example is for illustrative purposes. Due to the rapid pace of advances in technology, performing a test call is always recommended and the security features of videoconferencing platforms should be confirmed before use.

lasting approximately 5 to 15 s (video froze and a "poor signal" message appeared on the screen). Audio continued to function during these times so no recourse to an alternative means of communication was necessary. At one point, the iPhone battery was low and needed to be recharged to continue the call. The camera in the dental suite was accidentally moved several times and had to be repositioned. Finally, the video quality was acceptable, though it was noticed that red waveforms on the monitor display were harder to see and the video feed was occasionally out of focus, though it remained usable.

Discussion

Telehealth and telemedicine are well-established concepts in human medicine, emerging in the early 20th century and enjoying a rapid increase in use in the 1990s with the advent of Internet access combined with decreasing costs of technology for capturing and transmitting digitized data (6–8). In veterinary medicine, reports of telemedicine and telehealth emerged in the 1990s, but they have not yet experienced the same growth as in human medicine (2,9–11). A lack of familiarity and perhaps comfort with technologies available may be slowing this growth (2).

A recent, albeit small survey of veterinarians in clinical practice (n = 76 respondents), found that approximately 1/3 of respondents hardly ever/never used telehealth (n = 27/76) or telemedicine (n = 26/76) and use of videoconferencing for communication was low (n = 10/76) (2). Approximately 17% (n = 9/54) of respondents stated that telehealth and telemedicine were the same thing, reflecting its frequent interchangeable use in the human literature. Over 100 definitions of telemedicine have been identified in the human literature (3). It should be noted that the sample surveyed may not be representative of the profession [more than 75% of respondents were ≥ 40 y old and most (60%) were male)]. Interestingly, those surveyed were selected based on association with a veterinary college's distributed clinical year program, potentially impacting exposure of the next generation of veterinarians to telehealth.

Telemedicine has been successfully applied to all phases of human anesthetic practice, from pre-operative consultations, through intra-operative monitoring to post-operative and intensive care monitoring (12). The earliest reports of remote monitoring of general anesthesia in real time ("synchronous") (9) described the application of both purpose-built devices for collecting and transmitting information where data transmission speeds were limited (see Technology) and the use of existing telecommunications (13–15).

The use of real-time telemedicine contrasts with a store-and-forward ("asynchronous") approach with which most veterinarians are familiar. The store-and-forward approach commonly applies to teleconsulting for diagnostic imaging, in which data are collected and stored by the attending veterinarian, then forwarded for evaluation (7). The greatest challenge of real-time applications is a time-sensitive dependency on technology.

While the basis of this paper was the stimulus to meet a demand for anesthesia support within the constraints of the current pandemic, telehealth has an important role to play in accessibility to veterinary and human healthcare (remote settings, limited numbers of general practitioners and specialists) (2,9,12,15).

The remainder of this discussion describes specific considerations and challenges in performing teleconsulting in real time with video; a summary table illustrates the key points provided (Table 1).

Technology

Historically, both general purpose videoconferencing software and purpose-built systems have been successfully used (13,14). Key considerations in equipment and platform selection are cost, data security, and performance. In human medicine, particularly for surgery but also for pre-operative anesthesia consulting, dedicated towers incorporating video cameras, microphones, and electronic (often modular) instruments (electronic stethoscopes and otoscopes, and fiberoptic cameras) are available (12,16). For supervised surgery ("telementoring"), these are often combined with telestrator capabilities (being able to indicate landmarks and features on the surgeon's monitor) (16). These units have relatively high upfront and maintenance costs, currently precluding their use in veterinary medicine. In contrast, the combination of a video camera (e.g., smartphone), monitor (e.g., laptop computer/tablet), and videoconferencing platform, as described in the presented case, is suitable for most veterinary needs.

In recent years, streaming video and Internet video call/conferencing services have become very popular, driving huge investments in related technologies. Affordable consumer devices now have good quality cameras, microphones, and displays with processors capable of efficiently encoding and decoding "high-definition" video. Large investments in fixed and mobile Internet access continue to drive down the cost of device connectivity while improving performance. Meanwhile multiple services compete to provide good quality, reliable, and easy-to-use software for setting up and running video and voice calls and multi-participant conferences.

Table 2. Sample residential Internet service.

Time of day	Ping (ms)	Download speed (Mbps)	Upload speed (Mbps)
0730–0800	5 to 18	46.1 to 90.2	40.8 to 68.4
1200–1300	11 to 14	90.2 to 90.3	70.6 to 72.4
1500–1600	2 to 18	48.6 to 90.2	16.9 to 72.0
1730–1830	14 to 19	87.8 to 90.2	72.0

Data are ranges following daily testing during the week (Mon–Fri) by a co-author (DP) in his home. Ping speed reflects connection quality to server 100 km away. Data collected with speedtest.net. Note: Data reflect distance/number of connections.

Video capture

Options for video (and sound) capture include static and mobile video cameras. As technology has advanced, smaller handheld devices provide an acceptable level of quality, removing the need for additional hardware and software to connect a standalone video camera to a computer for transmission. The inherent advantage of using a video camera built into a device capable of transmission reduces options to laptop computers, tablets, and smartphones. For laptops and tablets, most popular devices all have "high-definition" or "ultra-high-definition" (> 1080 pixels) video cameras, recording at 24 to 60 frames per second (fps), with similar specifications for current smartphones.

Smaller devices have the advantages of portability, availability, and ubiquity, enabling *ad-hoc* consultations. Smartphones or other devices with mobile connectivity as well as Wi-Fi can be used in a wider variety of locations and provide a built-in backup communication channel. Mobile phone Internet in the US and Canada is currently used by around 80% of the population, making phones highly accessible and potentially capable of supporting video and sound transmission for teleconsulting (17,18).

Whether hand-held or affixed to a mobile stand (as described in the reported case), portability has the advantage of using a single device to easily capture different areas of the room, as needed. In some instances, it could be advantageous to have simultaneous unrestricted views of the patient and physiologic monitor, requiring 2 devices and a means of transmitting 2 video streams (13). Early reports, in which transmission capabilities were limited to satellite phones (data transfer rates of 64 Kbps), maximized use of available bandwidth by pairing a single video camera (on operating field) with physiologic data fed directly into a purpose-built device for data integration and transmission (14).

Video transmission

There are numerous considerations regarding video transmission, including data transfer rate, videoconferencing platform, and data security. The ability to view and provide timely input on viewed information depends on the achievable data transfer rate (sometimes referred to as bandwidth or connection speed). With high quality video, data transfer rates < 128 Kbps are associated with greater technical difficulties; lag or latency in

Table 3. Selected applications for videoconferencing.

Platform	Encryption	Secure login	Free?	Comments
Skype	Y, chats stored on company servers	Password	Y	
Skype for Business	Y, end-to-end possible	Password	N	Being replaced by MS Teams
Zoom[a,b]	Optional end-to-end when using application	Password	Y (limited 40 minute duration for $\geq$ 3 devices)	Can control participants joining calls and lock calls (preventing people joining)
Microsoft Teams[b]	End-to-end	Password, multifactor authentication	N	Limited to users of Office365 suite
WhatsApp	End-to-end	Optional (depends on device security)	Y	
FaceTime	End-to-end	Optional (depends on device security)	Y (Mac devices)	
REACTS[b]	Y	Password	N	
KARL STORZ VisitOR1[b]	Y	Password	N	Accepts inputs from auxiliary wired and wireless signals (e.g., physiologic monitor, electronic stethoscope). Data transmitted on private global network
KARL STORZ Viewpoint[b]	Y	Password	N*	
TeamViewer[b,c]	End-to-end	Password, multifactor authentication	N	

Note: Data based on information collected during week of April 27, 2020. Technology changes frequently and users should check that current provisions meet their needs.
[a] Opt-in security features available, including password protection and waiting room (users joining call can be screened before access is provided).
[b] HIPAA compliant (additional subscription service required for MS Teams).
[c] Provides remote screen sharing. Voice support must be provided separately.
* Software and private global network can be accessed from supported personal devices.

video and audio (16). Modern residential wired or wireless Internet connections are typically capable of upload and download rates much higher than this, enabling higher video resolutions and frame rates (Table 2). Videoconferencing platforms provide minimum recommended rates ranging from 1.5 to 2 Mbps, for example (19). Minimum rates assume the minimum of 2 devices are in use, with a higher transfer rate required if more devices are conferencing.

As data transfer rates have rapidly increased over time (Edholm's Law), delays in video transmission have subsequently decreased so that delays with current networks are in the millisecond range (16). In a simulated surgery study, delays in excess of 500 ms were associated with surgical delays and errors (20). Importantly, these delay times are 1-way, that is the transmission time in 1 direction (e.g., from surgical suite to viewer), and do not consider the additional time to respond, a consideration during teleconsulting. For interactive voice or video calls, 1-way mouth-to-ear delays of $<$ 150 ms are recommended to avoid a perceptible degradation in quality of experience to participants (21).

Advertised Internet data transfer rates are usually considerably higher than achievable rates as a result of network congestion and other factors (Table 2). For a connection between 2 devices, the slowest link in the chain, perhaps a weak local Wi-Fi network or lower upload rate, will limit the achievable data transfer rate. The ping time between 2 devices measures the current round-trip delay at the network level, indicating a lower limit on video/voice delay (Table 2).

Videoconferencing services and applications commonly measure and react to changing network conditions, improving or degrading video and voice quality in order to maintain a call with acceptable delays (22).

Wired network connections (e.g., Ethernet) provide reliable data transfer at high rates with low delays but may be awkward for portability and positioning. Mobile data connections (2.5G/3G/4G/5G) may offer a useful connectivity alternative with acceptable data transfer rates and delays, though subject to variable signal quality and commonly at greater cost than a fixed Internet connection (23).

Disconnections during videoconferencing have been infrequently reported in the literature, with 1 study (using Wi-Fi) reporting 7 disconnections, totalling 10 min out of 279 min of anesthesia teleconsulting time, none of which affected care or necessitated use of planned backup communications (24). The experiences in the reported case highlight the possibility of technical problems. Many users will have prior experience with communication issues and may naturally anticipate the potential need to reconnect, drop to voice only, or try another communications channel. Given the possibility of technical problems or failures, having an alternative method of communication is strongly recommended (13,25). In the case described, the backups included an alternative videoconferencing platform

(FaceTime, Apple) and telephone. Additionally, in the described case, a trial was conducted the day before the planned case, facilitating familiarization with the technology and software.

An important consideration that is well-described in the human medical literature, but minimally in the veterinary literature, is security of data during transmission and potential breaches of confidentiality (7,11,12,14,25,26). On involved devices and networks, basic security mechanisms such as making use of passwords, antivirus software, password protected and encrypted Wi-Fi, and other security hygiene methods should be implemented.

There are several methods available to protect data in transmission, including the use of dedicated, legally compliant services, encrypted videoconferencing platforms, and Virtual Private Networks (VPN). In North America, legally compliant services have been designed to comply with human healthcare regulations to protect the privacy and security of health information such as the US Health Insurance Portability and Accountability Act of 1996 (HIPAA), which cover the secure transfer and storage of data (records, images, and video) (27–29). Their development and maintenance come at a cost, which is recouped from users, limiting current adoption in veterinary medicine. When based on a suite of dedicated hardware, initial and ongoing maintenance costs are high, though there may be a role in centers wishing to provide regular remote support (27). Systems centered on software that can be accessed through personal devices (smartphones, laptops, tablets) come at a lower cost, with ongoing payments used to support continued development and maintenance (28).

Existing videoconferencing platforms vary considerably in the levels of security available, reflecting how communications are accessed, transmitted, and stored (Table 3). Hosting servers dedicated to videoconferencing on-site is cost-prohibitive and hosted services are generally used provided they meet legislated security requirements (30). Many services provide built-in encryption of data. Some services claim to provide "end-to-end" (device-to-device) encryption of data, where the service itself is unable to decrypt the transported data. However, as a service user, it is not generally possible to be certain whether end-to-end encryption is actually applied, in which jurisdiction(s) servers are located, how data are routed, how new software versions behave or how operating company policies change. In some instances, videoconferencing platforms can be compliant with health regulations for management of patient data, but this is typically a paid service and may require a contract between the provider and user (31).

VPNs are used by organizations to allow remote sites and workers to connect to their private internal networks over the public Internet using encrypted connections. General purpose VPN services aimed at consumers securely connect their devices to the public Internet. These consumer VPNs give a degree of local privacy and anonymity, but do not protect data traversing the Internet unencrypted when it leaves the VPN. For public videoconferencing services reached over the Internet, using a consumer VPN to access them does not give significant extra security. Dedicated services use encrypted connections directly between applications running on devices and the systems implementing the service, giving a good degree of security assuming the service provider is trusted (27,28).

An alternative approach to dedicated services and videoconferencing platforms, is to use a hybrid setup, in which physiologic monitor screens can be shared remotely and voice calling provided through an alternative means such as telephone (32). Though less convenient than a single package for video and voice, this may be suitable for occasional use.

Video viewing

Minimum requirements for video viewing are not well-established in telehealth. Several papers have discussed different aspects of display quality, though these largely focus on specific specialty requirements, which tend to exceed the specifications needed for synchronous teleconsulting (33,34). Screen resolutions of approximately 0.75 MP (1024 × 768 pixels) have been used successfully for surgical telementoring and limited applications in veterinary radiology (16,35).

Screen size is a further consideration, with surgeons remotely supervising laparoscopy favoring monitor screen sizes > 10″ over a 5″ smartphone (36). This may have added importance if more than 1 window is displayed concurrently (e.g., physiologic monitor and room view). A more general statement can be made regarding frame rates, with 30 to 60 fps perceived as smooth to the human eye, with a minimum acceptable threshold of 15 fps (37). As fps rate decreases, there is a longer delay between frames with the risk of the scene appearing "jittery" with moving objects jumping between points rather than moving smoothly (as in reality) (37).

Patient selection and risk

In the current COVID-19 pandemic, the CVMA considers veterinary practice and services essential (38) and at the time of writing, all provinces and territories classify veterinary practice and services as essential. In some cases, veterinary care has been restricted as emergency or urgent care. The Alberta Veterinary Medical Association does not currently make this distinction but states that: "What [veterinary] practices must provide is a safe environment for both their veterinary staff and clients." (ABVMA members bulletin, April 16, 2020). The argument in favor of performing the described case was based on a welfare concern from dental disease and high likelihood of pain. Untreated dental disease is an animal welfare issue and, in many cases, dental treatment should not be considered an elective procedure (39). The practice was able to follow provincial guidelines on physical distancing, barring clients from entering the practice, and appropriate use of personal protective equipment (PPE). The considerations for providing teleconsulting *versus* in-person support for this case were primarily centered on minimizing the number of personnel in the workplace when appropriate support could be provided remotely, and the perceived anesthetic risk of the case. It is currently unknown how synchronous teleconsulting affects procedural risk for a patient. General considerations, which apply to all cases (patient selection, teamwork, client communication), are discussed in this and the following sections within the context of teleconsulting.

As a specialty, anesthesia recognized the contribution of human medical error to patient morbidity and mortality before it was more widely appreciated and human error is now correctly viewed within the context of a systems approach to understanding and preventing adverse events (see Teamwork) (40–45). Furthermore, a large part of anesthesia management is preventive: patient stabilization before anesthesia, real-time interpretation of physiologic data and early intervention to prevent or limit adverse effects. Together, this proactive, rather than reactive, approach improves peri-operative stability and outcomes. In contrast, many of the basic technical skills employed by anesthetists do not require advanced training and can be performed by a competent general practitioner or registered AHT.

The risks associated with general anesthesia are multifactorial, and are variably influenced by species, age, and health status among other factors. In this case, ASA physical status classification (including absence of indication for invasive blood pressure monitoring and acceptable cardiopulmonary status) and client comfort with the procedure played an important role in case selection. Cases in which the ASA physical status classification was > 2, or when clients were uncomfortable with the lack of in-person support, were recommended for referral or delayed. Additionally, training, experience, and proficiency are considerations when teleconsulting, as the physical act of delivering anesthetic care is dependent on the attending veterinarian and AHT. In this case, the patient was referred because of anesthetic complications during a dental procedure that was left uncompleted. A definitive cause of the complications was never elucidated and having an anesthesiologist teleconsulting was considered prudent.

The consulting anesthetist in this case was residency-trained and had extensive clinical and teaching experience in academic and private veterinary hospitals. The consultant had previously worked with the attending veterinary dentist but had no experience with the healthcare team in that particular hospital setting prior to the first videoconference trial.

As described in the presented case, and reflected in the literature, complications can be well-managed with a well-prepared and trained team (13,14). There is some indication that having more than one person dedicated to anesthetic monitoring ("cross-monitoring") can aid in early detection of abnormalities (13).

Teamwork

For the reported case, the veterinary care team comprised the attending veterinarian and 3 AHTs (one dedicated to the dental procedures, one dedicated to anesthesia, and the third providing support as necessary). The team composition allowed a clear division of labor and responsibilities between dental procedures and anesthesia, similar to practice in an academic center (or larger referral centers). As with any surgical procedure conducted by a multidisciplinary team, there is a risk of errors and adverse events, particularly when personnel are less familiar with one another or communication is poor (41,42). Additionally, the delivery of anesthesia depends on interactions between anesthetist, patient, personnel, and equipment (43–45). These interactions are frequently "tightly coupled," so that even small changes in 1 part of the system can have a rapid, direct, and major impact on the patient (43,45).

An initial case planning discussion by videoconference served the dual purpose of testing the technology (13), ensuring pertinent patient information (history and current health status) had been clearly communicated and allowing the 2 anesthetists (AHT responsible for anesthesia and consulting anesthetist) to establish a working relationship. The attending veterinarian participated in the planning videoconference and approved of the proposed plan before the procedure. The role of telehealth during preoperative patient evaluation in human anesthesia has become widespread (12,46). In this case, the AHT responsible for anesthesia (under the direct supervision of the attending veterinarian) had examined the patient and was able to discuss current physical findings.

Given the critical role of communication in medical and veterinary error and adverse events (in which harm occurs to patients or personnel), the initial videoconference was a key part of case preparation (47). The establishment of a shared mental model (shared mission and plan to achieve it), flattening of any hierarchy between the 2 anesthetists, structured communication, and minimal use of slang/jargon all contribute to clear, timely communication and a consequent reduction in errors and adverse events (42,48,49). The consulting anesthetist used a checklist that consisted of sequential steps outlined in an anesthetic planning document that was shared and discussed with the lead AHT anesthetist 4 d before the procedure. The same document was used as a guide to review the physical examination and blood analysis findings on the morning of the procedure, ensure the anesthetic machine had been leak-tested and the correct circuit was prepared, review pre-medication and induction drug calculations/volumes and sequence of drug administration, review salbutamol administration and pre-oxygenation techniques, and finally intubation equipment preparedness and plan.

During the procedure, all discussion between the consulting anesthetist and AHT anesthetist took place in the presence of the attending veterinarian (speakerphone function was used) and it was clear from the working relationships established that the attending veterinarian maintained primary responsibility for patient care. Teleconsulting is subject to the restrictions of the VCPR and any existing legal framework surrounding consultation in a specific jurisdiction.

Client communication

Client consent for anesthesia teleconsulting was obtained by the attending veterinarian as per the established VCPR. The consulting anesthetist had a telephone conversation with the client in the week before the procedure, during which the patient's clinical history, current health status, and teleconsulting plan were reviewed. The limitations of remote *versus* in-person anesthesia support and specific anesthetic considerations relating to the patient were discussed in detail, including that ultimate case responsibility and decision-making rested with the attending veterinarian. The client was encouraged to contact the consulting anesthetist with follow-up questions or concerns as needed. The owner was very satisfied with the service provided and with the follow-up communication.

Overall, following discussion between the attending veterinarian and owner, it was felt that the risk was manageable and acceptable.

Future

It is anticipated that telehealth will continue to grow and evolve in veterinary medicine, with this occurring at an accelerated rate under the selection pressure of the current pandemic. Important considerations during this period will be the maintenance of a distinction between telemedicine and other branches of telehealth, accepted means of establishing a VCPR, optimizing use of available technology, awareness of technological limitations (particularly data security) and the potential adoption of videoconferencing suites and platforms dedicated to telehealth. When done well, telehealth promises a host of benefits including maintaining adequate veterinary services during times of restricted access and movement, remote access to general and specialist services, support for isolated communities (clients and veterinarians) and underserved populations, and reduced client and patient travel for pre- and post-procedural follow-up (2,9,50).

Conclusion

This report shows that anesthesia teleconsulting can be successfully implemented, including the management of anesthetic complications. While there are numerous technological aspects to consider, the performance of existing technology and communications networks can be harnessed to provide a positive experience for all parties and facilitate high quality patient care.

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