Telemedicine Applications in the Era of COVID-19

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Telemedicine allows for the effective delivery of health care to patients at a distance through the application of information technology to the field of medicine. This is optimal during the COVID-19 pandemic to reduce interpersonal contact to mitigate contagion.

Telemedicine Telesurgery latency malpractice

1. Introduction

The WHO defined Telemedicine as "*The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for the diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities*" [1].

With the outbreak of the COVID-19 pandemic, public health policies have been implemented by the national governments that focus on the reduction of viral transmission: especially social distancing, with quarantine and isolation strategies [2]. In this context, Telemedicine has been chosen as an ideal tool to answer the challenge and face the emergency [3][4]. Thus, the introduction of Telemedicine into the healthcare landscape, being a new discipline not yet rooted in the territory, has opened the discussion regarding its legal, ethical, and regulatory implications [5]. Nittari et al. highlighted the issues present in this field, especially the lack of well-defined regulations and ethical issues regarding protecting patients' data and informed consent [6].

A growing branch of Telemedicine is Telesurgery, which is defined as the use of medical technology, such as robotics, sensory devices, and imaging video that allows a surgeon to operate long distances [7]. Robotic-assisted surgery has been successfully used in urology, general surgery, gynecology, neurosurgery, and cardiothoracic surgery [8]. The main advantages of Telesurgery are the ability to perform immediate surgeries in remote regions while avoiding long-distance travel, maintaining high quality and low cost, and the consequent reduction in surgical staff required to meet patients' demands [9]. In addition, it can be used for the training of new surgeons, known as telementoring [10].

2. Telesurgery: Birth and Development

Telesurgery was born in the laboratories of the US military and only later transferred to the civilian sector. The first applications were on the battlefields and on US Navy ships in the 1990s. Many laparoscopic operations were performed by a robot controlled by a surgeon at the Landsthul military hospital in Germany, 4000 km away [11]. The first remote surgery was carried out in 1995 in Milan by urologist Enrico Pisani, who performed a prostate biopsy on a patient located at the hospital, 5 km away from the surgeon, who was operating from the Polytechnic building [12].

Apart from this short-range pioneering experience, the first telesurgical operation took place on 7 September 2001. Professor Jacques Marescaux and his team from IRCAD (Institute for Research into Cancer of the Digestive System) performed a laparoscopic cholecystectomy operation by commanding from New York the mechanical arms of a robot surgeon located more than 6000 km away, in Strasbourg (France). A high-speed fiber-optic service provided the link between the robotic system and the surgeon [13]. The surgical procedure, named “Operation Lindbergh” in honor of Charles Lindbergh, the aviator who made the first non-stop flight across the Atlantic in 1927, was a milestone in modern medicine and represented the beginning of a new era.

Since then, there has been a continuous refinement of the technology behind Telesurgery, leading in 2014 to VIP (Virtual Interactive Presence) and in 2015 to the prototype that implemented efficiently haptic feedback technology, the Telefap Alf-x. In 2019, the use of Telesurgery via a 5G network was successfully tested. Today, researchers have a technical and scientific background that makes it possible to imagine a near future in which Telesurgery will be the norm.

3. Telemedicine Applications: More Than Just Telesurgery

Telemedicine applications are countless and can be applied to virtually any medical specialization, not just surgery. The most straightforward application is the so-called Televisit. It is a communication between doctor and patient mediated by a digital interface. Through Televisit, not only does the doctor have the possibility of conducting a dialogue with the patient to acquire as complete an anamnesis as possible, but he also has the possibility of subjecting the patient to, for example, cognitive tests. A study on Alzheimer’s disease patients showed that the reliability of clinical questionnaires, such as the MMSE (Mini-Mental State Examination) and the Alzheimer’s Disease Assessment Scale cognitive subscale (ADAS-cog) administered via teleconferencing is comparable to that of the same questionnaires administered face-to-face [14].

Teleradiology uses systems capable of acquiring, processing, transmitting, and archiving X-ray images in analog and digital formats. This application dates back to 1967 when a radiologist at Massachusetts General Hospital installed a diagnostic station at Boston’s Logan Airport. Doctors in transit brought images of their patients, which were video transmitted by the diaphanoscope, to the hospital to obtain the medical opinion of local radiologists. The audiovisual microwave circuit linking the hospital with the airport enabled more than 1000 medical consultations to be carried out for the benefit of airport employees and travelers [15]. The main advantage of Teleradiology is the possibility of telediagnosis, i.e., the remote interpretation of radiological images, which is particularly useful in conditions of particular environmental discomfort or when a radiologist’s opinion with specific

expertise in a specific field is required. Telediagnosis is complemented by teleconsultation, i.e., two or more specialists can discuss the interpretation of particularly complex radiological images [16]. The possibility of teleconsultation is significant in modern medicine, where super-specialty branches are becoming increasingly common.

Telepathology is the histopathological transposition of teleradiology, where images of microscopic preparations replace radiological images. The microscopic image is captured by a camera, which then digitizes, compresses, and transmits it [17].

Telecardiology consists of the transmission of images obtainable from cardiology diagnostic equipment [18]. The most important field of application is the telereferral of electrocardiograms: an EKG carried out physically in one place is examined and interpreted by a cardiologist in another place. Another interesting area of application of Telecardiology that is gradually gaining ground is telerehabilitation. Cardiac telerehabilitation makes it possible to carry out all the exercises usually envisaged in cardiac rehabilitation, even in centers remotely connected to the cardiologist, where only the presence of nurses or physiotherapists is required. A third key area where Telemedicine applied to cardiology is highly beneficial is cardiac telemonitoring. Patients in need of cardiac monitoring can use wristwatches, wireless watches, and event recorders with finger electrodes to record their EKG traces from the comfort of their own homes and share them with their doctor.

The shortage of healthcare staff, particularly pharmacists, has meant that measures have had to be taken to implement drug distribution services in recent years. Telepharmacy aims to provide an effective solution to this problem. Telepharmacy services are based on the presence of three types of structures operating in a network: the coordinating pharmacy, i.e., the reference pharmacy, is managed by a pharmacist; the remote pharmacy, i.e., the peripheral pharmacy, is driven by a pharmacy technician; the remote dispensing site, i.e., the vending kiosk located inside clinics or other buildings.

The remote pharmacy and dispensing site are linked to the coordinating pharmacy via an audio-video computer system. There are essentially three pharmaceutical practices in which Telepharmacy plays a leading role: support to clinical services, remote education and handling of “special pharmacies,” and prescription and reconciliation of drug therapies [19].

There is also Tele-assistance and Tele-rescue [20]. Tele-assistance is a form of medical support provided remotely to a patient, directly at home (tele-homecare). It is a particularly suitable tool for periodically checking a patient’s general conditions and intercepting and managing any emergencies requiring direct medical intervention. Remote assistance is a service mainly aimed at the elderly, the disabled, those living alone or in a state of isolation. It is also beneficial for those working in particularly isolated and hard-to-reach environments, such as seafarers [21]. It allows people in an emergency or distressing situation to request immediate medical assistance by simply operating a device directly connected to an assistance center.

4. New Perspectives: The 5G Network

Fifth-generation (5G) wireless networks enable significantly more stable data transmission than their predecessors and up to 100 times faster (10 GB/s). Virtually no signal latency can be achieved by reducing latency to a surprisingly low 1–2 ms. The application of 5G technology to telematics is extraordinarily promising.

In December 2020, an Italian research team published the results of the first intervention performed remotely using a robot connected to a 5G network [22]. The intervention consisted of a transoral laser microsurgery procedure performed on a cadaver. In a room 15 km away from the anatomy laboratory of the San Raffaele Hospital in Milan, where the corpse was located, the surgeon removed a polyp artificially grafted onto the body's vocal cords. An experimental 5G network provided two-way data transmission linking both ends of the system (the robot surgeon and the human surgeon). The intervention went smoothly, with no connection problems.

A study published in Jama Ophthalmology attempted to assess the real-world viability of laser photocoagulation for diabetic retinopathy performed remotely, in real-time, through the support of 5G technology [23]. The study involved an ophthalmic surgeon from Peking Union Medical College Hospital in Beijing, China, who performed the procedure on six patients (nine eyes) between October 2019 and July 2020. The patients were examined by teleconsultation and then underwent Telesurgery through a laser system and a remote-control platform connected to a 5G network. From a technical point of view, with an average network latency time of 20 milliseconds, the surgeries were conducted without any delay affecting the surgical action. No loss of image quality or signal loss was detected. This is one of the first studies to assess the reliability of 5G in its application to Telesurgery, and further randomized clinical trials are needed before widespread application can be envisaged.

References

1. WHO. A Health Telematics Policy in Support of WHO's Health-For-All Strategy for Global Health Development: Report of the WHO Group Consultation on Health Telematics. 1997. Available online: https://apps.who.int/iris/bitstream/handle/10665/63857/WHO_DGO_98.1.pdf?sequence=1&isAllowed=y (accessed on 24 October 2021).
2. Di Trana, A.; Busardò, F.P.; Ricci, G.; Sirignano, A. Commentary: Tele-COVID-19: Does it improve the provision of health services? Eur. Rev. Med. Pharmacol. Sci. 2021, 25, 2152–2153.
3. Battineni, G.; Nittari, G.; Sirignano, A.; Amenta, F. Are Telemedicine systems effective healthcare solutions during the COVID-19 pandemic? J. Taibah Univ. Med. Sci. 2021, 16, 305–306.
4. Ricci, G.; Campanozzi, L.L.; Nittari, G.; Sirignano, A. Telemedicine as a concrete response to covids-19 pandemic. Riv. Ital. Med. Leg. Dirit. Campo Sanit. 2020, 2, 927–935.
5. Burke, B.L.; Hall, R.W. Telemedicine: Pediatric Applications. Pediatrics 2015, 136, 293–308.
6. Nittari, G.; Khuman, R.; Baldoni, S.; Pallotta, G.; Battineni, G.; Sirignano, A.; Amenta, F.; Ricci, G. Telemedicine practice: Review of the current ethical and legal challenges. Telemed. E-Health

2020, 26, 1427–1437.

7. Lakshmi, S.I. Telemedicine Applications and Challenges. In Encyclopedia of Information Science and Technology, 2nd ed.; Information Science Reference (an imprint of IGI Global): Hershey, PA, USA, 2009; pp. 3728–3733.
8. Choi, P.J.; Oskouian, R.J.; Tubbs, R.S. Telesurgery: Past, Present, and Future. Cureus 2018, 10, 2716.
9. Cazac, C.; Radu, G. Telesurgery—an efficient interdisciplinary approach used to improve the health care system. J. Med. Life 2014, 7, 137–141.
10. Butt, K.A.; Augestad, K.M. Educational value of surgical telementoring. J. Surg. Oncol. 2021, 124, 231–240.
11. Zagra, M.; Argo, A. Medicina Legale Orientata per Problemi, 2nd ed.; Edra: Milan, Italy, 2018; p. 111.
12. Pisani, E.; Montanari, E.; Deiana, G.; Trinchieri, A.; Zanetti, G.; Tzoumas, S.; Guarneri, A.; Sala, R.; Rovetta, A. Robotized prostate biopsy. Minim. Invasive Ther. 1995, 4, 289–291.
13. Marescaux, J.; Leroy, J.; Gagner, M.; Rubino, F.; Mutter, D.; Vix, M.; Butner, S.E.; Smith, M.K. Transatlantic robot-assisted telesurgery. Nature 2001, 413, 379–380.
14. Carotenuto, A.; Rea, R.; Traini, E.; Ricci, G.; Fasanaro, A.M.; Amenta, F. Cognitive assessment of patients with Alzheimer's disease by Telemedicine: Pilot study. JMIR Ment. Health 2018, 5, 8097.
15. Murphy, R.L., Jr.; Bird, K.T. Telediagnosis: A new community health resource. Observations on the feasibility of telediagnosis based on 1000 patient transactions. Am. J. Public Health 1974, 64, 113–119.
16. Hanna, T.N.; Steenburg, S.D.; Rosenkrantz, A.B.; Pyatt, R.S., Jr.; Duszak, R., Jr.; Friedberg, E.B. Emerging Challenges and Opportunities in the Evolution of Teleradiology. AJR Am. J. Roentgenol. 2020, 215, 1411–1416.
17. Farahani, N.; Pantanowitz, L. Overview of Telepathology. Surg. Pathol. Clin. 2015, 8, 223–231.
18. Molinari, G.; Molinari, M.; Di Biase, M.; Brunetti, N.D. Telecardiology and its settings of application: An update. J. Telemed. Telecare 2018, 24, 373–381.
19. Baldoni, S.; Amenta, F.; Ricci, G. Telepharmacy services: Present status and future perspectives: A review. Medicina 2019, 55, 327.
20. De Cola, M.C.; Maresca, G.; D'Aleo, G.; Carnazza, L.; Giliberto, S.; Maggio, M.G.; Bramanti, A.; Calabrò, R.S. Teleassistance for frail elderly people: A usability and customer satisfaction study. Geriatr. Nurs. 2020, 41, 463–467.

21. Nittari, G.; Pirillo, I.; Amenta, F.; Ricci, G. The right to medical assistance for seafarers. Ethical and practical consequences of the introduction of Telemedicine to improve healthcare on board ships. Mar. Policy 2019, 106, 103525.
22. Acemoglu, A.; Peretti, G.; Trimarchi, M.; Hysenbelli, J.; Krieglstein, J.; Geraldes, A.; Deshpande, N.; Ceysens, P.; Caldwell, D.G.; Delsanto, M.; et al. Operating from a Distance: Robotic Vocal Cord 5G Telesurgery on a Cadaver. Ann. Intern. Med. 2020, 173, 940–941.
23. Chen, H.; Pan, X.; Yang, J.; Fan, J.; Qin, M.; Sun, H.; Liu, J.; Li, N.; Ting, D.; Chen, Y. Application of 5G Technology to Conduct Real-Time Teleretinal Laser Photocoagulation for the Treatment of Diabetic Retinopathy. JAMA Ophthalmol. 2021, 139, 975–982.