CHAPTER

10

Telecare within different specialties

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Introduction

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Telehealth applications enable the improvement of care, the flow of health information, and patient referral to healthcare providers. Use of telehealth facilitates access to specialized medical services, overcomes geographic barriers, reduces the time spent between diagnosis and therapy, and helps in the early identification of health problems, especially in developing countries.[211]

Modalities for health provision differ across the world in line with the consideration that there are different systems for health provision in various countries. In general, these systems are composed of healthcare facilities with different complexities and practices. In most countries, primary care facilities are the gateway to the patient in the health network, and from them, patients are referred for specialized care in clinics and hospitals or for lab tests and image exams. For example, let's imagine the following scenario:

CLINICAL CASE

Mrs. M.N.R., 42 years old, arrives at the Basic Care Unit of her neighborhood for a routine consultation. In the consultation the patient reports a different mole on their skin, which appeared a few months ago and has been increasing progressively. When examined by health professionals, they noticed

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an asymmetric spot and uneven edges. As a conduit, they were referred to a dermatologist for examination by a specialist. After the dermatologist's evaluation, the hypothesis is raised to skin cancer, and the patient is referred to an oncologist and referred for a biopsy. When the diagnosis of advanced skin cancer is confirmed, the specialist doctor directs the patient to surgery and appropriate chemotherapy. After the procedures the therapeutic course was prescribed, and the patient was referred to continue the postoperative care with the nursing team. When she was discharged from the hospital, she was referred to primary care, to evaluate the dressing and to monitor the side effects of chemotherapy, if they occur.

In the scenario described, telehealth can be present in all steps. The family doctor conducts a clinical discussion with a dermatologist by videoconference before referring the patient. The dermatologist suggests that a biopsy be carried out before receiving it in the office. The patient goes to the laboratory to do the biopsy, and at the time the images are sent by a telehealth platform for specialists to confirm the report (telediagnosis). Upon receiving the patient in the office, the dermatologist already has in hand by means of the electronic record of the patient all the clinical data of the first consultation and complementary examinations and, after discussion with the oncologist by videoconference, confirms that it is an aggressive skin cancer and recommends the immediate removal of the lesions, referring the patient to a hospital. During the procedure at the hospital, the surgery is transmitted by videoconference to other professionals (telesurgery) for an online second opinion. The video of the surgery is made available in virtual learning environment, so that students discuss the case with their academic preceptors (teleeducation). After the procedure the patient returns home and receives care from the surgical site by nurses, who monitor it through the smartphone with regular sending of images and vital signs (telemonitoring) and regular consultations by video call (teleconsultation). After discharge the patient returns to the dermatologist for follow-up. The outcome is forwarded to the family health doctor of the patient through a telehealth platform attaching all clinical data. From now on the family doctor will monitor with the patient the appearance of new lesions.

In summary, several practices or modalities of telehealth (teleconsultation, telediagnosis, telemonitoring, teleeducation, etc.) can be used during the care cycle, involving different technologies and actors. This diversity of telehealth modalities can be used in different contexts and specialties. Those who strongly use medical imaging, such as radiology, or at the other extreme that do not need a sophisticated technological infrastructure, such as psychiatry, are the ones that use telehealth the most.[212]

Teleradiology, for example, deals with the transmission of radiologic images (X-rays, tomography, and resonances) to have the radiology report by specialists in other places or even countries.[213]

Qualifying the patient for referral to specialized care along with remote delivery of test reports are among the possibilities of this technological advance in care delivery. Telecardiology, for example, facilitates the performance and evaluation of cardiac exams, the issuance of reports, and closure of diagnoses remotely by cardiologists, who are not physically present in the clinic or hospital where the examination was carried out.

As a result of these advances, telehealth or telemedicine allows a greater interaction between specialists, health services, the patient, and his family. It is important to emphasize that good health practices demand the adequate use of standards that allow the interoperability of systems and respect existing ethical and legal aspects.

Since specialties are concerned more with care, this chapter deals more with telemedicine along with occasional mention of training and teleeducation. For interest of the readers, at least in the United States, the specialties most likely to use direct physician-patient interaction are radiology (39.5%) followed by psychiatry(27.8%) and cardiology(24.1%),[214] while those using tele for contact with fellow professionals were emergency care(38.8%), pathologists (30.4%), and again radiologists (25.5%).

Teleradiology

Arjun Kalyanpur and Feroz Latif

Overview

Teleradiology is a word that today epitomizes innovation in healthcare technology and symbolizes efficiency in healthcare delivery. Due to the fact that radiologic imaging has for the most part been digital since approximately the turn of the millennium, the advantage of being able to transmit radiologic data over networks has made this technology innovation extremely valuable in bridging the gap between the demand for and supply of radiologist expertise. There is a critical global shortage of radiologists. In parallel, there is increasing utilization of medical imaging, driven by the increase in prevalence of lifestyle-related diseases requiring repeated imaging, increased speed and resolution of imaging technologies, and rising standards of care. Teleradiology, with its foundations based on digital imaging/DICOM, secure image encryption, and broadband telecommunications, provides a technology solution to bridge this gap. It has a major impact in decreasing report turnaround time and in improving service levels in the emergency setting. It has significant benefit in improving access of remote areas to high-quality and timely diagnostics. Standard protocols for communication levels between clinicians and radiologists ensure that service levels remain high, commensurate with on-site radiology. By using the centralized reading room coupled with the night-day model, radiologist productivity is increased, and healthcare costs can be reduced. Current and future trends including cloud, workflow analytics, and artificial intelligence are discussed.

Concepts and applications

Technology adoption in teleradiology today is much more than just for image transmission and report distribution in comparison with when commercial teleradiology started off about a decade and a half ago. This is seen by the industry embracing advances in healthcare information technology and information technology in general, in areas like cloud computing, machine learning, and artificial intelligence very early on.

Fig. 1 shows the flow of information in a typical form of teleradiology. Please note in Fig. 1 that not all components shown here are a must, nor is this an exhaustive list. Some of these devices may also be combined into a single device. For example, in some setups, a unified threat management (UTM) device could replace firewall and router.

The primary source of radiologic studies for teleradiology is digital imaging modalities such as digital X-ray [computed radiography (CR) or digital radiography (DR)], CT scanners, MRI scanners, ultrasound scanners, PET-CT scanners, gamma cameras, and angiographic data, which are typically forwarded to digital PACS systems.

DICOM versus Non-DICOM

Most of the newer modalities support DICOM standards and can communicate with any other device that conforms to DICOM standards. For older modalities that do not support DICOM, the images that could either be films or in digital form have to be converted to DICOM format before transmission to the teleradiology provider.

Secondary capture

Secondary capture images are images that are converted from a non-DICOM format to a modality independent DICOM format.[215] For legacy devices that use films, high-end digital scanners are used to digitize the films and convert them to DICOM. Some modalities like X-ray can also be retrofitted with computed radiography (CR) to enable DICOM output. For modalities that already have digital output in the form of images and videos, specialized software is available to convert them to DICOM format. This apart, documentation like prior reports, lab reports, and requisition, can be digitized and converted to DICOM so they are available to the radiologists along with the images while reading.

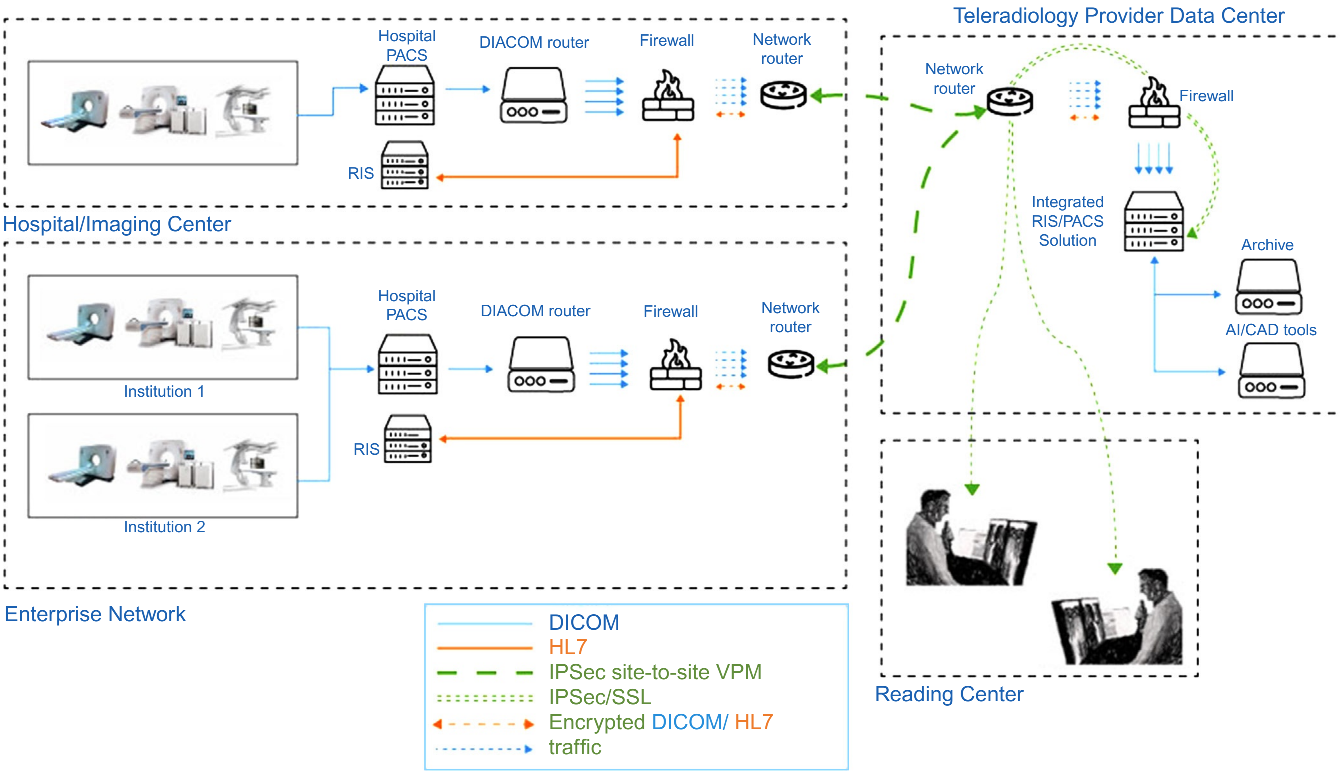

FIG. 1 Data flow in teleradiology.

Image transmission

The flow of images from the source to the teleradiology servers and further to the reading radiologists' workstation has to be fast, secure, and reliable. Several strategies are used to make this transmission smooth, staying within the boundaries of DICOM standards, which can be classified for this discussion into ones related to speed, security, availability, and integrity.

Speed

For emergent reads the turnaround time is usually within minutes, and it is critical that all images from the current study and any relevant prior examinations are made available to the reading radiologist at the shortest possible time. This is even more challenging as the amount of data produced by the newer generation of modalities keeps increasing. Speedy transmission of images is achieved in many ways. The most common method is to use compression. DICOM provides mechanisms for support of various compression algorithms, both lossy and lossless, such as JPEG2000, RLE, and even JPEG-LS. The type of compression protocol used can be found from the transfer syntax tag of the DICOM file. This built in support for compression in DICOM allows for the transfer of data between DICOM devices from different manufacturers.

Multithreaded or parallel transmission is commonly used to further speed up the transfer time in addition to compression. This is where specialized DICOM routers or gateways play an important role. Though most of the PACS support multithreaded transmission, these DICOM routers are designed to optimally utilize the available bandwidth and ensure fast and reliable transmission.

Many vendors provide proprietary algorithms to speed up transmission, but this would only work between nodes that use their software. The transmission of images between teleradiology servers and the image viewing software at the radiologist's workstation is again using DICOM protocols. In recent years, many vendors have implemented proprietary protocols of this to ensure all necessary images are available to the radiologists within seconds, if not minutes.

Security

As DICOM data contain a significant amount of metadata related to patient, study, etc., apart from the actual pixel data, ensuring confidentiality during transmission is a must, and many country- or region-specific laws need to be adhered to. HIPAA/HITECH act, rules, and regulations are one such set of regulatory compliance that needs to be achieved for teleradiology workflow in the United States of America.

This is achieved by ensuring all data in transit and at rest are encrypted and there are processes and procedures in place ensuring data security and availability only to authorized users. Usually an IPSec VPN tunnel is built between the hospital network and the teleradiology provider's datacenter. This ensures that all transmission is secured. DICOM also provides mechanism for encryption using the DICOM TLS protocol, usage of which is becoming common in the recent years.

Availability and integrity

Availability here refers to both the availability of data when required by an authorized user and also the availability of the teleradiology services whenever hospitals send studies for interpretation. For this, effective disaster recovery and business continuity plans and procedures have to be in place. Redundancy has to be built in for power, networks, application, database, etc. to ensure zero downtime.

It is important to maintain the integrity of the data and ensure accuracy and consistency of data. Data must remain intact during transit, and it must be ensured that it cannot be altered by unauthorized people.

Image management, viewers, and workflow

Management of images in terms of storage, further transmission to radiologists, and at times long-term archive is relatively challenging considering the huge amount of data. Design of this infrastructure should be guided by the information security availability, integrity, and confidentiality (AIC) triad. This is especially true in today's world of distributed computing and cloud architecture.

Once images are available on the radiologist's workstation, they can be viewed using DICOM viewers. These viewers can be in the form of a desktop application that can provide advanced features like 3D reconstruction, segmentation, and volume rendering or browser-based viewers that render the images in the web browser itself without having to install any software on the system. Web-based medical imaging is made possible by DICOMWeb, which is a DICOM standard and is a set of RESTful services. Some viewers are integrated with CAD/AI tools that can assist radiologists with a diagnosis on demand.

Analytics and AI tools also help with workflow. Tools that monitor a radiologist's report using natural language processing (NLP) and flag potential errors in laterality, body part, gender, etc. are one example on how technology can assist radiologists avoid discrepancies and improve efficiency. These tools can even alert the radiologist about calling the ordering physician to communicate critical findings.

Reports are usually distributed using HL7 messages. In the United States the practice of faxing back reports to the emergency department is still prevalent. Image transfer depends on the DICOM standard, which is already explained in Chapter 4.

Emergency applications

The origins of teleradiology lie in emergency diagnosis,[216] and till date the greatest impact of teleradiology has been in the area of medical emergency diagnosis. The clinical entities that are most greatly impacted by emergency teleradiology include the most life-threatening conditions[217–219] such as acute stroke, major trauma, pulmonary thromboembolism and aortic dissection, in all of which the cost of delayed diagnosis can be catastrophically high. By creating a framework whereby all emergency scans are reported within a 30-min timeframe, with further electronic prioritization of critical examinations as STAT priority, teleradiology has allowed for immediate diagnosis of such conditions, which in turn facilitates early intervention and superior patient outcomes.

The primary value proposition offered by emergency teleradiology is in decreasing report turnaround times. Within a radiology practice the implementation of teleradiology ensures rapid on-call response. These benefit both the patient and the treating physician, with special significance within emergency care.[220,221]

In the setting of emergency teleradiology, most communication occurs via two media, electronic and verbal (telephonic). The physical distance of the teleradiologist does not detract from the level of interaction.[219] Verbal communications of critical values are frequent in emergency teleradiology[222,223], given that the clinical spectrum is primarily directed towards acute care.

Teleradiology optimizes radiologist efficiency and diminishes healthcare costs

The practice of teleradiology is geared towards reporting efficiency, given that its primary goal is to generate and deliver an accurate and comprehensive report in the shortest possible time. This, in turn, promotes the most efficient usage of that most valuable commodity, radiologist's time, which has the potential to greatly decrease systemic healthcare costs.[224] Distribution of the caseload across the teleradiology enterprise ensures that radiologist time is most efficiently utilized, never wasted, while at the same time accommodating for spikes and troughs in the workload.

The reduction of healthcare costs by teleradiology can be facilitated by the day-night model wherein teleradiologists are geographically based diametrically across the globe from the hospitals where they provide services. This "follow the sun" model ensures that the radiologist does not need to stay awake at night, obviating the need for night shifts, which sometimes used to be every alternate week, thereby significantly enhancing radiologist productivity.[222,223] Other successful international models involve using radiologists who are of commensurate qualification in other geographic regions to reduce report turnaround time in a daytime outpatient clinic environment.[225]

Elective/subspecialty imaging: Another clinical application of teleradiology is in delivering specialized images to the subspecialist most qualified for their interpretation. For example, the imaging of a rare neurodegenerative condition in a newborn is best analyzed by subspecialist pediatric neuroradiologists, who are few in number worldwide. Similarly the use of telemammography can enhance the quality of a breast cancer detection program by directing images to a specialized mammographer. Virtual colonoscopy is another such specialized technique. Thus the use of teleradiology can be utilized to facilitate transfer of advanced imaging data to subspecialists and enhance reporting quality.[226–228]

Teleradiology services to remote areas

Deployment of teleradiology systems in remote and inaccessible locations where imaging equipment has been installed but no radiologist is available can be a lifesaver. With the exception of ultrasonography, which for regulatory and quality reasons requires physical presence of a sonographer, and interventional radiology, which for obvious reasons requires an onsite radiologist presence, all other radiologic modalities can be remotely interpreted. In remote locations, interpretation of radiologic images by qualified radiologists becomes challenging without teleradiology. In remote areas, such deployments done through public-private partnership between state governments and teleradiology providers can transform healthcare delivery.[219,229] Teleradiology can also be used to enhance screening programs for diseases of public health importance in endemic areas, as in the case of pulmonary tuberculosis.[230]

Virtual 3D Lab model: Postprocessing of imaging data is a labor-intensive and time-consuming task. If performed in a remote virtual environment, this can add efficiencies, reduce costs, and improve after hours turnaround.[231,232]

Quality and regulation

Teleradiology standards, such as those defined by the American College of Radiology, address the issues of image capture, transmission, review, and reporting while defining quality metrics for each of these processes.[233] Similarly the European Society of Radiology and separately the UK's Royal College of Radiologists have defined standards for the practice of teleradiology in their respective geographies.[234] Quality assurance driven by peer review is the keystone of good teleradiology practice.[235–237] The ACR RadPeer protocol presents a scoring framework for peer-review driven analysis of radiologist reporting quality.

Various standard organizations such as the US Joint Commission also regulate the practice of teleradiology. For international teleradiology, practice radiologists are required to be board certified (or recognized equivalent) and hold relevant licensure at the site of origin of images. The potential for malpractice litigation in the practice of teleradiology also requires appropriate insurance coverage that protects the practitioner at the site of image origin. As long as the regulatory requirements are complied with, the location of the interpreting radiologist is immaterial.[238]

Current and future trends

The cloud is a rapidly evolving phenomenon in recent years impacting most industries. Healthcare is no exception.[239,240] What this translates to in teleradiology is that patient images are leaving the server rooms of hospitals and beginning to reside on virtual networks of datacenters. This trend allows for three primary benefits: (a) extreme redundancy, as the images are distributed over a virtual network of servers that may be spread over different geographies, no longer a risk of the hospital PACS server "going down," traditionally a significant cause of loss of productivity in radiology departments worldwide; (b) decreased infrastructural costs that benefit smaller institutions/radiology practices—the cloud-based service can be utilized on a SAAS or a pay-per-use model, without high start-up infrastructural costs; and (c) most importantly, universal access to image data, without having to penetrate individual hospital firewalls, while still being HIPAA compliant. By this means the number of duplicate and unnecessary scans that are performed today can be drastically reduced, especially when patients are transferred from one healthcare facility to another.

Workflow and analytics: The teleradiology software of today has evolved considerably beyond routine image viewing and reporting features and incorporates new intelligent tools that route images seamlessly across networks to the most highly qualified radiologist, collaboration tools that allow a radiologist to interact online with a clinician and highlight lesions on radiologic images in a virtual environment, and analytic tools that allow every productivity and quality measure in an organization to be tracked in real-time mode.[241]

Mobile: New handheld devices with their high-resolution screens lend themselves to teleradiology on the go. Of greatest value for busy neurosurgeons, cardiologists, oncologists, etc., this allows physicians to quickly check their patient's images while commuting, between consultations, and even while on vacation, without having to drive to work and log in to a cumbersome workstation. For radiologists too, there are many evolving applications in the emergency arena, such as acute stroke and appendicitis, where mobile technologies can deliver benefit.[242–244]

E-training: To rapidly increase the pool of trained radiologists and address the current critical shortage of radiologists, drastic and innovative measures are needed, and e-training has proved to be one such game changer.[245] This is the educational tool of the future, with profound implications for healthcare education overall, not just in teleradiology, although given the virtualization and globalization of teleradiology, this is where e-training delivers maximum value.

Deep learning and artificial intelligence: The crux of all teleradiology is rapid report turnaround time (TAT).[244] The quality of a teleradiology provider is gauged by how tight TAT can be compressed, in the interest of enhancing patient care, while still maintaining the highest quality of interpretation. Tools that facilitate more speedy or accurate interpretation of images such as CAD, for example, for pulmonary embolism or lung nodules therefore can potentially enhance the teleradiology reporting process. A host of such algorithms driven by machine learning technologies, including tools for lesion detection, case prioritization, lesion segmentation and measurement, and report text generation, have recently been introduced, and many more are in development, which will be transformational in healthcare delivery as radiologist time and productivity will both be benefited. Teleradiology in that sense is at the dawn of a new era, as is all of clinical medicine.[246]

Since the beginning of teleradiology, a large number of benefits have been identified and described in the scientific literature.[216] Teleradiology is a branch of telehealth; its success is representative of the future of telehealth as a whole.

Telepathology

Sanjay Bedi

Overview

Pathology being an image rich specialty has immense possibilities of use of modern telecommunication technology to transfer images at a long distance to facilitate diagnosis education and research. Faster modes of connectivity and better resolution cameras have widened the possibilities. These may be a part of a complete patient record, that is, the EHR or components through mobile apps. Telepathology can be used for remotely rendering primary diagnoses, second-opinion consultations, quality assurance, education, and research purposes.[247]

Concepts and applications

Pathology as a subject involves gross specimens and microscopic images that are enhanced through various types of stains. It is hence largely image based and very amenable to digitalization. There is a patient history that is correlated with the images, and various diseases are accordingly diagnosed.

Telepathology mainly involves leveraging the enhanced capabilities provided by the better resolution provided by modern digital cameras with added maneuverability along with the ability to transfer the images over long distances provided by fast Internet connections mainly involving intraoperative telediagnosis, second-opinion teleconsultation, reference case archives, remote data and image processing, and quality assessment.

One of the earliest instances of telepathology took place in Boston in 1968. An academic pathologist, Dr. Ronald S. Weinstein, now described to be as the "father of telepathology" in a 1986 editorial outlined the actions that would be needed to create remote pathology diagnostic services. In Norway, Eide and Nordrum implemented the first sustainable clinical telepathology service in 1989.[13] This is still operational though decades have passed.

A digital slide is a classical whole slide image formed by imaging an entire physical (glass) slide, field by field, and then "knitting" these fields together to form a seamless continuous image that can be manipulated for morphometry, magnification, and color detection. One of the best known virtual slide collection is the "Juan Rosai's collection of surgical pathology seminars," curated by USCAP (see http://USCAP.org). However, now with availability of digital scanners, this is going to be more and more widespread, and multiple sites and institutions are making them available. With some display software, for example, aperio, one can scan and zoom around the image set.

Telepathology technologies

Digital pathology: It is an image-based information environment enabled by computer technology that allows for the management of information generated from a digital slide. Digital pathology is enabled in part by virtual microscopy, a method of capturing microscopic images and transmitting them over computer networks. This allows independent viewing of images by large numbers of people in diverse locations.

Pathology specimen slides are scanned, and high-resolution digital images are created for transmission. The image may be of an area of interest or larger like a whole slide imaging (WSI).

Telepathology enables a faster diagnosis. Patients in remote rural areas can be tested and diagnosed in a single trip to the nearest healthcare facility and obviate travel to a larger center, which is required often more than once, for example, for initial assessment and other investigation, on the date of the biopsy procedure, and later for results and ancillary procedures prior to definitive treatment. This delay in diagnosis can sometimes be fatal. This is not uncommon in traditional pathological systems due to logistical difficulties of coordinating the transfer of a patient.

The main categories of telepathology are as follows:

- Static image-based systems—images are captured from a digital camera connected to a microscope. An image area is selected and transmitted.
- Virtual slide systems—pathology specimen slides are scanned/videographed, and high-resolution digital images created for transmission.[1]
- Real-time systems—the operator remotely guides a robotically controlled motorized microscope. The consultant pathologist has complete control and can adjust the slide position, zoom, etc. so that the area of interest is brought under view and transmitted.
- Whole slide imaging (WSI)—digitization and scanning of a glass slide to generate a large sized digital image that can be viewed in parts in a manner that simulates microscopy.

Other benefits of telepathology are the following:

- Medical professionals in different locations can view images simultaneously and discuss diagnoses through teleconferencing.
- A doctor can consult with a pathologist who specializes in the patient's area of concern, such as liver pathology or lung pathology.
- A healthcare provider can get second opinions more easily.
- Patient data can be synchronized across various electronic health information systems.
- Once implemented a telepathology system is less expensive to operate than the traditional system.

Both telepathology and teleradiology are image-intensive branches. However, in teleradiology, the digital image is usually black and white, and hence transfer through electronic networks of at least the static image is easier due to smaller file size. On the other hand, in telepathology, the images on the microscope have to be captured using a special camera, and the point of lesion is sometimes not well identified at proper magnification. There is large color variation. Very-high-resolution images are needed to highlight the relevant color contrast and may also require different stains. The arrival of slide scanners, better cameras, higher bandwidth, and better viewing software, however, are allowing easier transfer of image transfers over long distances with substantial outcomes. Besides standard diagnostic work, the field of pathology education has especially benefited.

Mobile phones are now ubiquitous. With improved resolution of in-built cameras and better applications, a new world of mobile phone-based telepathology applications is emerging. Through specialized attachments, mobile cameras can easily capture images from microscopes and transmit them anywhere, allowing access to specialized opinion at point-of-care

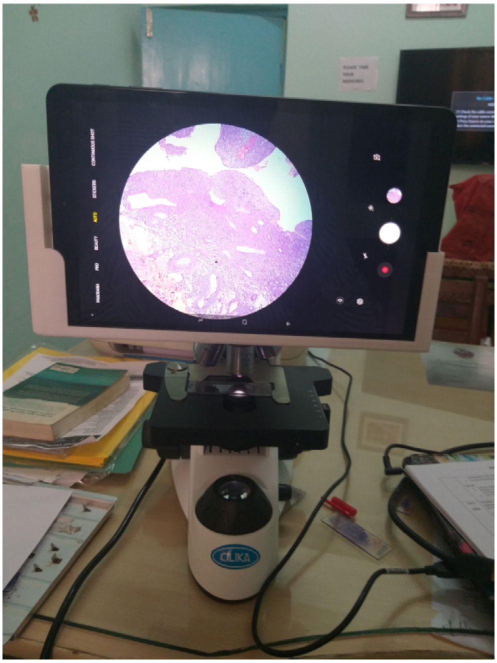

FIG. 2 An example of a modern microscope with a tablet replacing the eyepiece and providing all the functionality with global linkage via internet.

locations even in remote areas (Fig. 2). The equipment required is relatively inexpensive (except the phone). A request for consultation is possible from anywhere across the globe and include a simultaneous real-time correlation of both face to face and of the microscopic images. Social media tools like WhatsApp and Facebook are allowing pathology networks over the Internet as a real-time collaboration between multiple experts discussing pathology over mobile phones[248] (Fig. 2).

Even in low resource settings, better availability of high-speed networks is facilitating basic telepathology requirements through a simple microscope and a good mobile phone only. Image transfer can be done for the gross specimen and of the slides. Smart mobiles are making the previous investments in expensive systems, like those which allowed remote slide manipulation and zoom, infructuous.

Current and future trends

Artificial Intelligence (AI) is gradually making its entry into pathology with image processing software and automatic cell counters.[249] While this has been available for particle counting since long in hematology, now new arrivals on the scene are bringing image analyzers for tumor diagnosis in hematology, Pap smears, special stains and counting of nanoparticles in viral genomes.

Teleophthalmology

Manoj Rai Mehta

History

Ophthalmology was arguably the first branch of medicine to use technology of digital imaging and transferring of information through electronic communication channels for clinical and research application. It all started with the monitoring of retinal circulation during travel into space by astronauts during the Apollo missions.

Concepts and applications

Visual disability and blindness are major handicaps that disallow easy movement. Going for treatment is a challenge as they need to be accompanied by a caregiver. In a vast country like India where geographic terrain challenges are compounded by a skewed distribution of knowledge resources, teleophthalmology is proving to be a vital part of solution of taking high-quality medical care to the masses in areas with poor transport connectivity. Professional skills of paramedical personnel can be enhanced through online and offline interactions with skilled medical personnel and empower them to take certain decisions on ground zero and also plan timely referrals to the concerned lead facilities.

Key essential enablers

The **fundamental principles** of teleophthalmology are similar to other branches. These include acquisition of information by digital means, for example, an image through a slit lamp or fundus camera, transfer to a concerned person or organization, get relevant feedback, and use it to manage the patient. Besides a computer and connectivity, which can even be a smart mobile phone with inbuilt connectivity, one requires relevant software and hardware for acquisition of data. The available historical analog images can also be digitized before further transfer.

Hardware includes anterior and posterior segment cameras, tele-ERGs (electroretinography), adaptors for mobile phone cameras, etc. Software, including DICOM, may be required for transfer of images in different formats. A dedicated stand-alone or cloud-based server (public, private, or hybrid) is required for data storage. Additional software may be used for data retrieval and analysis. Mobile apps are going to be a game changer in due course.

Besides the traditional seeking of opinion from peer or expert group, which is important in anyone working alone, there is a special role for remote or otherwise poorly accessible areas. It can compensate for a shortfall of trained professionals. It can allow remote teaching and skill acquisition of not only the eye surgeon—whose work including surgery can be remotely supervised—but also the desired personnel in related fields such as ophthalmic assistants. Community-based care and research projects can be initiated, which includes the phenomenal outcomes of Aravind Eye Care System.[3]

Making a success of telecare for management of eye diseases depends on training. It also requires a challenging attitudinal change among the medical fraternity to break off the traditional mold. It is not an esoteric science and works like an adjuvant to the existing healthcare delivery system.

Case study 1[147]

Our team created a prototype model with scalable operations with the possibility of universal application (worldwide). This model was created under the aegis of National Program for Control of Blindness for the state of Mizoram as a tripartite agreement among the major stake holders:

(1) state health services
(2) provider of connectivity and support services
(3) Society for Administration of Telemedicine and Health Informatics (SATHI) as knowledge and lead operational partner

A hub-and-spoke model for the delivery of services was planned by the eye department of District Hospital Aizawl. The district hospital played a lead role in the planning and execution of surgeries and coordinated with the peripheral vision centers situated in geographically remote areas with limited access to surface transport.

Vision center concept and definition

The Vision Center (VC) was operationally headed by a paramedical person, who is trained in operating equipment and software; performs routine eye testing; dispenses, manufactures, and fits spectacle lenses; identifies and diagnoses main causes of decrease in vision; and specifically screens for cataract and diabetic retinopathy. VC was also nerve center for dissemination of education, information, and counseling of patients regarding eye care and common eye problems. The paramedical staff employed in the centers were from different streams—ophthalmic assistants, pharmacy graduates, and optometrists. A local project coordinator was stationed in Aizawl to take care of logistics and support and data collation. The Department of Ophthalmology at District Hospital Aizawl was identified for technical support and carrying out cataract surgeries. A tertiary care facility at New Delhi was identified for on- and offline consultation of specific cases as well.

Operational landmarks

- Setting up of VCs at chosen sites

  The sites were geographically remote but with a possibility of a fairly robust connectivity. The VC-in-charge staff were expected to live within the premises to ease travel and safety considerations as well. All VCs were provided with standardized equipment plan and operational manuals. Besides routine management and telecare, they also did school camps and surveys (Fig. 3). Machines for fitting spectacles lenses were also included in the program.
- Training of the VC-in-charge staff

  Perhaps the most crucial aspect of success was training of the staff. Induction training was held off-site in Delhi at a tertiary care eye center. A rigorous 15-day module was prepared to reorient the para medical staff towards learning and imbibing new set of skills.[146] A compressed clinical training capsule was created based primarily on pictorial teaching aids. There were short modules on general

FIG. 3 During the SATHI Project in Mizoram, eye camps done by the ophthalmic assistants helped create awareness as well as collect data.

management, accounting, social skills, and social marketing as well. A 2-day skill development workshop on cutting and fitting of spectacle lenses was arranged at the premises of a leading international manufacturing company. All the trainees were given extensive training on image capturing, running the software, and data transfer. Online training continued as well as refreshers courses during the project period.

- Kick-starting the program

  Two senior mentors from SATHI went to Aizawl to start the program. Three VCs were started immediately and three more within a fortnight.
- Monitoring and fine-tuning

  The program was monitored from the head office and periodic reports updated. SATHI mentors from Delhi visited from time to time to iron out operational problems and provide continual training and skill enhancement.

The total number of consultations in the first year was 3928, which crossed 10,000 over the 3 years of the sanctioned project period. The project was handed over to the state government after successful implementation of the pilot program. The project was accorded with an award for "Best Medical IT Project in the North East in 2014."

Case study 2

The Pan African Telemedicine Project[12] was conceived to help increase the skills of the medical fraternity of the African continent and to help exchange ideas between certain hospitals in Africa and tertiary care centers in India. Teleophthalmology was a part of this project. Teaching sessions on fluorescein angiography and management of diabetic retinopathy were organized for the University of Cairo, Egypt. Regular online consultations were arranged for Seychelles, Kenya; Tanzania, Egypt; and other countries on a mutually agreed timetable. Live streaming of surgeries was also a part of the program.

There are several teleophthalmology projects running concurrently in India. Sankara Nethralaya, Chennai; Arvind Hospital, Madurai; and LV Prasad Eye Institute, Hyderabad, are some of the leading organizations that run their own programs through their own dedicated staff.

Conclusion

Teleophthalmology is a "financially viable" adjuvant to the existing medical care delivery systems. However, it requires an innovative approach in the implementation with reorientation of the medical caregivers. From classical tenets of direct examination, one has to move towards image analysis, remote interview, and remotely controlled interventions.

Teledermatology

Keila Taciane Martins de Melo Oliveira and Magdala de Araújo Novaes

Overview

Teledermatology utilizes the application of ICT to allow on-site specialized doctor intervention, since it has a large visual component converted easily to a digital format. There are additional benefits to the traditional methods of dermatological assessment, as it supplies the health professional with diagnosis assistance, assessment of the progress of chronic conditions and therapeutic responses, tracking of increasing injuries, patients monitoring, and health promotion.

Concepts and applications

Like other specialties, teledermatology can obviate the need of on-site physician intervention for dermatological patients. However, besides being a remote care solution, it also helps add efficiency, practice, and lower costs. Furthermore, it has potential to stimulate health planning, clinical case discussions, and health research, besides providing dermatological care to populations in remote areas with poor access to in-person specialist consultations.

Teledermatology is the third largest user of telemedicine, behind teleradiology, and telepathology.[250] The methodology is sending digital images along with a complete anamnesis, and physical examination results to a dermatologist teleconsultant for opinion and feedback. Though store-and-forward or asynchronous mode is preferred, this can also be performed in real time using a videoconference between the doctor, the patient, and the teledermatologist. There are also hybrid teledermatology practices, which combine synchronous and asynchronous elements. Teledermatology has of late moved forward to mobile applications too. Visual examination can be combined with teledermatoscopy, which allows tracking and sorting of dermatological conditions, including malignancies (Fig. 4).

Although real-time teledermatology provides better potential to clarify doubts, this modality maybe inconvenient due to its need for coordination of visit timings and schedule. More than 80% of teledermatology programs in the United States use the asynchronous form. It provides greater accessibility and lowers service costs in the management of skin lesions with a reliability (diagnostic concordance) similar to synchronous systems.[251]

A component teledermatology is teledermoscopy, which has shown promise for screening of melanoma, besides allowing collaboration for diagnosis and management of various cutaneous lesions. Teledermoscopy

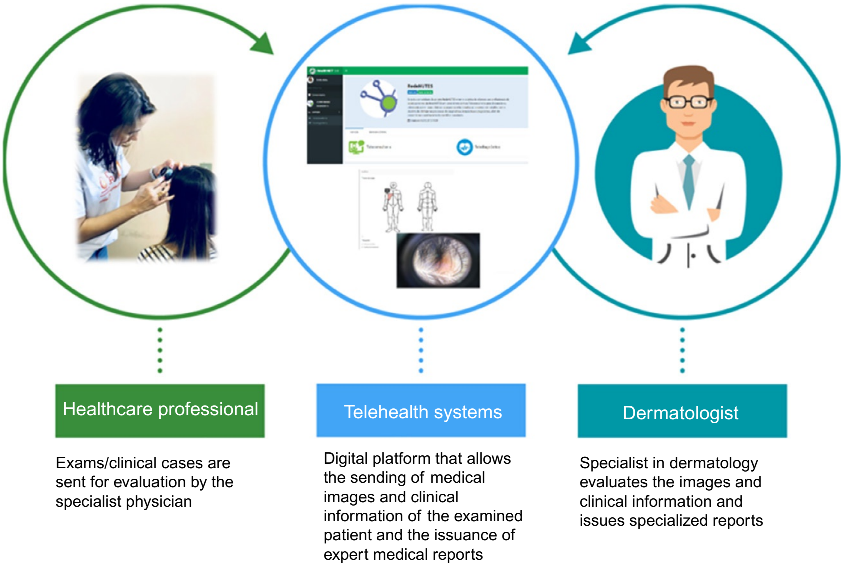

FIG. 4 Flowchart of information in a typical teledermatology setting.

combines conventional dermoscopy with digital image capture and allows long-term storage of pathological features. The physician gets to visualize and monitor changes in the morphological structures over time based on the stored content, allowing better correlation between clinical macroscopic examination and microscopic analysis. There can be further aggregation with concomitant use of teledermatopathology and telecytology, resulting in the increase of diagnosis accuracy. Considering economic and geographic factors, and as well as better clinical reasoning, teledermatology has gained increasing importance as an innovative method of professional aid besides being fundamental to enable wider health access.

Studies suggest that clinicians and teledermatologists have full or partial agreement in terms of diagnosis and injury management in over 75% of cases.[252] In pigmented skin lesions also, values of over 75% have been shown as per a concordance analysis between the pathological examination and teledermoscopy. This involved 43 pigmented skin lesions (11 melanomas, 23 melanocytic nevi, 3 basal cell carcinomas, 3 simple lentigines, and 2 seborrheic keratoses).[253]

In fact, teledermoscopy offered better diagnostic accuracy when compared with in-person dermatoscopic examination. In a recent study, teledermatology reached considerable levels of agreement when compared with standard attendance for clinical diagnosis of multiple skin lesions. Piccolo and colleagues compared the diagnosis of 66 pigmented skin lesions of macroimage and dermatoscopic with in-person clinical diagnosis. Another study found 91% correlation between teledermatology associated with teledermoscopy and on-site clinical evaluation of the lesions.[254] However, more clinical trials are needed.

Teledermatology requires a certain infrastructure to assure quality. Besides the technological infrastructure (the presence of computer and equipment for remote diagnostics at the health units; capture and storage of clinical data; and access to an adequate electronic system for teledermatology records, Internet, etc.), there are issues related to physical environment (guarantee of privacy, lighting, and comfort), and doctor-patient-teleconsultant relationships (guarantee of safety and confidentiality).

Finally the need for adequate training of the teledermatology professional regarding photodocumentation process cannot be overemphasized. This process aims to standardize the capture and storage of images targeting its quality and reliability to allow an assertive diagnosis to the teleconsultant.

Current and future trends

Teledermatology has emerged as an important support tool towards diagnosis and management of skin diseases, expansion of dermatologists' reach, reduction of waiting time between appointments, contribution to disease tracking, and health promotion.

It is also useful in the primary care for screening patients and qualifying patient's referrals, with a resultant reduction in unnecessary referrals. Recent research shows that this practice has the potential to reduce by 50% the number of specialized in-person consultations, with reports that over 85% of patients were satisfied, related to faster access to the expert without a need to spend on transportation.[250]

In 2010, 38% of the countries of the world had some kind of teledermatology program, and 30% had governmental agencies dedicated to this practice. Countries with higher economic power showed greater initiatives towards this. In the United States, teledermatology was developed by the army. And in around roughly two decades, the network has saved approximately US$ 30.4 million in travel costs. Since 2012, military teledermatologists from 40 locations have held about 40,000 consults.[255] Highly integrated systems, such as Kaiser Permanente in California, and countries where healthcare provision is the states' responsibility are far ahead in teledermatology.

In developing countries on the other hand, many patients never see a dermatologist, despite a disproportionate burden of skin disease. In sub-Saharan Africa, skin complaints represent up to 24% of medical visits, while only 14% of sub-Saharan African countries have trained dermatologists.[250]

Teledermatology can help in correcting the uneven distribution of dermatologists across the globe, mostly with the use of asynchronous teledermatology. It can lower costs and is very viable. An example is Africa Teledermatology Project, operating since 2007. It allows clinical discussions of neglected patients in Africa, by dermatologists from the United States, Europe, and Australia. Besides clinical services the project allows training of health professionals through teleeducation using local cases as examples.[255]

In Brazil a country of continental dimensions and a predominantly tropical climate, the population gets a high amount of sun exposure and increased risk of skin cancer. Teledermatology can play a key role in supporting cancer diagnostics and overcome the shortage and uneven distribution of specialists. Some reports are hereby provided.

The first such attempt was ***Telederma***, a joint project between the Hospital of the Federal University of Rio Grande do Sul (UFRGS) and the Telemedicine Department at the University of São Paulo (USP). 95.8% diagnostic agreement was achieved, boosting the promotion of new strategies, such as the teledermatology of Santa Catarina State Integrated Telemedicine and Telehealth System, Amazon Protection System, and Telemedhansen, focusing on leprosy diagnosis.[256] More recently, the Telehealth Center of the Hospital das Clínicas of the Federal University of Pernambuco has started teledermatology and teledermoscopy programs for the diagnosis of skin cancer for the patients from remote areas.

Many advances are yet to come with artificial intelligence and powerful image analysis software. These technologies associated with teledermatology can increase the quality and speed of diagnosis and, for example, perform predictive analyzes for the diagnosis of cancer, with greater long-term availability of patient data.

Telecardiology

Sunita Maheshwari, Praveen K., and Sejal Shah

Overview

An increasing incidence of heart disease accompanied by a chronic shortage of cardiologists, especially in rural and remote areas, makes telecardiology an exciting new method bridging the patient-cardiologist gap. Telecardiology, as of today, includes not only televideo consultations with a cardiologist but also technology platforms that allow transmission of electrocardiograms (ECGs), echocardiograms, and angiograms. In addition, the teleconsult with the cardiologist has moved beyond just audiovisual communication to the usage of the digital stethoscope so cardiologists can see the patient, hear their heart sounds, view their reports, and finally give them an opinion and recommend management.

Thus telecardiology has moved from the video consults a decade ago to a full-fledged cardiac assessment from afar. Cardiac diagnosis at a distance is the way of the future, and this subchapter aims to highlight the current status of telecardiology.

Concepts and applications

The Global Burden of Disease 2015 study estimated 422 million cases of cardiovascular diseases (CVD) in 2015, showing that CVD still remains a major cause of health loss for all regions of the world. Cardiovascular disease is the world's No. 1 killer with 17.5 million people dying each year from CVD, an estimated 31% of all deaths worldwide.[150,151] In poorer countries the effects of CVD are even worse. For example, the Indian subcontinent is home to 20% of the world`s population and among the regions with the highest burden of cardiovascular disease in the world. The Indian rural population and urban poor are facing a "double burden" with acute CVD illness in addition to a rapid growth in incidence of chronic disease. It is not just the poor who are affected. With unhealthy lifestyles, decreasing physical activity, increasing stress levels, and increasing intake of saturated fats and tobacco, the rise of CVDs is seen in the economically privileged population as well.[152,257]

Children, too, are afflicted with heart disease. With a global incidence of 1%,[153,154] nearly 180,000 children are born with heart defects each year in a country such as India. Of these, nearly 60,000 to 90,000 suffer from critical cardiac lesions requiring early intervention. Approximately 10% of present infant mortality in India may be accounted for by congenital heart diseases alone. The burden of rheumatic fever and rheumatic heart disease (RHD) currently falls disproportionately on children and young adults living in low-income countries with an incidence of an average of 0.9/1000 and accounting for 233,000 deaths annually.[258]

Where are the cardiologists? Based on a WHO report released in November 2013, the global health workforce shortage that was 7.2 million in 2013 is expected to reach 12.9 million by 2035. This is expected to have serious implications for the health of billions across the world, if not addressed. For instance, several countries in Asia and Africa face a challenge of shortage in trained healthcare personnel at all levels, especially in the rural areas. There is only about 1 doctor for every 1700 people in India, and it faces more than a 60% shortfall of specialists at the community health center level. There is a shortfall of 600,000 doctors and 1,000,000 nurses to reach the WHO recommendation of 1 doctor for every 1000 people. The situation is even worse when it comes to cardiologists. India trains only about 200 new cardiologists every year, an inadequate number, given the disease burden.[259,260] The same is true for many parts of Africa and the world.

There is a shortage of adequately trained specialists, technicians, and nurses for adult and pediatric cardiology to cater to noninvasive diagnosis and invasive and medical management. As a result, mortality from cardiovascular disease remains high.

One solution for the inequitable distribution of specialists is telecardiology. This encompasses teleechocardiography, tele-ECG, teleconsultations, and teleeducation. Imagine a cardiologist in a traffic jam in a major city utilizing his or her time to review an echocardiogram of a patient in a remote town, giving a diagnosis and directing therapy. With telecardiology, this is now possible. The advantage is that specialist advice is available for patients in remote areas eliminating the need and expense of unnecessary travel. Cardiac diagnosis at a distance is the way of the future.

Some telecardiology solutions are detailed in the succeeding text:

Digital stethoscope

Hearing the heart sounds is an integral part of cardiology and is now possible remotely as well. Studies have shown that the digital stethoscope may be more sensitive than the conventional stethoscope.[261] Using it for remote hearing makes it a valuable tool in telecardiology. Digital stethoscopes (Fig. 5) are compact electronic stethoscopes combining a high-resolution visual display with traditional auscultation. Using the device, medical professionals can perform dynamic remote auscultation. In addition, the visual waveforms presented in the format of the classical phonocardiogram can be transmitted to the specialist at the remote end for analysis and validation.

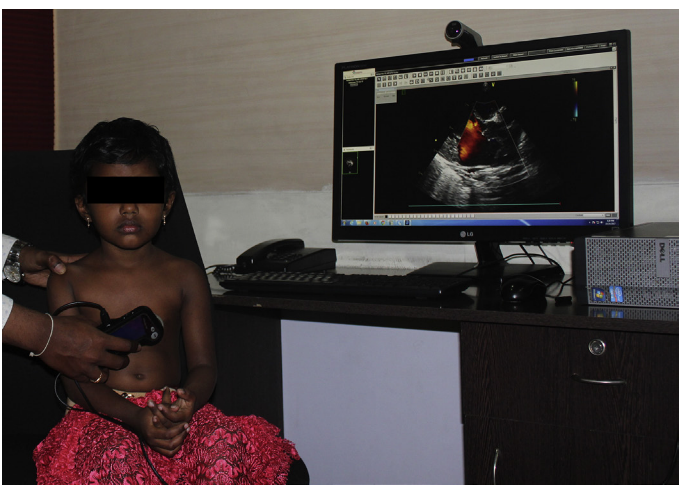

FIG. 5 Digital stethoscope.

Teleechocardiography

Echocardiograms, which are the most used diagnostic modality in cardiac structural and functional evaluation, need experts interpreting them to arrive at an accurate diagnosis. While technicians and physicians can be trained[262] to acquire echocardiographic images, many times a skilled cardiologist is needed to give an interpretation and plan management. Most recent echo machines are DICOM compliant, so transmission of these images is possible using a cardiovascular PACS. One issue in the transmission of echocardiogram images is its size as many are cine files, which requires robust compression techniques without losing the quality of the images.

CardioSpa (Telerad Tech, Bangalore) is one example of a cardiovascular PACS system, which has the ability to provide the cardiologist a seamless platform receiving all types of cardiac evaluations on a single platform from which they can interpret and report. The platform uses compression techniques, which brings the size of the images down by 40% for the ease of transmission that is then decompressed at the specialist end making teleecho possible without loss of image quality. The platform can also accept standard formats of ECG that can be transmitted through its workflow platform to be remotely read and reported by cardiologists. There are several other technology platforms available such as CARESTREAM Vue web-based PACS and UltraLinq. Many cardiac ultrasound manufacturers have developed dedicated cardiac workstations such as EchoPACS from GE and Q station from Philips.

Tele-ECG

An electrocardiogram (ECG) is the first line of diagnosis for cardiac diseases, and this has an important place in telecardiology.[156] ECG is a useful diagnostic tool in the diagnosis and management of ischemic heart disease and cardiac arrhythmia, and its availability in the primary care setting is now common.[262]

However, interpretational skills are not universally available at the primary care level, and obtaining rapid, accurate ECG reports with specialist input remains a challenge. The lack of reliable ECG testing and reporting under these circumstances may mean that some cardiac conditions are being missed. Routine availability of ECG interpretation at the primary care level can facilitate early referrals to secondary care while reducing unnecessary referrals where appropriate. This can be facilitated via telecardiology.

Transmission of ECG can be performed by either scanning the ECG and transmitting it or interfacing the ECG machine with a telecardiology software platform or to the existing cardiac PACS. There are now several products available in the market that can transmit ECG data directly from the device to the cloud, which can then be sent to the cardiologists on their smartphones for quick reporting. Research on low-cost devices for usage in poorer countries is imperative. In India the Bhabha Atomic Research Center has developed a 12 lead credit card-sized tele-ECG that can be connected via Bluetooth to a mobile or PC.[263] iMMi Life (www.immilife.com) a commercial venture has arrangements to send ECGs done by an empaneled doctor anywhere to five different cardiologists—including one in the vicinity to get a report on the possibility of myocardial infarction within minutes, so that emergency measures like aspirin and even streptokinase can be initiated.

Given the high prevalence of cardiovascular diseases and the limited number of cardiologists in small and remote towns in Brazil, telediagnosis of electrocardiogram is an important tool to face this shortage. The Brazilian Telehealth Program, since 2007, provides remote diagnostics service of electrocardiogram (tele-ECG) as the most important examination for clinical support for the primary care settings. Several states of the country offer this service using a 12-lead electrocardiogram, from large states like Minas Gerais with 853 towns to smaller states such as Pernambuco with 185 municipalities. In Minas Gerais, since the beginning of the service in 2005 until January 2016, 2.5 million ECGs were performed, in addition to 1024 Holter exams, and in Pernambuco, from 2016 to 2018, more than 21 thousand were performed[264] (Fig. 6).

Recently, tele-ECG has moved from the domain of hospitals and health centers directly to the patient home as well. Single-channel cardiac event recorder devices integrated into iPhones or Android smartphones allow

FIG. 6 Example of a tele-ECG performed at family health facility in a rural area. Telehealth Center, Clinics Hospital, UFPE, Brazil.

for automatic analysis, storage of ECG, and transmission to the patient's personal physician for review. The AliveCor Kardia Mobile ECG is one such FDA-approved device. Zoll, Philips, and other such companies also have products in this space.

Teleconsultation

Telemedicine technology can be leveraged to connect with people/providers who need a specialist consultation. Simple and traditional audio-video technology can help cardiac patients to reach out in time to the right people and make a significant difference in the outcomes. Although adoption of telemedicine technology has been relatively slow worldwide due to many factors, this is changing, and its increased usage will help obviate the shortage of specialist cardiologists in remote and rural parts of the world.

Teleteaching in cardiology

There is an acute shortage of teaching manpower in the existing medical colleges and training programs especially in Asia and Africa, particularly at the postgraduate level. There is a similar shortage of trained pediatric cardiologists available to interpret pediatric echoes and direct care, especially in rural and remote areas. The training of pediatric cardiologists is key to improving outcomes of children with heart disease.

Current and future trends

Telecardiology is an innovative solution that can help address the issue of specialist shortage for teaching, clinical diagnosis and disease management worldwide.

Telecardiology can thus be a bridge between the patients and the specialists or between the primary physician/caretaker and the specialists. It can be in the form of diagnosing a new illness, treating a cardiac illness, closely monitoring the progress, providing educational material, counseling, etc. The following are some situations wherein teleservices can make a difference in the healthcare scenario:

- New patient evaluation. With the help of clinical history and clinical examination including using a digital stethoscope, telecardiology can help the team make a tentative plan including decision about the investigations needed and counseling regarding the possible diagnosis.
- Follow up to review the investigations advised and confirm the diagnosis and advice regarding the management.
- Follow-up after surgical or catheter intervention to review clinical outcome.

- Basic support in a triage prior to shifting the patient to a tertiary cardiac center, thus ensuring a more stable patient and an improved outcome.
- Handling nonemergency situations like chest pain in a stable patient.
- Diagnosing critical heart disease in the antenatal period and helping in advising immediate postnatal care or reassuring an expectant mother.

Advantages of telecardiology

- Saves time: Early consultation with specialists becomes feasible, and an inbuilt appointment system reduces long waits at clinics or hospitals.
- Reduces travel time: No travel needed for the patient especially when mobilization is difficult like in elder patients or even sometimes doctors. Cardiologists increase their reach to patients not in their immediate geographic location.
- Helps improve quality: Improves the knowledge of the referring general physician and reduces missed diagnosis due to the lack of specialist input. It also can provide a platform for teaching the medical fraternity and reduce professional isolation. In contrast to telephonic conversation or email opinions, video communication helps the patient, and the specialist sees each other helping them to understand the nonverbal gestures like body language.

Teleobstetrics/prenatal telemedicine service

Danielle Santos Alves and Magdala de Araújo Novaes

Overview

Obstetric telemonitoring is a promising area in which real-time tracking of biomedical parameters aims to improve the quality of the assistance provided, reduce unnecessary referrals, improve education in health, and reduce maternal fetal morbidity and mortality. Beyond this, combined with a shared EHR, it could support more timely problem detection by health professionals, pregnant women, and family.

Concepts

Pregnancy is a period with significant physical, psychological, and social changes not only in a women's life but also of the companion and family. In this context, doubts and insecurities may appear.[265] In many countries, there is a lack of qualified professionals to provide minimal gestational follow-up as per WHO recommendations.[266,267] This is even more critical among women of low socioeconomic strata, rural zones, and places far from the specialized health centers.[268,269] Early detection of complications is crucial to avoid maternal and fetal repercussions. It is intrinsically related to an improvement in the quality of the care provided, starting from the first prenatal consultations until the postnatal period.[267,270–272]

In this way, teleobstetrics or a distant obstetric practice mediated by information and communications technologies could be an alternative to reduce the distance between primary care health professionals and specialists, as could help the pregnant women.

Applications

Teleobstetric applications can benefit different healthcare processes across different levels of care. Primary care professionals (PCPs) manage the patients at home and in health clinics, and their referral/follow-up by the specialist is required only for cases in which the PCP has some doubts, which could be that the pregnant woman presents with some complication or factors of risk, which are not within the primary level's attributions. Many strategies are used: smartphone applications for health education, assistant support, "gestational daily," high-risk pregnancy monitored by devices who collect biomedical parameters (e.g., maternal and fetal cardiac frequency), among others.

Obstetric telemonitoring is understood by the exchange of information in the monitoring of maternal and fetal parameters that occurs in a virtual way (i.e., by devices, desktops, and/or smartphones).[273,274] It aims to improve healthcare, provide early detection of injuries, ensure local intervention before dislocation or even hospitalization,[273] and reduce unnecessary referrals, besides providing education in health and reduction of maternal and fetal morbidity and mortality. Obstetric telemonitoring is seen as an efficient alternative to decrease the distances between health professionals in primary care and specialists, ensure quality referrals, reduce costs as well as unnecessary hospitalization.[266,269,275–277]

The use of "gestational daily" could facilitate the information exchange between health professional and pregnant women, besides to stimulate the more timely access of healthcare by the women.[274] Some applications are related to health education, recommending the women's "active protagonism" in healthcare actions.[278,279]

Another advance is in the use of wireless devices to capture and track home-based data through smartphone applications which is then shared with the specialist. These include bracelets with sensors to get the vital signs, telephone oximeter, electrodes for monitoring uterine contractions, detection and reading of fetal heart rate, and portable urine analyzer.[280–283]

However, one limiting factor for the use of this technology is the lack of access to all of these devices for the less affording populations, due to high costs (relative to income). An additional issue is that the applications currently in use concentrate on the prenatal period. Few applications exist in relation to labor or the postpartum period. The few identified are related to the uterine contractions during the labor and breastfeeding recommendations. Important parameters like fetal heart rate, maternal BP, and fetal movement are not typically captured.

Global experiences in gestational telemonitoring

In a systematic review of the literature, successful follow-up teleobstetric experiences of women and relatives were observed in developed countries[281,284] with less experience in developing countries.[266,269,273,285] Several articles have proposed new technologies for home-based monitoring during pregnancy.[284,286]

In Australia a study was carried out using a portable respiratory device for the control and monitoring of asthma and other respiratory problems in pregnant women, found good results, and reduction in the number of cases of more severe seizures by early detection.[287] In California (the United States),[280] detections of changes in the urine (used in the preeclampsia/eclampsia anamnesis) were performed using a portable monitor within an iPad. In Turin, Italy, an application has been developed that collects and stores data on the daily life habits of pregnant women (diet, physical activity, and hydration), allowing healthcare professionals to remotely monitor and act when necessary.[279]

A study carried out in South Africa[286] works as an example of experiences in developing countries for the early detection and treatment of preeclampsia during home visits for pregnant women. Collected clinical data was translated into a scale of points, which could offer a possible diagnosis with options of therapeutic interventions. In Pakistan an application has been developed that monitors information from pregnant women and issues medication and healthcare alarms.[266]

Different devices with a diversity of parameters have been evaluated. These include monitoring the respiratory pattern of pregnant woman,[287] urinary alterations,[280] blood pressure, and oximetry[286] as well as uterine contractions.[282] A study conducted in the Netherlands conducted global gestational analysis wherein uterine contractions, fetal heartbeat, maternal heart rate, and fetal electrocardiogram were evaluated.[284]

Regarding fetal follow-up, it has been observed that there is less diversity of equipment for this function, with a focus only on the baby's heart rate,[284,288] leaving gaps regarding aspects such as evaluation of fetal movement and fetal biophysical profile. The main features preferred for fetal heart monitoring included special acoustic sensor to capture the

BCF, USG doppler,[288] portable electrodes for detection of BCF, and portable monitor for cardiotocography.[284]

Current and future trends

Many women seek information and advice on the Internet or via "pregnancy help" applications at the major virtual stores (Google, Apple, Amazon, etc.). But this information is not always based on scientific evidence.[272] It is important to develop virtual and safe environments for the access of information by pregnant women and family members. A worldwide trend is the use of mobile personal health record (mPHR) for health interventions, since smartphones have advanced technological capabilities and a growing ubiquity of use in the health profession.[274,277]

Preliminary cost-benefit studies have obtained encouraging results in reducing expenses for health provision with lower levels of complexity and are closer to users. Some advances such as the use of mobile devices connected to smartphones are restricted to developed countries. There are not enough reports from developing countries where maternal and fetal morbidity and mortality rates are higher.

Regarding fetal health, there have been weaknesses in the follow-up. Better correlation with maternal health is required for complete fetal evaluation. It is essential that both be monitored together. All gestational aspects need to be connected in the developed applications.

The primary focus of most studies has been largely restricted to gestation with few reports focusing on childbirth and the puerperium phases. These too need to be better researched, since although the prenatal period is critical and easy to perform, follow-up period also needs to be addressed since there is a high incidence of complications and mortality in relation to childbirth and puerperium.

It is necessary to address the entire network of care to pregnant women, especially for the portion of the population that faces the problem of access to basic health services. From a structuring of the service to holistic monitoring, integrating the different levels and services of healthcare can bring a paradigm change in obstetric and neonatal care.

Telecare in geriatrics

Gunnar Hartvigsen

Overview

Telecare is about getting access to the patient and/or his/her data from a remote location to support independent living, often in the patient's own home. The population of elderly, in particular, those suffering from chronic disease,[289] has increased, and often multimorbidity has increased need for care on a longterm basis. However, better as well as a bigger range of telecare equipment is available.[290] Simultaneously, limited access to healthcare personnel makes telecare a key component in offering adequate healthcare services to the population at large.

Applications

Telecare has gradually been accepted as an important tool within contemporary 21st century healthcare systems. Lack of clinical evidence, however, is a problem inhibiting widespread use. One reason for the unavailability of evidence is that it is technology dependent, and many components are commercial off-the-shelf (COTS) products. There is an inherent conflict of interest leading to refusal of publications.

Another reason is that many advances are only published as internal reports and/or in national languages. One example is the telecare project in Alta, Norway, in 1999.[13] The project was initiated to test how future mobile communication could improve home care services. To test this a broadband radio network was established, and a mobile version of an electronic health record (EHR) was implemented. This enabled access to the central EHR with the possibility of sending messages to community doctors, dermatologists, and pharmacies.

Both the home care nurses and the patients' experiences were positive. The nurses were very pleased with the possibility of updating the EHR together with the patients in the patients' homes. The easy access to information reduced potential problems of simultaneously memorizing several things with a reduced need for memo systems and thereby potential sources for errors. Another experience was that the patients could take part in the nurses reporting in a positive way. By taking pictures of patients' ulcers, the nurses could document the progress of the ulcer treatment. The solution also supported joint study of ulcer pictures. This also improved the nurses' knowledge of ulcer treatment. With email service the nurses did not have to keep waiting on the telephone. Instead, they could send requests asynchronously, and the doctors could respond after completing their other consultations. In addition, the email contact with the local pharmacy was positive. Majority of these requests were questions regarding prescriptions.[13]

Similar telecare services can be successfully installed in nursing homes. Online access by nursing homes can improve healthcare support for the elderly. When Kroken nursing home and two assisted living homes in Tromsø, Norway, in 2003 were connected to the Norwegian Healthnet, it became the first online institution for elderly in Norway.[291] The goal of the Kroken project was to connect a part of the care sector in Tromsø municipality to the Norwegian Healthnet and to offer the staff at Kroken nursing home the same services as those that had been offered within specialized healthcare. The project established electronic communication between nurses and supervisory physicians to exchange questions and answers via secure email. In addition, it was an established electronic communication between the nursing home and the university hospital for answers to lab tests and received discharge summaries. The experiences were positive. Both the staff at Kroken and the regulatory doctors reported that such a service was required. They preferred to use email instead of telephone to contact the regulatory doctors in between regular visits. A limited negative effect was the need to change the routines and to learn to use the new tools.

A more recent example of telegeriatrics in small rural hospitals describes how a telegeriatric service model can be used to overcome the long distance from hospitals with geriatrician-supported comprehensive geriatric assessment and coordinated subacute care. The components of this service included[292]

- geriatrician consulting done from remote location using wireless, mobile, high-definition videoconferencing
- a trained host nurse at the rural site
- structured geriatric assessment configured on a web-based clinical decision support system
- routine weekly virtual rounds
- support from a local multidisciplinary team that was established to overcome these barriers"

The earlier model was found feasible and sustainable even beyond the study period. Based on their findings, Gray et al.[292] conclude that their telegeriatric service model seems appropriate for use in small rural hospitals.

Teleoncology

Mariana Boulitreau Siqueira Campos Barros, Magaly Bushatsky, and Magdala de Araújo Novaes

Overview

Cancer is one of the leading causes of morbidity and mortality worldwide, with about 14 million new cases in 2012.[293] It was responsible for 8.8 million deaths in 2015, and with nearly one in six deaths due to neoplasms, it is the second leading cause of death globally. For the next two decades, the incidence is expected to rise by about 70%.[294] Teleoncology, defined as telehealth applied to oncology, emerges as a strong strategy to narrow the gap between oncology specialists and other health professionals by providing support in genetic counseling, surgeries, radiation, bone marrow transplantation, palliative care, and the construction of a therapeutic project with a multiprofessional approach, sharing images of examinations or slides of pathology by teleconference, as well as professional oncologists and patients, by teleconsultations for chemotherapy administration supervision or oral medications, nutritional or emotional support.[295,296]

Concepts and applications

The first teleoncology connection on record, occurred in 1995, when an oncologist working in the University of Kansas in the United States, was linked to a rural medical center located more than 250 miles away.[297]

In the United States, in 2013 and 2014, a randomized controlled study of prostate cancer patients after radical prostatectomy compared consultations conducted through telehealth with office visits and found equivalent efficiency between these variables: waiting time, total time dedicated to care, and "face time." There was also equivalent satisfaction between the patient and the oncologist; however, whether the cost reduction between the two groups is significant, needs further analysis.[298]

Currently, there is a diversity of models for the teleoncology practice in health services, which we highlight

- Face-to-face visits complemented by teleoncology for the consultation and supervision of the chemotherapy administration.
- Consultation and supervision of oral medicines by telemonitoring. Cancer patients were given the option of electronic monitoring of their symptoms so that health problems could be resolved quickly and effectively through an electronic device called a "health buddy."[a] This device can be connected to phone or mobile applications giving them immediate access to their care coordinators.
- Replacement of face-to-face visits by teleconsultations for evaluation and chemotherapy administration supervision in home care (Fig. 7).
- Discussions of clinical cases in meetings of multiprofessional team, by web or videoconference.[299]
- Training of health professionals' experts and those in remote locations through videoconference or distance learning platforms.

As per protocol, teleoncology is only adopted after the initial assessment visit and preferably once first dose of chemotherapy has been delivered by the tertiary care centers. It is only after these first contacts and with the greatest engagement of the patient in their care that remote practices

[a] Source: https://wmhin.org/wp-content/uploads/2016/02/Solway_Health-Buddy_WIN2016.pdf.

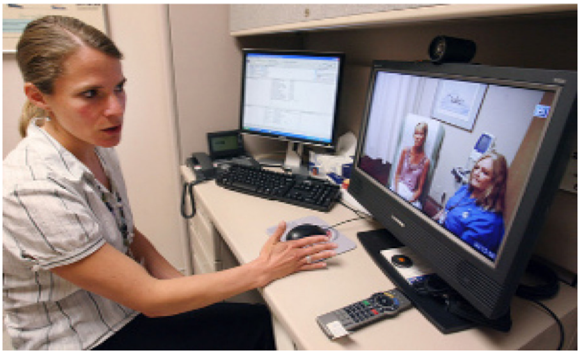

FIG. 7 Teleoncology for evaluation and chemotherapy administration supervision in home care. *From https://www.saltlakecity.va.gov/features/The_next_step_in_tele-health.asp.*

are initiated. Subsequent care is through tele, preferably from the patient's own home, but always as an accompaniment to traditional care depending on the patient's criticality.[300]

After consent for treatment a brief overview of telemedicine is explained to the patient. Once the patient feels familiar with the system, the specialist continues with the anamnesis, assisted by the doctor at the remote location with physical examination, review of X-rays, and laboratory results, and finally discussing diagnosis and treatment plan.[297]

While the specialist provides clinical supervision of patient care, teleoncology practice is a collaborative effort from the outset when local health staff identify and consult patients who need special care. In addition, the role of community nurses is critical to effective and efficient coordination of patient care. The clinical support, education, and management of medicines provided by telehealth nurses aim to increase drug adherence, decrease readmission rates, and prevent chronic complications of the disease.[297]

At the cancer center in Townsville, Australia, from 2007 to 2009, oncologists use videoconferencing to perform follow-up services and specialized consultations for 20 other rural hospitals. In this model, when the patient is evaluated to begin chemotherapy treatment, oncologists prescribe and send the telehealth care plan to the places where chemotherapy and therapy are administered by competent nurses.[300]

Under telesupervision, one needs to understand adopted strategies to train doctors, nurses, and health interns who work far from referral centers or for training in modern techniques of care. However, in addition to videoconferencing, platforms for asynchronous storage and transmission and mobile applications can and should also be used. These strategies contribute to the early detection of cancer and professional updates regarding new clinical protocols.[300]

An example of adopting multiple models simultaneously was carried out in Brazil in the years 2015–17. A quasiexperimental study used teleoncology in childhood cancer prevention and in the regulation of suspected cases for referral centers, with telehealth as a driving force for the local healthcare network. Over 4 weeks, PCPs participated in a videoconference course on early diagnosis of pediatric cancer. After this educational intervention, they were encouraged to refer the suspicious clinical cases to the higher unit. In 2 years, eight teleconsultations were generated, four of which were clinical cases and had their referrals qualified, none needed to be regulated to the reference unit, ruling out the diagnostic hypothesis of cancer.[264]

Current and future trends

Early detection of cancer favors a greater chance of cure, survival, and quality of life for the patient. Stimulating the screening of some types of cancer, such as breast cancer and cervical cancer, for example, should be performed at all levels of healthcare. Likewise, caring for patients already diagnosed requires close monitoring of the team, and psychological aspects need to be considered. Teleoncology presents itself as a strong strategy to face these challenges.

The use of new technologies such as cloud-based services and mobile technologies is increasing. These services facilitate remote practices and bring together providers, professionals, and patients, but the adoption of well-established clinical protocols associated with safety, ethical, and legal issues in the practice of teleoncology is necessary.

Other relevant aspects are the continuous training of the professionals involved in the care and the costs involved in the treatment. In many countries, access to chemotherapy or other care is limited, so the associated use of teleoncology to traditional services can improve patient care conditions.

There is overall population growth, particularly of the aged, contributing to a rising contribution of neoplasms in the global morbidity and mortality scenario. The question arises whether existing models of care in various global health systems are prepared to provide sufficient access to preventive, curative, rehabilitative, and palliative aspects of oncology-associated care and also able to meet the growing demand. Without teleoncology, it is unlikely that dedicated cancer units can manage all categories of patients, that is, those needing a firm diagnosis and those needing treatment or palliative care for various types of neoplasia.

Thus it is important to implement a line of care for suspected cases of cancer, with teleoncology as a strengthening of the reference network and counter reference.[264]

Teleneurology

Shivani Ghoshal

Overview

Neurology has changed remarkably over the last 20 years, and there is an increasing demand for timely neurological evaluation in both acute and outpatient settings. The disparity between the need for neurologists and the availability of local neurological care is growing, particularly in rural and underserved areas. Teleneurology is a technologically feasible solution that allows neurological expertise to be delivered to remote locations to supplement or replace in-person neurological care and bridge the current gap between neurological supply and clinical demand. As it has developed, teleneurology serves as a viable practice extension whether practicing in an inpatient setting—as a neurohospitalist, stroke specialist, or neurointensivist—or as an outpatient neurologist.

Concepts and applications

Teleneurology has demonstrated feasibility in evaluating general and subspecialty neurology outpatients including those with dementia, headache, epilepsy, movement disorders, neuroophthalmologic disorders, neurocritical care issues, and stroke.

Telestroke is a subset of teleneurology that focuses on the evaluation of patients with acute stroke syndromes for possible IV tPA administration or other emergency stroke treatments such as interventional clot retrieval. In the current standards of practice in neurological care, the decision to treat patients with acute ischemic stroke with IV tPA must be made within 3–4.5 h of symptom onset; more timely treatment equates to better patient outcomes and less complications from medication administration. Availability of neurological expertise is crucial to this process; in a survey of 278 ED physicians from 24 hospitals, 65% of physicians reported feeling uncomfortable giving IV rtPA without a consultation.[301]

Telestroke evaluations can be performed with a videoconferencing camera or using a complex, third-party robotic device that integrates videoconferencing with advanced optics and neuroimaging integration. In several clinical studies, telestroke has shown both feasibility and safety, as well as comparable interrater reliability of the virtual and bedside neurological examinations.[302] Notably, patients treated with IV tPA after remote evaluation by telestroke had outcomes that were similar to patients who were treated by bedside evaluation[303]; earlier treatment with IV tPA resulted in a greater probability of good functional outcome.[304] From its implementation, telestroke services have increased thrombolysis treatment rates, improved clinical outcomes, and cultivated opportunities for referring centers to gain stroke center designation status.

Teleneurocritical care

Not infrequently, critically ill patients require urgent consultations for neurological problems other than stroke, though the supply of neurologists and specialized staff trained specifically in neurocritical care issues are few. The critical care unit is another domain where robotic telepresence or teleneurology serves to monitor critically ill patients, evaluate unexplained coma, and respond quickly to unstable patients. Availability of remote monitoring of patients in the intensive care unit (ICU) by telemedicine enables ICUs without availability of neurocritical care expertise to expand and improve coverage, especially in disorders such as coma and status epilepticus, which may require continuous EEG monitoring. Disorders such as spinal cord injury, severe traumatic brain injury, and subarachnoid hemorrhage show better patient outcomes with specialized expertise and early intervention.[305] A metaanalysis of studies that compared outcomes before and after instituting tele-ICU found reductions in patient mortality and hospital lengths of stay with tele-ICU.[306] In another single-center study of a large academic medical center involving 6290 patients, the application of tele-ICU showed improved patient outcomes and fewer medical errors and greater adherence to best practices.[307]

Outpatient teleneurology

Though teleneurology is best known for its impact as telestroke in emergency room and inpatient settings, teleneurology has been successfully applied to outpatient evaluation of many nonacute neurological conditions as well. Often, teleneurology is useful for follow-up visits after an initial in-person evaluation. Remote evaluation of movement disorders, multiple sclerosis, epilepsy, headache, and dementia is feasible and regularly performed. In a neurological patient for whom mobility is impaired or travel is difficult, this may help with long-term follow-up and treatment adherence. In particular for patients with Parkinson's disease (PD), several large networks have successfully cared for patients with PD by telemedicine; remote standardized assessment of motor function in PD is well accepted and correlates well with in-person evaluation.[308]

Continuing medical education and research

Teleneurology may be helpful for purposes beyond traditional patient care. Educational opportunities for both patients and healthcare professionals alike can be provided over a telemedicine source. Through telemedicine, in rural areas, local neurologists may benefit from consultation with subspecialists at tertiary care hospitals and from a wider network of community neurologists. By establishing a wider network of neurologists in practical communication, teleneurology may help improve standardized examinations used in remote monitoring and care.[304]

Future trends

Teleneurology reflects opportunities for neurologists to help bridge the supply and demand mismatch between available providers and the clinical need. Though teleneurology is best known currently for its efforts in stroke care, teleneurology is rapidly growing beyond telestroke to supply neurological services to rural hospitals and areas with limited or no neurological coverage, from inpatient, to outpatient, to critical care services. The extension of teleneurology may be helpful for remote recruitment of patients into acute stroke and critical care treatment trials and study follow-up of recruited patients.

Telestroke remains one of the best-studied and validated models for telemedicine, aided by stroke's standardized National Institutes of Health Stroke Scale (NIHSS) metric for examinations. The variability that often accompanies subjective signs in neurological disorders may require further research to better standardize teleexamination and symptom assessment. More studies are needed to explore the limits of telemedicine for neurological diagnoses other than stroke. Standardized scales for neurological examination will likely improve both utilization and interrater reliability within teleneurology.

Telediabetes

Gunnar Hartvigsen

Telediabetes is one of several telemedicine services that has proven to improve patients' health and the delivery of health services to people with diabetes.

Concepts and applications

The main goal of diabetes treatment is to optimize glycemic control for which, over the years, clinical studies have suggested a number of possible action points, including

- increased frequency of visits to a multidisciplinary diabetes clinic resulted in lower HbA1C[309]
- more frequent regulations of insulin dosage[310]
- continuing training of people with diabetes[311]
- improved diabetes education[312]

In 2004 a report about a 10-year-old telediabetes program found sustainability with three indicators of success[313]:

- the administration took a long-term view of the value of the telemedicine service;

- Telediabetes enabled structured use of staff time and facilities;
- Service delivery followed national diabetes standards and a well-defined cycle of care within a long-term quality improvement program.

According to the International Diabetes Federation,[314] we still have a long way to go before every diabetes patient has reached his/her treatment goals.

A 2015 review of telemedicine intervention in the management of diabetes (telediabetes), gestational diabetes, and diabetic retinopathy identified 73 articles, published between 2005 and 2013, that met the criteria for inclusion in the final analysis. They looked for evidence based on the following factors: feasibility/acceptance, intermediate outcomes (e.g., the use of service and screening compliance), and health outcomes (control of glycemic level, lipids, body weight, and physical activity.)[315]

Variations in the definition of telediabetes and diabetes subtype, setting, technology, staffing, duration, frequency, and target population existed, as also differences in the measurement of outcomes. However, the authors did find evidence that telemonitoring and telescreening had positive effects in glycemic control and reduction in body weight and contributed to an increase of physical exercise. Another effect of telediabetes was its potential for changing diabetes control and prevention behaviors, in particular for type 2 and gestational diabetes. The review concluded that "there is strong and consistent evidence of improved glycemic control among persons with type 2 and gestational diabetes as well as effective screening and monitoring of diabetic retinopathy."

Several studies have proven that telediabetes is equivalent to clinical visits.[316–318] One paper reported that 79% of the patients did not find problems related to not meeting the physician in real life.[319]

Self-management of diabetes is a complex task, which involves maintaining healthy blood glucose levels through a balanced diet, physical activity, and medication (insulin) and success depends on extensive monitoring of these parameters.[13] A large number of tools have been developed for self-management of diabetes.[320,321] We also have experienced that patient groups have taken initiatives themselves to develop advanced tools that are not (commercially) available.[322]

One of these interactive mobile tools is the Norwegian Few Touch application/the Diabetes Diary/"Diabetesdagboka," to support people with type 1 and type 2 diabetes to manage their health.[323] Blood glucose and physical activity data is captured wirelessly from sensors, and tagged with nutrition data and insulin usage through a simple user interface. The data is processed and presented to the user. Users can easily view progression of daily blood glucose levels, their physical activity, and how they are doing as compared with their set goals for blood glucose level, diet, and physical activity.

An important design goal has been to present the data in a simple and user-friendly manner. To optimize usability, blood glucose and physical exercise data are transferred automatically to the user's smartphone running the Diabetes Diary. Users may choose to record only the time of their meals, or they can easily add a rough description of what kind of food they had. The user can also find information about diabetes and some practical advice. A model has also been developed to transfer the health values to an electronic health record (EHR) or make the data from the Diabetes Diary available for healthcare personnel.[321]

The functionality of the Few Touch application is described[323]:

- *Automatic data transfer*. To capture blood glucose data and exercise data, the Few Touch application uses a blood glucose meter and a step counter. To optimize usability, data from these sensors is automatically transferred using a "no-touch" principle. This means that the users do not need to initiate data transfer from the sensors; the sensors set up short-range communication to the smartphone automatically. A more recent version of the diary includes the possibility to record data from CGMs.
- *Entry of nutrition data*. The users can record their food intake using two different levels of detail: (a) a simple choice of the kind of meal (breakfast, lunch, etc.) or (b) choosing the kind of food they eat (bread, pasta, etc.). This design has been chosen to make the data entry process as easy as possible, enabling the user to decide on the level of detail to record. Thus the process requires only two or three screen touch or navigation moves. Summary reports appear after each entry, for example, the current status of their nutrition habits.
- *Motivational information*. By including daily tips and information related to practical situations, that is, information that is sufficiently "down to earth," the aim is to motivate and educate the user. Newer functionality includes the possibility to reflect upon the development of the glucose level.

Current and futures trends

Since 2008 nutrition has become a focus area for diabetes control. A major issue is identifying the appropriate nutritional value of food items, for example, those typically found in Norwegian supermarkets.

By the use of the included camera, the users can take pictures of their meal for later examination. In a pilot study,[324] the image included the following information: time, date, activity, blood glucose measurements before and after the meal, the insulin dosage (in insulin units), and optional comments from the user. A Diabetes Diary has been used in several clinical studies.[325,326] User feedback from the 6-month user intervention demonstrated good usability of the tested system, and several of the participants adjusted their medication, food habits, and/or physical activity.[323]

Of the five different functionalities, the cohort (of initial users) considered the BG sensor system the best.

In 2015 the former Few Touch Application was renamed “Diabetesdagboka” (Norwegian) or “Diabetes Diary” (English). There is also a Czech version. Diabetesdagboka is available on smartphone (Android and iOS) and smartwatch (Pebble). The Diabetes diary has its own website and Facebook page.

Many test users still appreciate the system and are regularly using despite 10 years having passed. There are approximately 4000 users in Norway. New functionalities have been added, for example, a color bulb that switches between yellow above 10 mmol/l, green between 4 and 10 mmol/l, and red below 4 mmol/L according to the connected person’s blood glucose level. If the person uses a CGM, the bulb will be updated whenever the user’s phone receives a new blood glucose value. Another add-on is a panel mounted in the user’s home that constantly shows all the user data recorded in the patient diary.

A systematic review of telediabetes services within indigenous communities based on findings from the United States, Canada, Australia, and India identified several enablers of telemedicine,[327] including

- the use of cultural and spiritual elements
- acknowledgement of local beliefs and traditions
- *and* appropriate community engagement

Another success factor was the participation of indigenous health workers since they spoke the local language and could help clinicians to better understand the local community.

The main barriers of telediabetes services included

- potentially high fail-to-attend rates
- lack of technical skills associated with the operation of telehealth equipment
- *and* lack of availability of local staff

They argued that the understanding of the enablers and barriers related to healthcare services in indigenous communities is essential when planning a telediabetes service.

Telepsychiatry and telemental health

Rodrigo da Silva Dias and Magdala de Araújo Novaes

Overview

The practice of telepsychiatry encompasses a large number of activities through ICT with transfer/exchange of a range of medical information including EHR, images, and video. These activities may focus on: psychiatric evaluations, therapy (individuals, group or family), patient and provider education as well as medication management. The exchange of data can involve patients, primary care providers, specialists, and health care managers. Telepsychiatry has been identified as one of the key elements to improve treatment and expand care in mental health by the WHO. Due to its ubiquity, telepsychiatry can be made available in extreme situations, for example, war zones and humanitarian shelters. It is progressing towards becoming a model of hybrid care, with technology platforms getting associated with conventional care to bring great benefit to patients.

Concepts and applications

Telepsychiatry uses mobile devices, phone, email, chat, text, and two-way videoconferencing to deliver psychiatric care over a distance. Primary telepsychiatry practice includes psychiatric evaluations, therapy—be it individual, group, or family—patient education, and medication management. It covers other activities like consultations for primary care providers, other specialties, healthcare managers, and exchange of medical information (EHR, images, videos, etc.).[328,329] The telepsychiatry ecosystem has established technical and safety standards with proper certifications (e.g., HIMSS and HIPAA) enabling the adoption of this practice both in public and in private healthcare environments.

Telepsychiatry is one of the key elements to improve treatment and expand care in mental health within the WHO's Grand Challenges in Global Mental Health Initiative.[330] Telepsychiatry processes are varied with as many different approaches. When there is a real-time exchange of information (e.g., videoconference), it is named synchronous telepsychiatry; otherwise, it would be termed as store-and-forward (e.g., recorded material sent by email or other platform for an expert comment) or asynchronous telepsychiatry. On a regular basis, telepsychiatry is performed in medical facilities (hospitals, outpatient clinics, and nursing homes), but can also be performed in military and correctional institutions, and even in schools. These not only are restricted to patient care but also include training, supervision, and evaluation of health teams and managers, whether specialized or not in mental health. Due to its ubiquity, telepsychiatry can be made available in extreme situations like war zones and humanitarian shelters. Cultural and ethnic differences can be minimized.

Although the studies have generally been conducted with small population samples and other methodological limitations, the results have been positive towards use of telepsychiatry.

Considering the age range and the type of mental disorder, we find some scenarios where telepsychiatry shows efficiency. There is great acceptance among children and adolescents in general. Telepsychiatry has been found efficient in the follow-up of autistic spectrum disorder[331] and attention deficit hyperactivity disorder (ADHD)[332] as well as in psychiatric emergency services.[333] There is also positive evidence in the approach towards obsessive compulsive disorders (OCD), conduct disorders, eating disorders, paranoia, anxiety, or PTSD.[334,335] Among the elderly the cognitive and mental functions assessments showed promising findings.[332]

In adults, telepsychiatry has shown a comparable accuracy and reliability with face-to-face evaluation in different disorders: depression, anxiety, posttraumatic stress disorder, eating disorders, substance abuse, and schizophrenia.[332,336] A significant role of telepsychiatry has been observed in suicide prevention and in emergency rooms.[328,337] A post 2004 tsunami telemental health program started by SATHI (Fig. 8) is still continuing and even expanded in scope to general patients long after the disaster aspects had been well managed.[120]

The main technology used in telepsychiatry is the videoconference. The appropriate virtual environment for service has the objective of obtaining the best possible therapeutic bond. This should be well illuminated so that you have a good view and quiet enough that the communication takes place in the most natural way possible. The space should be minimally decorated and without the activities of other people to avoid distractions and ensure privacy. The technical specifications of the equipment should provide the best quality of interaction between the two poles: transmission

FIG. 8 Photos from SATHI's telemental support program. The psychiatrist (top right) is advising health workers and the patient (below), while the happy boy with his sister on the left was nearly suicidal before undertaking the treatment. *Photographs curtsey SATHI and OXFAM India Trust.*

band ensuring synchronicity, camera with good lightning, and sensitive microphones. Preferably, they should allow up to three people to be seen, especially in childcare. Equipment that provides a more open field of vision for observing motor or specific activities is required in special situations, such as testing and assessing interactions between people. Flat screens guarantee eye contact. During the attendance, both ends must always check the perfect understanding of the information exchanged. Identification of the participants and the confirmation of authorization for participation in the consultation are standard procedures. In the case of care being focused on children and adolescents, parents should also give this authorization.[334–336] In Brazil, initiatives in telemental health already occur throughout the country. Videoconferencing is widely used for specialists to interact with the family health team to discuss clinical cases of patients with mental disorders (Fig. 9). Video and web conferencing are also used as tools for training in mental health care for non-specialized staff to reduce referral of patients to a specialized network and provide clinical support for patient management.[338]

Another significant point is the establishment of technical and safety standards and certifications (e.g., HIMSS and HIPAA) enabling the adoption of this practice both in public and in private healthcare environments. The activity of telepsychiatry must still be in accordance with the legislation, norms, and conducts that regulate the exercise of the activities related to healthcare. It is also necessary to follow the technical guidelines suggested by the associations and telehealth entities of each country. However, we still find a great variation of norms and laws.

FIG. 9 A web telepsychiatry session, connecting a hospital psychiatrist to a nurse in primary care facility. Telehealth Center, Clinics Hospital, UFPE, Brazil.

In some countries, such as Brazil, there are more restrictions on medical activity and greater freedom and structuring for psychotherapeutic care.[338] Recently, rules and procedures for due financial reimbursement are being guaranteed as in the United States. Ethical issues are still being debated regarding the licensing and professional boundary concerns and the online therapeutic relationship.

Current and future trends

Like any other activity involving the incorporation of new technologies in health, telepsychiatry presents innumerable possibilities. The incorporation of new media with the use of mobile apps and physiological and behavioral data collection technology (e.g., sensors and wearables) shows great promise.[334] Mobile apps, despite financial barriers related to smartphone costs—which in any case are decreasing—are very well accepted by patients. The apps allow ecological momentary assessment (EMA) techniques and are developed for different actions in the care of mental disorders such as psychoeducation, communication, context sensing, and interventions.[334] More recently, augmented reality and virtual reality headsets have been incorporated as well. Passive data collection methods (geographic location, voice, and chat content) also with smartphones are being researched more recently. There is still a lack of studies on the effectiveness of the applications and their development and incorporation into the care workflow.[339]

It is clear that the evolution to a model of hybrid care, where platforms using technologies associated with conventional care would be the model of care bringing great benefit to patients. These platforms would gather the data collected (actively and passively) via web, mobile phone, sensors, and self-reports. It is still inclusive because it allows the participation of caregivers, family members, or otherwise.[334] The incorporation of artificial intelligence (AI) has also shown promise as a decision support tool both at a distance and/or at the consultation point. The use of robots both as an assistant of the health team and for assistance of patients has been growing, especially in dementia and autistic spectrum disorders.[340]

Telesurgery

Shashi Gogia

Overview

Telemedicine has been largely concerned about providing a remote opinion about a health condition, and telehealth has added components regarding medical education, public health, and administration. Surgery by its very nature is procedure related. Assuming that more general aspects would be discussed elsewhere, this subchapter restricts to specific components pertaining to procedures.

Concepts and applications

Telehealth in the surgical arena helps in enabling distance-based support for pre and postoperative care, teleeducation, telementoring of actual procedures, and telerobotics—that is, the performance of the procedure through remote means.[b]

Preoperative preparation

Assuming that the surgeon is present at a different location than the patient or his PCP, most patients are referred to him with a summary note on the problem. They may or may not be accompanied by phone call. There would be a tentative diagnosis—for example, a breast lump or lymph node for which a biopsy is required or a definite indication for surgery like a hernia, hydrocoel, and appendicitis. Notes are text, but there can be photos, measurements, and preliminary tests that can be shared through a store-and-forward platform.

The remote surgeon may elect to reconfirm the diagnosis by a remote examination through VC (Video Conference) or by sharing of photographs. Further tests may be ordered like a CT and MR, with special views etc., to not only confirm the problem but also to help in the planning of the surgery. General preoperative checkups like BP, blood sugar, chest X-ray, ECG, and viral markers can also be routed through the PCP. Appointments are then provided so that the patient reports directly to the OR for a day care surgery and, even if not, ensuring minimal duration of preoperative stay.

Operative procedure

ORs are designed for efficient management of the procedure. It is a strictly physical encounter. Comfort and convenience of the patient and efficiency with sterility are the key deciding factors. IT (Information Technology) and related automation that has crept in so far has been largely to ensure a no-touch technique like opening and closing doors, taps for scrubbing, light adjustment etc. Patient monitors ensuring safety of the patient by itself do generate data, but any action has to be performed on the spot by the anesthetist.

Remote presence and telecare have been ushered in with increasing use of endoscopy. Overall movement and control of the instruments is maintained by the surgeon, with constant viewing done through the

[b]There is a separate subchapter on this in Chapter 12—Ed.

FIG. 10 Modern operating room with monitors, medical images support, electronic patient record access, with possibility of remote assistance by others physicians. *Photograph curtsey Dr Shoab Padaria.*

monitor (Fig. 10). The addition of physical as well as geographic distance and of robotic control of movements has been the next step.

Postoperative care

Once the patient is out of intensive care and all tubes are removed, there is little justification in making the patient stay in hospital. Early discharge allows for decrease in costs besides reducing the need for relatives to take time off work to stay nearby or make regular visits. Option of a video or telephonic consult ensures that there is safe, cost-effective, and quality care provision in a more homely environment.

Constant interaction between the PCP and the surgeon ensures quality care with little or no travel. Stitch removal, dressings, even the removal of a urinary catheter, etc. can easily be done by a PCP. Ensuring safety during transit is important. Also the surgeon has to be acquainted with the capability of the local care provider, besides availability of particular required equipment and drugs. For example, though removing of surgical staples (https://www.wikihow.com/Remove-Surgical-Staples) requires a special instrument, it can also easily be done a small mosquito forceps. Some telementoring may be required, for example, the author himself regularly teaches village health workers on how to tie a multilayer bandage for ulcers and lymphoedema.[c]

[c] Discussed under Wound Care and Lymphedema in Chapter 9.

Training of a surgeon

Most medical teaching is didactic. Training of a surgeon requires a more hands-on approach. Besides attending the OPD or wards, trainees have to be a part of the OR team with the rule—(1) ***see*** first, then (2) ***assist***, and then (3) ***do under supervision*** before being allowed to operate independently. Medical colleges in the 20th century used to have viewing windows above the OR (Fig. 11) for step 1. Currently, systems exist to train a surgeon virtually. These are (1) ***video-based learning*** for step 1, (2) ***simulation techniques*** for step 2, and (3) ***telementoring***. for step 3. In the first two steps, there is no physical contact by the student with the patient or anything else in the OR. Hence, safety and sterility are ensured.

Video-based learning

This is part of any CME or surgical conference these days. Either live streaming from the OR, or a recording of the live procedure is provided. The same can be viewed from anywhere across the globe using tools and sites like Livestream (www.livestream.com), WebEx (www.webex.com), Citrix (www.gotomeeting.com), and Zoom with methods to ask questions during live or real-time viewing. The cameras can be made to zoom; multiple cameras allow shots from different angles and focus on areas of importance. Automatic recording of procedures is standard, which allows one to freeze, reverse, fast forward, etc. like any other video. Thus video-based learning is far more flexible than any live viewing of a procedure.

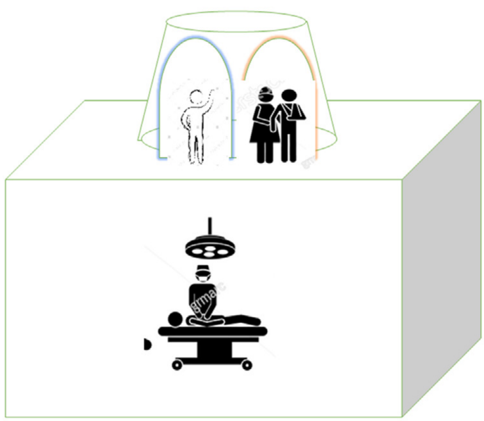

FIG. 11 OR design of teaching hospitals in the 20th century. These provided for glass windows on the roof for viewing of the procedure by students.

Computer-based simulation

These are methods similar to training of pilots with a focus towards operating on the human body. The user can hold instruments and manipulate them while viewing the TV monitor. Most common is the one used for training of endoscopy procedures. The earliest laparoscopy trainer was a simple plastic box covered with a rubber screen; from there the instruments were inserted. One could view from the outside or through the scope. Telescopic cameras with a light source make the experience more authentic. The latest trainers use and replicate actual normal and pathological anatomy through holograms and allow instruments to dig in, that is, virtual surgery is now possible (http://www.echopixeltech.com/). Stereotactic 3D imaging can be useful in the planning of surgery.

Telementoring of procedures

For procedures being done at a remote area, a less trained surgeon can be *teleguided* by a more experienced surgeon. Telementoring would require real-time connectivity for obvious reasons.

Mentoring and training nurses on how to do a particular dressing or to remove a drain is now fairly routine (*see previous text*). One of the earliest examples of mentoring an actual surgical procedure was in 2005 from India—a medical officer posted at the Guruvayoor temple in Kerala managed to insert a chest tube for a tension pneumothorax in a pilgrim with remote guidance from a surgeon at Amrita hospital in Kochi.[341]

Telementoring by radiologists for diagnosis of inadvertent intraoperative lung injury and pneumothorax or other problems is well described. The surgeon uses a special probe and uploads through his smart mobile.

On the higher end, even an experienced surgeon may occasionally call up a colleague or senior when in trouble like severe bleeding or unable to find the parathyroid tumor. Though mostly these calls are on the phone, live video sharing would make it better. Videos would be ongoing if an endoscopic procedure is in progress. For nonendoscopic procedures, special equipment has to be setup with extra effort and time wastage so there has to be ample justification.

Regulation and future trends

In summary, different modalities of telesurgery and remote practices can help the surgeon across the board, that is, from surgical planning, right up to postoperative care. Teleeducation—which does not require any extra infrastructure can be a constant accompaniment to allow basic training and professional updating. There are still issues related to the regulation of surgical practices at a distance in countries where restrictions are applied. On the other hand the use of artificial intelligence in surgical planning and monitoring is growing, as well as the use of robots and portable devices to monitor the patient during the whole cycle from pre- to postoperative care.

Teleotorhinolaryngology

Arindam Basu

Overview

Teleotolaryngology refers to the surgical discipline of distance-based practice of ear-, nose-, and throat (ENT)-related surgery. The ENT discipline includes surgical, diagnostic, and treatment procedures such as external (external otitis), middle (otitis media, perforation, and withdrawal of tympanic membrane), and inner (including hearing and balance and skull base ears) ear diseases; diseases attributed to nasal cavity and surrounding sinuses (septum, meati, frontal, and maxillary sinuses) and nasopharynx; and diseases of the oral cavity, palate, oropharynx, tonsils, adenoids, larynx, and esophagus.

Clinical applications

Clinicians commonly utilize a “scope”-based diagnostic procedures in ENT surgery: here the clinician projects light in “cavities” and then directly observes or projects the sometimes magnified image on a screen, with a choice of printing or further processing. For example, a handheld otoscope is a device that has an inbuilt light source and a magnifying lens. For diagnosis of pathologies in the external ear or the tympanic membrane, the clinician would insert the otoscope inside the external ear cavity, project light that reflects off the tympanic membrane, and reveal the anatomical details of the tympanic membrane. Thus the clinician is able to identify pathological lesions inside the external ear, perforations in the tympanic membrane, distortions in the tympanic membrane reflecting changes in the middle ear, accumulation of fluid, and/or the presence of cavities. The clinician can also video record these images for further clinical decision-making. Similarly, for examination of the nasal cavities and sinuses, the clinicians use fiberoptic endoscopes that can project light into the recesses of the sinuses (the maxillary sinuses), and using these devices, it is possible to diagnose diseases and pathological lesions within the nasal cavity. The fiberoptic endoscopes also enable the clinician to photograph or video record the lesions. In the larynx, or in the deeper recesses of larynx, the clinician can use laryngoscopes or video laryngoscopes to view and record lesions.

Clinicians also use another set of diagnostic procedures in ear, nose, and throat surgery: different forms of "functional recordings" of the organ systems. *Hearing* is recorded in the form of an audiogram using audiometry. An audiologist produces sound waves of variable frequency and intensity using either sets of tuning forks or sounding machines to the patient, and the patient in turn indicates the threshold at which he or she can perceive the sensation of sound. This results in recording an *audiogram*; interpretation of the audiogram provides an assessment of the hearing loss (conductive hearing loss or sensorineural hearing loss). The audiogram can be printed or can be recorded electronically. *Tympanometry* is a procedure where sound waves and pressures are projected on the tympanic membrane and the pressure measurements are recorded in the middle ear. These measurements indicate the pressure within the middle ear and the presence or absence of fluid for diagnostic purposes. *Electronystagmography* evaluates the performance of the vestibular organs, that is, the cochlea within the inner ear by mapping rapid eye movements and assessing the performance of the muscles that control eye movements. *Posturography* is another series of tests that are used to study balance of patients with vestibular dysfunction. Those who have problems of ringing in the ear ("tinnitus") and sensation of fullness in the ear with vertigo or dizziness undergo electrocochleography (a recording of the electrical activities of the inner ear organs) as diagnostic tests for Meniere's disease. *Video stroboscopy* is a procedure to study the movement of the larynx.

Each of the earlier procedures indicate that ear-, nose-, and throat-related diagnoses are dependent on a range of tools that can record images and electrical activities or other forms of information that can be transmitted over long distances, thus facilitating remote diagnoses for patients. Likewise, clinicians can use the results of these tests to diagnose and plan clinical management of patients who are located at some distance, or using store-and-forward technology, it is possible for clinicians to diagnose disease conditions and plan management of patients with diseases in the head and neck region. This practice of remote diagnosis and management of patients with diseases in the head and neck is referred to as teleotolaryngology.

Indications are situations where the practitioners are located remotely or in places not easily accessible or in extreme weather situations, as well as in military operations.[342–344]

In combination with the nature of anatomical and diagnostic processes that rely on either imaging or recording functions, a series of innovative processes and tools have enabled the use of teleotolaryngology. Smartphone-based devices that can record and image eardrums are tested.[345–347] Remote consultations where tertiary consultants work together with primary care providers or family practitioners and general practitioners are useful in the management of common conditions.[348,349] Examples of robotic surgery within ENT are mentioned in the relevant chapter

Future trends

In summary, teleotolaryngology provides opportunities for extending conventional diagnostic tools to aid distance-based diagnoses; they are useful in situations where remote care is needed and can be inaccessible. New tools are available using handheld devices such as mobile phones in a range of disease conditions. On the horizon are transoral surgeries, and tonsillectomies by robotic surgery provide an opportunity to extend the scope of telecare in ENT for situations such as emergency management of peritonsillar abscess, foreign body retrieval under expert guidance, and telementoring of emergency ENT procedures in primary care settings.

Teledentistry

Ana Estela Haddad, Denise Garrido Silva, and Ana Emília Figueiredo de Oliveira

Overview

Teledentistry proposes the use of telecommunication technology to provide dental education and dental care, not only for underserved populations or in distant locations, but also offering support to patients and a second opinion for dentists, whenever necessary.

Concepts and applications

The use of information and communication technologies (ICT) applied to health, whether in healthcare, education, or related to management or research activities, has to do with the emergence of telehealth. The concept of "teledentistry" proposes the use of telecommunication technology to deliver dental care across geographic distances to underserved patient populations.

"Teledentistry" was described in scope and meaning by Folke from the University of Texas in 2001.[350] However, the roots of teledentistry are same as other forms of telemedicine and highlight the definition adopted by the Association of American Medical Colleges: it is the use of telecommunications to send data, graphics, audio, videos, and images between localities and people distant from each other for clinical purposes. Chan et al.[334] suggest the adding of oral healthcare and education to the definition in the previous texts. The early notions of teledentistry were outlined in 1989, at a conference of the Westinghouse Electronics Systems Group in Baltimore.[351] An American Army project in 1994 called "Total Dental Access" had used data transmission over a telephone line, both synchronous and asynchronous (store and forward), as one of the pioneering projects in teledentistry. Soldiers serving in remote areas requiring dental care could be referred to and get further advice from specialists.

Teledentistry is also useful to supplement traditional teaching methods in dental education and in long-distance continuing educational providing new opportunities for dental students and dentists.[352] Teleconsultations can be real time or store and forward.

A multicenter study investigating the use of ICT in dentistry in Latin America analyzed 94 questionnaires answered by teachers and researchers and 221 questionnaires by clinical dentists. Teachers emphasized the importance of using ICT to promote collaborative learning and a series of innovations in education. They also identified the use of the electronic patient record in Brazil, Uruguay, and Colombia.[353]

There is a good applicability of teledentistry, for attending to the oral health of populations in remote regions. Its use by dentists and patients is very well accepted. However, payment for teledentistry services is still a critical issue for sustainability.[354]

Teledentistry is implemented in some developed countries and needs to be encouraged. Teledentistry in Brazil has developed in a similar manner to other fields. In the public health sphere, there have been two decisive aspects: the first was related to the fact that the Unified Health System (SUS) implemented by the Ministry of Health included dentistry since 2003, making it a participant and beneficiary of the national health policy; the other was following the recommendation of the World Health Organization Resolution WHA 58.28/2005,[355] Brazil adopted eHealth as a strengthening tool for Unified Health System (SUS) and started the Brazilian Telehealth Program.[240] Later the Open University of SUS was created. Under the Brazilian Telehealth Program, dentistry is a part in the range of offerings of teleconsultations and discussions related to oral health, in parallel to other topics in medicine, nursing, and other health areas. These are held for medical professionals, nurses, dentists, dental technicians and auxiliaries, technicians and auxiliaries in nursing, and community health agents, who work in primary healthcare.

A growing body of evidence supports the use of teledentistry, in particular, for early detection of dental diseases.[356] A role in specialist restorative care has been described in the Highlands and Islands of Scotland (HIT)[357] with the greatest benefits and cost savings, being recouped if patients had to travel long distances to visit the hospital. Teledentistry is especially suitable for management of referrals of older dependent adults with oral mucosal disease.[358]

In Alaska the Dental Health Aide Therapist program makes use native dental therapists and telemedicine to address inequity in access to dental care. The program began in Alaska as an expansion of the Community Health Aide Program. Alaskan Natives were trained and employed as dental health aide therapists with an expanded scope of practice to perform prophylaxes, restorations, and uncomplicated extractions and provide preventive care in Alaska Native villages.[359]

Teledentistry has the potential to improve access to oral healthcare and eliminate the disparities in rural areas and urban communities. Interdisciplinary communications will improve dentistry's integration into the larger healthcare delivery system. Implementing teledental applications necessitates full comprehension and consideration of the healthcare environment and also a commitment to completely integrate teledentistry within that environment.[360]

Recently a cost-effectiveness analysis was conducted comparing the use of teledentistry in delivering specialist dental services for rural patients as against the traditional method of consultation in Australia. The results showed that teledentistry is a cost-effective method to deliver dental care and an alternative to face-to-face consultation.[361]

Future trends

Teledentistry will be used in many other ways, such as quality and safety assessment, clinical decision support, medication e-prescribing, consumer home use, and simulation training. Although dentistry maintains a separate history, context, and identity within the wider scope of telehealth, it merges well with related applications and in the principle of integral healthcare, which is better achieved through interprofessional work and training in health. It is important for professionals, professors, researchers, and stakeholders to take this view into consideration. Such articulation of teledentistry within the scope of telehealth and related public health concerns helps in strengthening health systems, leading to the benefit of the whole population.

Teleemergency service

Kriti Gogia

Preamble

Twenty years ago, I recall a series of frantic calls to the doctor, a rushed cab to the hospital, and almost a month of painful dressings for my cousin when she burned her foot. Then 5 years ago, in a similar episode,[362] telehealth accelerated the healing process for a friend. His first response was a Google search for treatment options, followed by forwarding a picture of the injury to his physician, for further advice.

He was required to make a physical visit only once, progress being monitored through later exchange of photographs.

Concepts and applications

Telehealth is especially useful in emergency care, where time is of the essence. In 1995 the Global Emergency Telemedicine Services was launched collectively by the Ministries of Health in France and Italy.[363] That initiative was aimed at providing an immediate telemedicine-based response to any emergency situation globally. Since then, applications of telemedicine in emergency medicine have progressed from improving emergency response in rural settings[364,365] to reducing patient load in urban hospitals[364,366] thereon to video consults directly to the patient's home.

A recent survey in the United States observed emergency to be the second most frequent application of telemedicine.[367] With the severe and time-sensitive nature of ED-related injuries, a simple teleconsult can often be lifesaving. Rural areas in particular suffer from the drawback of lack of access to timely care. The same survey also observed that rural areas had a higher tendency than urban areas to utilize telemedicine in emergency care.[367] Telemedicine can go a long way towards addressing this socioeconomic gap.[341] Examples of successful applications of telecommunications in emergency response situations can be found across the globe.[341,368]

Teleradiology or transmission of digital images was one of the earliest and most effective applications of telehealth in emergency.[341] Another popular application is teleconsults to specialists from emergency departments in an effort to improve patient care and decision-making regarding transfers to a specialized trauma center.[364,366] Vitals of the patient in an ambulance can now be remotely monitored by the hospital, saving crucial time and enabling the hospital to provide the best possible care in the shortest possible timeframe.

Telemedicine has been found to be particularly successful for treating wounds and other minor injuries remotely.[366,368] One particular hospital in New York, the United States, introduced teleconsultation as an option in the ED.[369,370] Once a patient is checked into the ED, if the severity of his condition is not too high (e.g., for wounds, rashes, and upper respiratory infections), he/she is given the option of seeing a physician remotely. The history, vitals, and routine tests are still conducted by an in-person nurse/assistant; however, the attending doctor converses with the patient via videoconferencing in a room in the hospital (Fig. 12). The advantages of this process are that it significantly cuts down on the wait time for the patient (as much as 75% sometimes), decreases burden in the ED, and frees time for the on-call doctors to see more urgent cases. Early surveys have shown high satisfaction scores among patients with this process.[369,370] A number of hospitals in the United States are now implementing similar programs in their emergency departments.

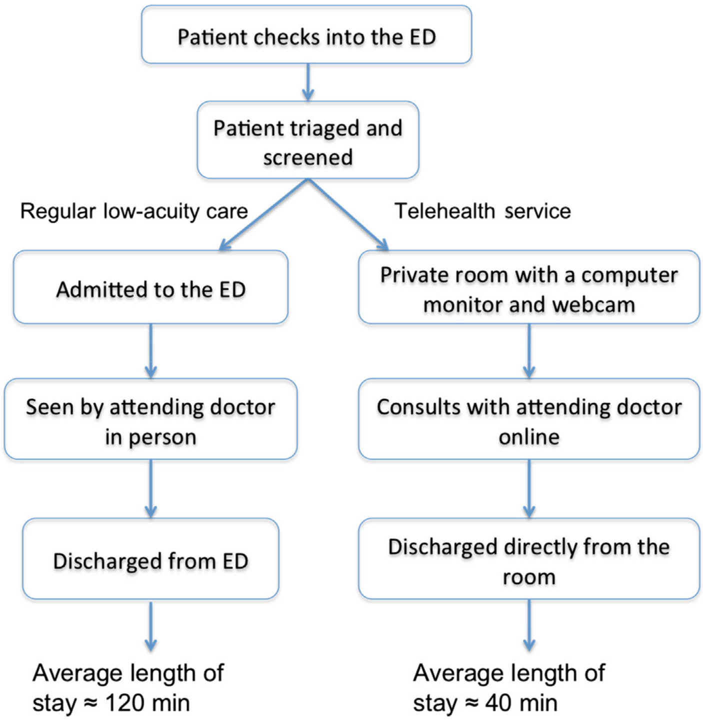

FIG. 12 Flowchart depicting telemedicine intervention.

Software and apps now exist that make even a visit to the ED unnecessary. It is now possible for the patient to connect with an ED physician from his home and receive a consult within minutes. If the symptoms are sufficient for the physician to make a diagnosis, the patient can skip any tests or hospital visits and directly pick up a prescription from the pharmacy, saving time and cost, decreasing burden in the ED, and allowing appropriate care delivery to the sicker patients. Such an app was recently launched in a New York hospital.[370] The On Demand Virtual Urgent Care App provides patients with immediate access to an ER physician for a teleconsult. The physician can then further advise them on the necessity of making an ER visit.

Current and future trends

A 2015 report of a survey done in Pondicherry, India, found emergency telemedicine systems to be cost-saving, time-saving, and as effective as in-person examinations by both healthcare providers and patients.[371] They performed telementoring for emergency procedures by residents. There are other similar examples of nonmedical persons instructed on emergency life-saving procedures like tracheostomy and putting in a chest tube for tension pneumothorax.[341]

Recent studies on teleemergency in developed countries have shown high levels of user satisfaction for the patients and the healthcare professionals, in terms of quality of care, interaction, and health outcomes.[364,366] The rate of return to the ED, after evaluation through a teleconsult, was observed to be similar to a regular visit, indicating similar rates of success.[366,369] These studies however have been limited in their approach due to the dynamic nature of the ED and limitations of scales for measuring qualitative patient outcomes. While these studies hypothesize an expected cost-benefit for both patients and providers, in terms of reduced visits to the ED with increased teleconsults, the same is yet to be evaluated. More rigorous and methodological studies are needed to identify both strengths and limitations of the current approaches in teleemergency; however, early results have been undeniably positive.

Tele-ICU

Rohit Raghav Gupta

Overview

Tele-ICU refers to the use of integrated audiovisual communication and electronic health systems to remotely monitor and manage patients in the intensive care unit (ICU). Also referred to as virtual ICU, remote ICU, or eICU, these systems are increasingly being integrated into academic and private institutions with over 13% of adult ICUs in the United States having some form of tele-ICU coverage.[372]

Depending on institutional resources, location, and bed capacities, Tele-ICU can offer powerful solutions for a variety of challenges. In geographic regions that have been traditionally medically underserved, tele-ICU can provide a workforce solution, where hiring an in-house staff intensivist might not be a viable alternative. For health systems having multiple satellite facilities, tele-ICU can help, by implementing best practices across facilities improving infection morbidity and mortality outcomes. By securing access to specialist intensivists, patient interventions can be planned in advance; triage decisions, leading to referral to higher care centers can be done in a safer and more expeditious manner. Conversely, inappropriate transfers can be minimized by providing expertise, guidance and close follow-up remotely.

Tele-ICU models

Several tele-ICU models exist that offer flexibility in terms of their input and resources for hospital systems to consider.[373] For most health systems, tele-ICU models exist as a hybrid from among these models.

In the continuous care model, tele-ICU physician monitors and manages patients in real time over predetermined time shifts. This can serve to provide night coverage remotely, while the onsite intensivist provides care in the daytime or alternatively provide 24/7 coverage. In the continuous care model, the teleintensivist would serve as the primary attendant who would work typically with on-site physician extenders or hospitalists to implement a plan of care.

In the scheduled care model, tele-ICU teams offer periodic consultation to the primary team caring for the patients. These are typically scheduled as planned consults during rounds once or twice a day.

In the responsive care model, tele-ICU consults are obtained in an unscheduled manner in response to clinical changes, in lab alerts, or for other unanticipated reasons.

Tele-ICU logistics and resources

Investing in a robust tele-ICU infrastructure is critical for the success of any program. This includes access to reliable secure Internet access with adequate redundancies for ensuring stable communication channels. A well-integrated electronic medical record system allowing the intensivist to review hospital labs, imaging, consult notes, and data from prior visits is required. Finally, it needs technological solutions for teleconferencing capabilities not only to communicate with the onsite medicine team but also with patients and their families.

All these resources can be located in a defined centralized facility where the tele-ICU staff would be located. This is commonly seen in tele-ICU facilities that provide continuous coverage to multiple hospital locations simultaneously. An alternative is a decentralized structure where tele-ICU staff provides care from flexible locations like their homes and offices using the Internet.

Staffing for tele-ICU teams can vary depending on the model of coverage and patient population. The tele-ICU team includes an intensivist physician who can be joined by critical care nurse practitioners (NP), registered nurses (RN), pharmacists, and registered nurse (RN), pharmacists, data entry staff, and quality management consultants. Depending on the program design, tele-ICU patient-to-RN ratio of 30:1 and patient-to-physician ratio of 50–150:1 can be implemented.[374]

Challenges

Several factors exist in the implementation of a successful tele-ICU program. It is important to have close integration between the tele-ICU and onsite hospital team. This includes a clear delineation of responsibilities, defined workflow pathways, and algorithms for escalation of processes.[374]

The idea of tele-ICU is to strengthen and support the onsite medical team rather than serve as their replacement. Building trust between teams requires close involvement of nursing and physician leadership and through close collaboration and joint training sessions.

Alongside these measures, special focus needs to be placed on documentation, patient data confidentiality, patient and family counseling, and quality improvement metrics.

Some of the challenges facing tele-ICU include credentialing, licensing, and malpractice regulatory requirements that are yet to catch up with the advancement in the field.[375] Another barrier to more widespread adoption is the current limitation in the ability to bill and secure reimbursements for tele-ICU services. These are gradually changing as regulators recognize the scope and potential of tele-ICU services.

Impact and future trends

As tele-ICU services have grown, more data has become available to assess their impact. Two recent metaanalyses have shown reduction in ICU mortality but with conflicting data on hospital mortality and length of stay.[376,377] Given the heterogeneity of tele-ICU models and multiple other factors affecting outcomes, more studies would be needed to conclusively determine overall trends. More significantly the use of tele-ICU teams for best practices like the ventilator care bundle and central line and urinary catheter utilization has shown to lead to reductions in duration of mechanical ventilation and ICU length of stay.[378]

Over the coming years, tele-ICU is expected to expand and provide a greater role in managing critically ill patient population. The use of a thoughtfully designed proactive integrated tele-ICU program will serve to improve patient safety and hospital outcomes while simultaneously offering avenues for cost reductions.

Teledialysis

Gunnar Hartvigsen

The idea of supporting dialysis patients at remote satellite stations or even at home started to evolve in the late 1980s/early 1990s. In Italy the first teledialysis services included follow-up care for every session in local and remote stations.[379] In 2003, Edefonti et al. concluded that teledialysis is useful in detecting and solving the clinical and technical problems of automated peritoneal dialysis.[380]

In Northern Norway, teledialysis started in September 2000 as a project to connect the university hospital to two remote satellites.[381] Based on the positive results from the project, Teledialysis has continued as a routine service since then and even spread to several places in Norway.

Dialysis in Norway is primarily offered as hospital-based hemodialysis (dialysis center).[13] This means that patients have to visit the renal unit three times a week for up to 5 hours. Many patients live far from the hospital and may have to spend up to 6–8 hours on commuting to and from the hospital 3 days per week. Long distances make it appropriate to decentralize dialysis treatment as much as possible. This is achieved either as "satellite dialysis" provided by smaller hospitals or nursing homes or by home dialysis (either hemodialysis or peritoneal dialysis).

The University Hospital of North Norway (UNN) in Tromsø, Troms County, has the medical and administrative responsibility for patients undergoing dialysis in the neighboring county of Finnmark. With a total population of 75000 in an area of 50000 km, the challenges in offering specialist healthcare services for the population are huge. UNN has the responsibility for three hemodialysis satellites in Finnmark.[381]

The aim of the teledialysis service was to improve the quality of patient care by providing patients and nurses at the satellite units with the same quality of follow-up care and support as that received by patients and healthcare staff at UNN.[13] With the help of telemedicine, they wanted to establish a joint workplace by incorporating staff at the satellites into UNN's everyday routines. Thus the nurses at the satellite centers had to be integrated into the daily routines at the nephrology department at UNN. The quality of patient care was improved by doing patient rounds in Alta and Hammerfest from UNN over a real-time video link. Before teledialysis became a routine, all communication between health staff at the satellites and UNN took place via telephone, paper documents were sent via traditional mail, and the nephrologists visited the satellite locations every fourth week. The patients from Alta and Hammerfest also had to travel to UNN every third or fourth month for follow-up.

The Norwegian Healthnet had installed a 2-Mbit/s network between all three sites. For security reasons a virtual private network (VPN) connection was used for all data transmission except videoconferencing (VC). Different VC solutions were evaluated. Equipment was chosen based on technical requirement specifications such as knowledge and experience analysis, support for both internet protocol (IP) and Integrated Service Digital Network (ISDN), built-in Multisite Conference Unit (MCU) menu and operating manual in Norwegian, and the possibility for connecting biomedical equipment and external camera to the VC equipment. In the system selected, also the expressed wish from the healthcare staff for a portable system and a rack for this purpose (codec, camera, and monitor) was met, even though the VC equipment did not qualify as biomedical equipment. Traditional VC equipment together with/connected through medical isolating transformers (in accordance to the technical standards IEC 60601-1) allows the use of VC in patients' room. VC use is as follows[13]:

- The nurses have day-to-day contact from Monday to Saturday. Here, current problems are discussed every day in a 15-min session to each satellite.
- Doctor and nurse have rounds every 14 days, alternating between Alta and Hammerfest. The rounds include review of all the patients and patient rounds. Ultrasound apparatus is used if required.
- At UNN, they have in-house training once every 14 days. The satellites participate in the in-house training through videoconferencing.
- The system is also used for emergency problems if needed.

In addition to VC, transmission of heart and lung auscultation and fistula murmurs was part of the telemedicine system. An electronic stethoscope was connected, but the quality of the transmitted heart or lung sound was not considered good enough for medical purposes. On the other hand the possibility of connecting the stethoscope to a PC and transmitting the sound to the doctor using a secure email solution was found to be more attractive. Ultrasound support was desired for providing guidance for inserting needles in deep blood vessels and for training new nurses on how to insert needles. Its direct use and a doppler sometimes outside the telemedicine context helped the diagnosis of pathological conditions in the blood vessels and fistulas and displayed "difficult" blood vessels.

Dialysis machine software is an online therapy data management system. PCs with software were installed at all sites to monitor the hemodialysis machines and to achieve a common electronic patient record system. The software provided the following capabilities for the clinician working at a remote location: direct downloading of dialysis parameters such as arterial, venous, and transmembrane pressure; conductivity; temperature; ultrafiltration rate; data on blood volume; and data storage of laboratory test results; nurses' reports; medication taken; blood pressure; and weight.[13]

For data security reasons and to enable simultaneous access to other hospital electronic sources such as digital radiographs and the main patient record systems, the server with the dialysis software was installed within the UNN's network with a VPN to the satellite units. This gave the nephrologists simultaneous access to other information sources provided by the hospital (digital X-rays and the patient's main electronic health record). In addition, all the necessities of data security could be achieved. For UNN the technology has improved the reliability of the advice given by its staff. For the satellites the faster response and higher information quality add to the reliability of the care they provide.[13]

The technological solutions together with new service delivery routines have strengthened cooperation between UNN and the satellite units. Patients benefit from greater continuity in checkups, follow-up, and treatment, as well as the opportunity to talk to UNN health professionals directly. The technology has improved the reliability of the advice given by its staff. In particular, the audiovisual contact both with the health staff before the rounds and with the patients during the rounds has contributed to this improvement. Both health staff and patients report this. A number of acute problems can be solved via telemedicine, and this could avoid the need for several emergency admissions. In addition, admissions for checkups are no longer necessary. Follow-up now takes place in almost the same way as for patients at UNN. For the satellite stations, it appears to be easier to fit VC into day-to-day routines. The software can also be used to allow nurses to do other things in the office while they monitor the machines via the PC screen.[13]

Annual costs included investments in teledialysis and broadband as well as time costs for specialists and nurses participating in the service. Both doctors and nurses must set aside time for teledialysis. Time is needed for the transmissions themselves and to prepare as well as do follow up work. The office service also needs to spend extra time for updating the electronic health record. Access to technical staff when needed is also important. Costs are saved because patients no longer need to travel to UNN four times a year for regular checkups. Now the necessary tests and procedures were performed at the satellite units. Travel costs and costs of overnight stays at the hospital are avoided. Costs are also saved for emergency admissions. In addition, the specialist's travel to Alta and Hammerfest has decreased to every 6 weeks instead of every 4 weeks.

The patients have been positive to this service and the staff satisfied with the experience of using teledialysis applications. They were most satisfied with the VC equipment and the electronic health record. Some of the staff at UNN thought that the electronic health record was as useful as the VC, because the record enabled computer-mediated communication. Ultrasound apparatus and the stethoscope were barely used, due to sound problems, less experience, and fortunately the lack of relevant medical problems.

Organization of teledialysis at the responsible institution needs to be individualized as per the needs of a particular hospital, depending on the number of doctors and nurses, where the equipment is located, etc. Before starting the program, it is recommended that plans and routines be drawn up for scheduling the connection and the content of the transmissions, for example, a weekly plan in which all activities and its responsible staff is plotted. The doctor and nurse responsible must be designated in the roster for the department. VC demands fixed schedules, as all the parties involved, that is, the patient, nurses, and the specialist as applicable, need to be available in synchronicity. There is a need for constant communication between the parties involved throughout. The possibility to use VC outside the scheduled timetable as per need also has to be catered to.[13]

The limitations of the system lie in the possibilities for diagnosing complex clinical conditions in which advanced diagnostic aids such as contrast X-rays are needed, or where the technical quality of the telemedicine equipment does not make it possible to differentiate between various potential diagnoses (e.g., with auscultation of the lungs: pulmonary congestion or pneumonia). When teledialysis is well established between sites, it is very important that all health staff members involved know who has the responsibility for the equipment and the network. Even so, it is recommended to identify a "super user" at each site in addition to this. It is also important to ensure access to technical personnel such as biomedical, information technology, and telecommunication staff.[13]

Some basic recommendations are the following:

- Before start-up, it is recommended that plans and routines be drawn up for scheduling the connection and the content of the transmissions.
- Establish a service that is as simple as possible, both technically and in relation to costs (depending on what you want to achieve).
- Ensure that the network is fast enough and as reliable in operation as possible.
- Take security considerations into account.
- Provide access to a common electronic patient journal that is up to date (should include laboratory data, X-ray result, and possibly images).
- Establish audiovisual communication such as videoconference.
- Ensure access to technical support personnel, such as biomedical, information technology, and telecommunication staff (for service and support when the system does not work).

The following were identified as unnecessary:

- online monitoring software of the hemodialysis machines
- electronic stethoscope (due to the quality of the transmitted audio)
- ultrasound

Telerehabilitation

Ganesh A. Joshi

Overview

Telerehabilitation overcomes the barrier of distance and time and provides access to patients having temporary and permanent disabilities for accurate diagnosis and prescription by physiatrist (physical medicine and rehabilitation or PMR specialist). A physiatrist can bring the patient in terms with his realistic potential through telerehabilitation and thus mitigate hazards of unscientific miraculous cures that trap doctor shoppers.

Telerehabilitation offers regular communication between the members of the rehabilitation team and realtime assessment of the patient's environment. Thus it improves the patient satisfaction and quality of life cutting down the cost and labor of accessing healthcare. Telerehabilitation facilitates realizing the goals of mainstreaming persons with disabilities in broad aspects beyond the scope of healthcare.

Concepts and applications

Disabilities of permanent and temporary nature affect every alternate household, but physiatrists are unevenly distributed across the globe. Telerehabilitation facilitates the physiatrist to reach out to many more patients to provide diagnosis and management through virtual mode than it was possible sitting in his clinic/institution/home visit. It is also possible to monitor the progress of treatment with better and continuous communication with the paramedical staff involved in rehabilitation. The two-pronged approach of rehabilitation management, namely, person with disability and his/her environment, is made possible through telerehabilitation in a very economical way providing 24X7 access to health for persons with disabilities at their location.

Physiatry is a medical specialty concerned with diagnosis and treatment of temporary or permanent disabling conditions through multiple interventional strategies. It aims to minimize morbidity and maximize quality of life with the objective of achieving optimal independence. The physiatrist treats persons with traumatic conditions like spinal cord injury, traumatic brain injury, amputation, and limb deformities; neurological disorders like stroke, parkinsonism, and multiple sclerosis; painful conditions like arthritis and osteoporosis; cardiopulmonary disabilities; cancer complications; disabling conditions of vision, hearing, speech, and intellect; and habilitates children with developmental disorders like cerebral palsy and autism. Physiatrists thus handle long-term and mostly lifetime care for all age groups from pediatric to geriatric. Physiatrist typically undertakes problem-based approach to rehabilitation management considering the patient's priorities and provides healthcare at primary, secondary, and tertiary level of prevention and emergency management.

Disability and rehabilitation

The WHO defines disability as an umbrella term, covering impairments, activity limitations, and participation restrictions.[382] Rehabilitation is a set of measures that assist persons with disabilities to achieve and maintain optimal functioning in interaction with their environments. It must address physical, psychological, social, educational, vocational, and recreational abilities of the person in a given environment. Rehabilitation processes need to work on two fronts (1) the person with disability (physical and psychological) and (2) the environment (living and nonliving).

Problem statement

People with disabilities are often seen as different from so-called "normal" humans. In fact, functioning and disability coexist in all human beings. The WHO made an effort to clear this issue by creating the International Classification of Functioning, Disability and Health (ICF) in the year 2001.[383] It is an integrative biopsychosocial model (Fig. 13) that provides a common language for all healthcare personnel that can be adapted for telemedicine applications.

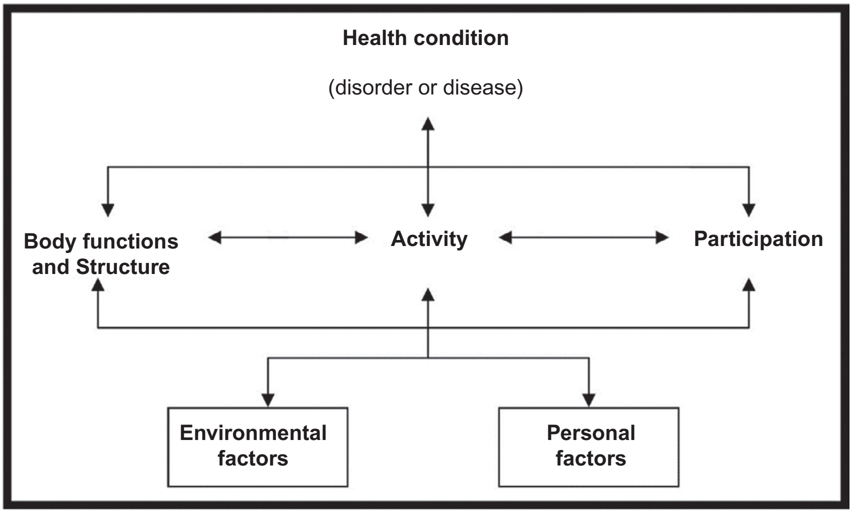

FIG. 13 Interactive model of ICF.

The WHO report on disability, 2011, indicates that 1 billion people globally experience disability, that is, every alternate household has a person with disability.[382] The underdeveloped countries and rural areas have a higher prevalence of disability but have less or no access to a physiatrist. The WHO has targeted better health for people with disabilities during its action plan 2014–21[384] that states the following:

- Half of persons with disabilities cannot afford healthcare, but they are 50% more likely to suffer catastrophic health expenditure.
- They have the same needs of general healthcare as others but are
  - twice more likely to find inadequacy in the health provider's skills and facilities,
  - thrice more likely to be denied healthcare,
  - four times more likely to be treated badly in the healthcare system.

Applying telerehabilitation

The following advantages of telerehabilitation make it very useful for healthcare of persons with disabilities:

- cutting short the time and distance between the patient's home and clinic
- overcoming accessibility problems of transport and healthcare center
- reducing cost of healthcare including consultation, therapy, equipment, admission, diet, referrals, transport, etc.
- mitigating communication barriers due to language and literacy level
- safeguarding patients from unscientific claims and miraculous cures

Telerehabilitation is available at any location and at any time and thus overcomes the following problems of rehabilitation management:

- unguided rehabilitation services offered by paramedical and rehabilitation personnel at remote locations without physiatrist's diagnosis and prescription
- difficulty in following a complex physiatric prescription at home including dose and timing of drugs, exercises, self-care activity, diet, and the use of assistive devices
- financial and psychological stress caused by lengthy admission periods
- access by the physiatrist to the home and work environment of the patient in real time to suggest necessary modifications

Diagnosis

Telerehabilitation provides a facility for the physiatrist to reach out to the patient at his home or nearby healthcare facility for specialist diagnosis. The person with disability may have difficulty in giving history due to difference in dialect, literacy level, dysphasia, mental illness, deafness, autism, blindness, intellectual deficiency, etc. As compared with only one informant who was escorting the patient in clinic but may not be well versed with the full extent of patient's problem, in the home care setting, a number of family members and friends are likely to be available to obtain the problem details and corroborate the same further.

The facility to record and retain these oral interactions translated to various languages makes it very useful for diagnosis. Thus a deaf patient may communicate his symptoms in sign language that can be interpreted and conveyed to the physician more accurately and recorded for future use. Under expert guidance over telerehabilitation, palpation and maneuvers can be conducted by the family physician within the comfort of the patient's own home while inspection and auscultation can be transmitted digitally. While a video clip of the gait and any episode of seizure is a logical tool that patients are already using to obtain a medical opinion, some forms of physical examination like manual muscle testing, range of motion, and functional independence measure can be done by paramedical staff at the bedside, and the recording transmitted digitally. Comparing the findings with older reports is essential for the diagnosis of conditions like postpolio syndrome. These findings also help to decide the line of management and to fulfill legal obligations like disability certification. Some questionnaire tools for screening of developmental disabilities can be used over telerehabilitation and thus help in early diagnosis. Investigations like electrocardiography and pulmonary function tests done bedside and transmitted in digital format help in confirming diagnosis. After having seen the doctor once, patients with less mobility find it easy to provide pathology and radiology test results over electronic media like smartphones, email, or through videoconferencing.

Physiatric prescription

The physiatric prescription includes pharmacotherapy, surgical intervention, therapeutic exercises, retraining in daily activities, assistive devices, diet, and environmental modification. Counseling the patient to follow all components of the physiatric prescription ensures success of the rehabilitation management. This is customized for each patient according to his health condition, expectation, and environment. Telerehabilitation provides direct access to the sociocultural and topographic environment of the patient at home, school, work, or any other section of his society in real time. Real-time assessment of environment through telerehabilitation makes it easy to prescribe necessary changes on a continuous basis without the need of a physical visit.

Treatment and monitoring

The physiatric prescription is executed by multiple members of the rehabilitation team that includes paramedical and rehabilitation professionals. Therapists provide exercise therapy, pain relief, gait training, speech therapy, psychotherapy, activities of daily living training, etc. Many more personnel like special educators, mobility instructors, and vocational trainers are also involved. The highly sophisticated component of the care is provided at the specially equipped rehabilitation center for a limited time period. Then these treatments continue at home by the patient himself or family and other caregivers or maybe engagement of domiciliary paramedical staff. Physiatrist can monitor the treatment on a regular basis through telerehabilitation and guide the healthcare personnel and/or caregiver(s) for faster and directed rehabilitation. This supervision by the physiatrist lowers the complication rate with better handling as and when the complications do occur. Efforts towards direct psychotherapy, speech therapy, and physiotherapy through telerehabilitation are also under way. IoT can help monitoring of cardiorespiratory fitness during exercise schedules and alarm for maintenance of prostheses and implants like baclofen pump, and ventriculoperitoneal shunt. In this era of neuroprosthesis like functional neuromuscular stimulation and cochlear implants, the fine-tuning and maintenance of the devices can be effectively done through IoT. Reminders can be set for daily routines like drug intake, diet, exercise time, and clean intermittent catheterization.

Assistive devices

The assistive devices prescribed by physiatrist include orthoses, prostheses, mobility aids, and assistive technology. IoT can help the patient to control his environment with the help of various assistive devices. With handheld devices, CAD and CAM, bedside virtual cast can be taken from the patient's body part transmitted digitally to fabricate orthoses and prostheses in workshop at distance. The physiatrist can be present for fitment and checkout over a telerehabilitation link, and the records can be retained for future use. Mobility aids like crutches and wheelchairs can be prescribed and supplied with better suitability to the patient and his environment. The assistive technology for daily activity, mobility, communication, or environmental control can be prescribed based on the evaluation of the individual patient and his environment over the telerehabilitation link. The augmentative alternative communication devices used for autism, cerebral palsy, dysphasia, etc. can be provided, and training sessions can be arranged over telerehabilitation. A global repository of assistive technology shall make it possible to share appropriate devices for use.

Referral

Telemedicine provides a peer-to-peer referral link between family physician, physiatrist, and other specialists to improve knowledge sharing during the treatment. The referral to physiatrist is useful in pre-, peri-, and posttreatment stages in various medical and surgical conditions. For example, the presurgical planning of amputation level is essential for the success of prosthetic fitment. During various long-term illnesses, prevention and management of pressure ulcers can be best achieved with physiatric advice. Post spinal injury patients may have life-threatening complications like autonomic dysreflexia that can be managed by simply removing the inciting stimulus like impacted stools. In a similar way, referral from the physiatrist to various medical and surgical specialists over telemedicine link can facilitate rehabilitation management. AIIMS, New Delhi, India, regularly runs telerehabilitation consultations for its hospitals in rural areas and Andaman and Nicobar Islands. It also undertakes teleeducation classes for African countries to teach physiatry to, thus filling the gap of the faculty.

Community-based rehabilitation

Rehabilitation makes the person aware of his realistic potentials and enables him to decide what is best for him and thus empowering him for better inclusion in society. Community-based rehabilitation (CBR) provides suitable interventions by using community resources. CBR is the practicable modality of providing rehabilitation services at the remotest areas and is facilitated by telerehabilitation. Telerehabilitation serves to handle all the five axes of CBR[211] (Fig. 14). Health axis is managed through telemedicine as given earlier. Education axis is handled through teleeducation using hardware and software allowing special education. Livelihood axis involves skill training and upgradation, obtaining and retaining employment that is made possible through information communication technology. Social and empowerment axes involving marriage, recreation, culture, justice, advocacy, and self-help groups are already taken care by social media, but much more can be done. Thus telerehabilitation serves to be a solution for composite and comprehensive habilitation and rehabilitation of persons with disabilities.

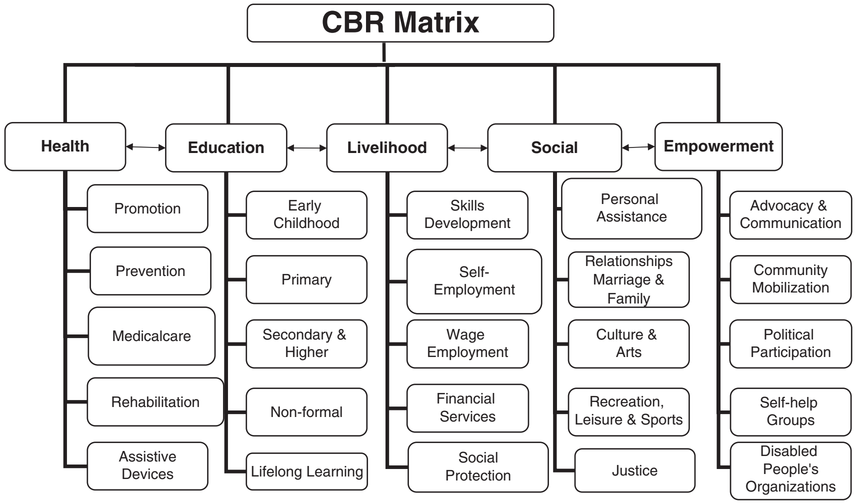

FIG. 14 CBR matrix.