Telesonography - the 5th dimension of ultrasound examination

Background

At the very beginning, ultrasound examination was the result of reception of the ultrasound wave return from one ultrasound wave emission: uni-dimensional mode M. A second step in the evolution of ultrasound technology was to extend to several waves received in the same time yielding bidimensional (2D) examinations. Years later, a third dimension was successfully developed: plain images were examined by the whole volume as tridimensional (3D) images. The impressive success of 3D examinations, especially in the obstetrical field, lead to the fourth dimension: visualization of 3D images in real-time (4D). In a short time, based on fast development of information and telecommunication technologies, ultrasound images were transferred remotely to distant locations, which may be considered as the 5th dimension. All these evolutions were the result of a process based on needs fulfilled.

Definition and history

Telemedicine was a term coined in the early '70s, which literally means "healing at a distance", signifying the use of information and communications technologies (ICT) to improve patient outcomes by increasing access to healthcare and medical information [1].

In 1950, USA and Canada started to transmit radiological images and introduce a new notion: "telegnosis". During the same period (around 1954) the first medical application of ultrasound in medicine was also developed [2].Telesonography uses communications tools and applications to provide faster and improved ultrasonography examinations by receiving remote expert's opinion. Beginning of transmission for ultrasonography examinations via Internet was in the middle of the 9th decade of the twentieth century in Canada, Europe and Australia, in echocardiography and obstetrics [3-6].

Telesonography structure

Remote transmission of ultrasonography exams needs 3 components: an applicant with equipment and software (placed near the patient), an intranet or Internet connection, as well as a telesonographer with dedicated software for reading, associated or not with remote control capacities of examination [7].Telesonography usefulness has been demonstrated in veterinary medicine, also [8]. The importance and complexity of the subject has generated the need to synthesize the information in e-books [9].

Transmission at distance of ultrasound images can be achieved in 2 ways: storage and transmission versus real-time, with each variant having its own advantages and disadvantages. Store and forward process is simpler in 2 perspectives: it does not require synchronization of experts and does not require high and constant transmission speed. The disadvantage of sampling errors was exceeded in recent studies that have implemented such solutions, by storing 3D images whose interpretation facilitates the work of the experts [10]. Remote real-time transmission of ultrasonography runs in best conditions in high speed Internet connections with capabilities of remote control of images, although this does not seem to be a prerequisite [11].

Telesonography equipment includes dedicated systems or classic equipment with Internet transmission possibilities. Split components were developed recently: separate transducers adapted for mobile devices with specific software like smartphones, tablets, laptops, etc. [12-14]. Applicant categories include patients (emergencies, people from remote places, from

Conventional telemedicine session with an applicant seeing the patient and a remote telesonographer as the expert sports, with disabilities, etc.), medical doctors (ultrasound-naïve doctors, trainees and residents, doctors without experience, specialists within other specialties, etc.), medical students, nurses, etc. A high speed network is preferred, either mobile (3G with maximum speed of 21 Mbps, 4G with maximum speed of 100Mbps, or satellite with maximum speed of 6/12 Mbps) or fixed (ADSL with a maximum speed of 12 Mbps, ADSL 2 plus with a maximum speed of 24 Mbps or even optical fibers with a maximum speed of 100 Mbps). Last, but not least, a specialist telesonographer with experience in ultrasonography has to assume the result of telesonography examination [15-16]

Telesonography categories

Telesonographic projects have used, over the last 2 decades, one of 2 methods, depending on specific parameters, needs, possibilities and specialty features. Telesonography networks experimentally developed to follow the principle of "fulfillment of needs", were designed for assessment and monitoring of certain isolated communities or certain pathologies. Therefore, projects were carried out on the islands [17-18], on ships [19], on remote locations or even in space [20-22].

In terms of pathology concerned, the projects were implemented in the areas of emergency medicine, obstetrics and gynecology, cardiology, pediatrics, internal medicine branches and in primary care, etc. Few projects focused on the impact of telesonography in the educational process [23]. Hence, all projects have increased the chance of participants in accessing quality healthcare by reducing effort and time. Some projects evaluated functional parameters such as image quality [24-26], the social, financial and "quality-of-life" impact, developing various solutions to the needs identified: training lay persons in obtaining quality images [27] or developing robotic arms that are remotely guided by an expert to obtain high quality ultrasound images [28-30].

During earlier years of the "telesonography era", the performance equipment that could provide remote transmission of images had high prices, discrepant with income of the areas requiring wide access. Development of the Internet and the availability of telecommuting programs (often offered freely on the Internet) have changed the situation and led to increased concerns for developing more accessible telesonography networks [31-35].

In the same time, a tendency to miniaturization for transducers and equipment (in order to make them more portable) has taken place.

Attaching versatile transducers at smartphones or tablets opens a new perspective for telesonography bringing the ultrasound transducer into the doctor's pocket, closer to the "old" stethoscope [12-14]. Recently, the term "echoscopy" has been coined to point out this evolution [36-37]. Nevertheless, the main problem that requires solving in the future is the availability of specialists in ultrasound by improving their working time and creating virtual collectives that provide state-of-the-art services that will be increasingly demanded by telesonography.

Clinical applications

Emergency medicine

In order to increase the efficiency of saving lives at risk in emergency situations, emergency medicine society has developed various protocols such as Focused Assessment with Sonography for Trauma (FAST). Through a short workout (20 minutes), paramedics were able to transmit ultrasound images interpretable in an average time of about 4 minutes, while the experts were able to provide an accurate assessment of the medical images and, consequently, to take corrective actions [38-39].

Obstetrics and gynecology

In this area the gap between the need for monitoring pregnancy or following-up chronic lesions, on the one hand, and the small number of specialists with an appropriate level of training, generated several projects of telesonography as compared to other areas. They used both the "store-and-forward" [40], as well as "real-time" technologies [41]. The examiner was being verbally guided remotely [42] or examination was performed using robotic arms [43]. In all cases the results were good, arguing for the necessity of implementation in other areas.

Cardiology

Echocardiography is particularly related to the speed of movement of heart valves during examination. For correct interpretation of the images a proper transmission speed for Internet or "store-and-forward" data is required, through usage of corresponding compression solutions [44]. A second feature is that examinations are limited and the placement and movement of the transducer influences the quality of the examination. In this field, a robotic arm was therefore used as a tool to increase picture quality [45].

Pediatrics

The same criteria were applied in examining children echocardiographs remotely, the result being even better, with a tremendous impact on the quality of life of young patients [46-47].

In conclusion, telemedicine achieved an impressive impact in recent years, while telesonography is definitely an area that will be developed in parallel due to the usefulness and increased availability associated with the downward trend in prices. The future looks bright and will certainly tell if this can be expanded to other diagnostic and therapeutic applications of clinical ultrasound.

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