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REVIEW ARTICLE

# Telemedicine in emergency care: methodological and practical considerations

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Telemedicine has today been incorporated into routine practice in many medical specialties. Advances in new information and communication technologies, along with the greater accessibility of these technologies and improvements in the connectivity of medical equipment, now facilitate the care of patients who have difficulties visiting a hospital or clinic. One of the most important applications of telemedicine is its use in emergency care. The experience gained in other medical specialties has greatly increased the range of emergency medical care situations in which telemedicine can be used both inside the hospital and in remote locations. Moreover, the particular characteristics of emergency medical care, such as the need for speed and a reliable diagnosis, mean that there is ever growing demand for more and better equipment and solutions. Increased communication between emergency professionals and other specialist clinicians could facilitate improved diagnosis and a consequent reduction in morbidity and mortality among patients attending emergency departments. The aim of this paper is to review the potential applications of telemedicine in emergency care and the necessary technological infrastructure. [Emergencias 2009;21:287-294]

**Key words:** Telemedicine. Emergency Medicine. Technology. Information and Communication Technologies. ICTs. Telematics.

## Introduction

The growing application of new communication and information technologies (CITs) in the world of medicine means that informatic processes are becoming increasingly available in healthcare management. In the twenty-first century society, technology is already part of the practice of medicine in all its aspects (clinical, surgical, educational, etc.), allowing certain actions that until recently were unthinkable. In fact, one could say that Medicine, in general, clearly depends on technology, for example to improve diagnostic tests through increasingly advanced and low cost tests[1].

The World Health Organization defined Telemedicine (TM) as "the use in consultation of medical knowledge via communication networks when distance is a determining factor"[2]. This definition makes clear the need for advanced technological support so that the practice of medicine should not be limited by distance from the patient. Technological infrastructure allows the exchange of information between the various parties involved in an act of TM and its main objective is to provide multimedia network services (transfer of audio, video, images, data and text) that enable healthcare attention between distant locations.

## Telemedicine in emergency healthcare

TMR has great potential in the field of emergency medicine (EM) since a large part of previous TM experience in other medical specialties fully applies in the field of EM. Emergency healthcare is complex but its most important requirement is rapid and correct decision-making on diagnosis and treatment. In addition, this

occasionally must be performed in situations other than in a hospital emergency department (ED). Thus in the case of accidents, emergencies, natural disasters, etc., healthcare is necessary in poor conditions and, most importantly, away from the reference health center, so that the distance factor and the time factor acquire great relevance for the successful diagnosis and treatment of affected patients.

In this context, remote tele-consultation by specialists in an emergency situation may be important for rapid, correct and specialized decision making, whether clinical or surgical[3], on immediate questions such as whether and where to transfer the patient or what therapy should be administered[4]. Rapid and specialized prehospital treatment improves prognosis in terms of mortality and morbidity and avoids complications and secondary effects[5].

The evolution of CITs towards greater reliability of new equipment is producing better quality healthcare for both professionals and the patients[6]. The implementation of CIT applications and TM will have a significant impact on public health practice in emergencies. Electronic patient registration, real-time monitoring systems and electronic medical records are some examples of the improvement expected due to CITs in the care of ED patients[7].

In any case, the implementation of TM systems in the area of emergencies is not new. Recent reviews of literature on this subject have shown that it is technically feasible, clinically effective and seems cost-effective, although this point requires further study[8,9].

## Telemedicine in out-of-hospital emergency care

In the case of outpatient care, TM in ambulances allows medical personnel direct access to a specialist. Reliable transmission of vital signs enables patient assessment by specialists in the specific pathology and immediate reception of appropriate treatment guidelines until the patient's arrival at hospital[5]. In conditions of extreme urgency (for example, myocardial necrosis, etc.), TM in the ambulance allows the initiation of patient monitoring and specialized treatment, as well as notifying the hospital, thus avoiding complicaciones[10]. For example, in one study paramedics telephone communication with cardiologists from the referral center for assessment and interpretation of electrocardiograms (ECGs) resulted in a 54-minute reduction in attention time in patients with myocardial infarction and ST-segment elevation (STEMI)[11]. For this study, 12-lead tele-ECG were validated for use in TM[12], and were shown to be feasible and useful[13-15].

The application of TM to out-of-hospital emergency assistance is also allowing experiments in the selection (triage) of patients before admission to the hospital emergency department. In this case, monitoring of tele-triage by specialists is recommended[16], but more relevant is the demonstration that tele-triage can significantly reduce (by 53%) the number of unnecessary visits to the ED[17].

The widespread application of technologies in the world, such as mobile phones, has opened up a range of possibilities for specialized care at the ED. For example, the participation of citizens in hypothetical emergency assistance. Thus, it is said that when cardiopulmonary resuscitation is performed by properly advised individuals using either simple applications installed in the mobile phone or direct telephone communication, mortality due to sudden death syndrome can be reduced significantly[18,19].

Monitoring of chronic patients by telephone is also important because protocols of emergency action can be transmitted immediately. This is the case, for example, of patients with chronic disease and depression with a very high suicide rate that may be reduced by constant telephone follow-up[20]. Patients with chronic diseases, such as cardiovascular or neurodegenerative diseases, may also thus be attended urgently by TM.

In this context, another situation is remote monitoring of treatment for patients with stroke, using TM. Videoconferencing facilitates thrombolytic therapy for these patients, resulting in better prognosis[21-23] and emergency care can be delivered faster. However, for some specific cerebrovascular disorders, such as basilar artery occlusion, patients should be immediately transferred to specialized centers, since TM would not provide any advantage in this situation and might even endanger patient evolution[25].

## Telemedicine and specialty emergencies

TM in the ED has very interesting applications in a number of specialties. These applications derive from the experience of the TM outside the scope of emergency care.

Thus for example, experience in tele-ophthalmolgy using images sent directly to an ophthal-

mologist by TM, provided a 100% concordance between the initial diagnosis made during the emergency tele-consultation and the final diagnosis made directly by the same ophthalmologist. In fact, 98% of patients indicated a preference for being treated at ED with tele-ophthalmologic support as opposed to the usual emergency consultation where they could be personally attended by a medical resident in training[25].

Diseases classified in the area of neurology and neurosurgery constitute a significant proportion of the activity of emergency services. In this case, almost immediate diagnosis and treatment are required to reduce mortality and neurological morbidity, although the diagnosis depends largely on the correct interpretation of radiological images of the patient by expert neurologists and neurosurgeons.

Thus, transmission of high-quality radiological images has proved very useful for ED physicians with little relevant experience who receive support from expert neurologists and neurosurgeons that provide the precise diagnosis[26].

In the hospital environment, electronic Personal Digital Assistant (PDA) devices, connected to wireless telephones or cell phones, are increasingly used for connecting to a central server at the hospital, allowing the transmission of audio, visual and vital signs from a remote site, such as the bedside, in real time[27]. Thus, in certain models of tele-radiology, both the consulting physician and the specialist can share the same information in real time using synchronous transmission of radiological images between the physician at the bedside and the radiologist at their workplace[3]. Moreover, some advanced prototype PDAs with transmitter modules of vital signs (noninvasive blood pressure, oxygen saturation, 6-lead electrocardiogram, blood glucose and body temperature) are proving useful in first aid emergency treatment[28].

Radiology is one of the specialties increasingly influenced by TM. Radiologists are responsible for providing constant radiological interpretation services, but as a result of the incorporation of new diagnostic tools for imaging, emergency radiology has experienced a marked increase in work over the past 5 years. In addition, there is a decreased number of radiologists available and the difficulty of establishing radiology night shifts. One solution to this problem may lie in the use of tele-radiology outside the borders and time zones of the country, using protocols of transmission of specific images such as DICOM (Digital Imaging and Communication in Medicine, a recognized standard protocol for exchanging medical images) or by Internet with security protocols.

Night-time radiology consultations could be covered by radiologists in foreign countries during their day time work period[29]. Thus, coverage of radiologist residents on call by skilled radiologists elsewhere in the world is today a fact. These programs have demonstrated better health coverage, increased quality of resident training and reduced stress and anxiety of night shifts when supported from the outside specialists in making diagnostic decisions[30].

Furthermore, TM in pediatric emergencies can be a valuable tool. Thus, in the care of acute respiratory illness in children, 85% of emergency consultations were resolved at the same clinic by means of TM consultation between the primary care physician and the specialist[31]. Tele-echocardiography in infants can also distinguish between those that require immediate attention in a referral hospital from others who have minor heart conditions that can be addressed in other ways, this allows rapid diagnosis, appropriate treatment and reduced ambulance transfer costs[32].

## Telemedicine in rural areas, prisons and military bases

In rural areas, emergency medicine is often complicated by limited technical and human resources for healthcare. That is why TM can be an important tool to improve the quality of health care in these areas, and there are many experiences of rural TM where distance to the reference hospital is critical. A crucial factor is the training of nurses supported by a TM system in real time in conjunction with medical specialists at the referral center. This obviates, in large part, the limitations of rural healthcare and results in a high degree of satisfaction of users, both patients and health personnel, as well as managers[33].

Analysis of costs resulting from the use of TM usually favor its use since TM reduces unnecessary transport of patients or medical staff. Thus, in a study in Peru, in the province of Alto Amazonas, a significant reduction in emergency transport was observed, which confirmed that the system was efficient and also demonstrated that the additional costs of maintaining the system were lower than the direct costs of the health system[34].

Prisons constitute another example of the need for healthcare in situations of isolation, where TM may have an important role[35]. In fact, tele-consultation prevents unnecessary emergency transfer of

patients and reduces time to receive attention[36]. It must be remembered that the transfer of prisoners involves not only ambulances and medical personnel, but also security forces, which significantly increases costs.

The concept and experience of TM in Military healthcare may be a good model for use in civil emergencies and humanitarian crises[37-39]. Thus, physician monitoring using videoconferencing significantly reduces unnecessary air transfers and consequently also reduces costs. TM can be an essential tool in supporting the process of decision making by physicians. In extreme cases of humanitarian crises, TM networks based on satellite communications can facilitate consultation[40], and mobile phones with satellite communications are the models of choice in these situations[41].

## Characteristics and technology of telemedicine application in emergencies

The large number of technological options available for conducting TM offers great flexibility, adaptable to different situations and applicable to emergency medicine from different perspectives. Thus, the user can choose between simple systems, which use Internet as the communication system, and dedicated communications networks that allow high-security consultations, and any of these options may suit the workplace , budget, etc. In any case, all offer different possibilities which must be evaluated so that they can achieve the proposed objectives of a TM system.

## Methods of telemedicine

In general, there are two basic modes of operation that will determine the type of technology to be used[42]:

- *TM in real time or synchronous mode:* in this mode, medical professionals interact in real time through video conferencing with live transmission of medical data. This modality, the most widely used and the maximum expression of TM requires high bandwidth communication to support the transmission of all the required health information.
- *TM in delayed or asynchronous mode:* Also known as "store and forward"(S & F), this mode is used in situations that are not urgent and in which a diagnosis or consultation may be deferred. In this case, patient diagnostic information is obtained at the remote site, stored and forwarded to the reference centre through appropriate communication channels and, finally, the information is processed and displayed in the reference center for specialists[43]. This model is commonly used in many medical specialties including dermatology[44,45], cardiology[46], radiology[47], otorrhinolaryngology[48], pediatrics[49,50], traumatology[51], etc. But this mode has limited applications in the field of emergency medicine due to the need for real time consultation and rapid diagnosis.

## Requirements for TM implementation

The benefits of TM systems depend primarily on the various medical devices used to capture patient information and the telecommunications infrastructure used. An important feature is communications bandwidth, whose requirements vary depending on the transmitted signal, its volume and required response time. Thus, quality videoconferencing TM needs a minimum dedicated bandwidth in a range between 0.5 and 1 Mb/s, while for sending pictures, vital signs and medical data less bandwidth is required. In a TM system, different elements can be distinguished (Figure 1), used for patient monitoring, data scanning and transmission through communication networks, and visualization of health data at another point. Accordingly we have:

1. *Terminal devices to capture biomedical signals:* ECGs, dermatoscopes, endoscopes, cameras, sensor-based systems (vital signs, ECG, glucose sensors, mobility and/or position sensors for the elderly or people with reduced mobility, etc.).
2. *Services, components and telematic applications for healthcare management.* All are software applications that enable service coordination (appointments, agenda setting), patient identification, patient file management (medical records system), messaging, data security systems, etc.
3. *Telecommunications equipment and systems.* The equipment used for both the patient and the specialist varies depending on the requirements. These include telephone terminals, personal computers, PDAs, video stations, computer peripheral equipment such as digital cameras, document scanners, high resolution screens, etc.[3].
4. *Communications network.* This allows the transmission of information to a referral center. Access to a communications network depends on the geographic location of the available technology, the bandwidth required, costs, etc., and in

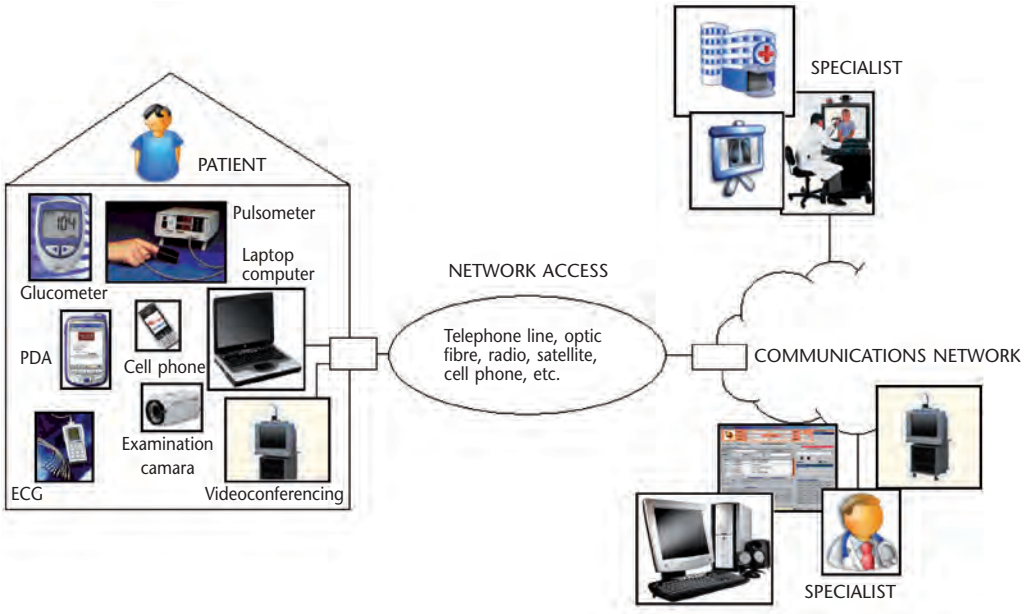


**Figure 1.** Components of a telemedicine system. PDA: Personal Digital Assistant.

TM, it must comply with a number of features such as scalability, transparency, fault tolerance, geographic coverage, security, etc.. We can distinguish two types of access: physical access (via cable) and wireless access (via radio).

a) *Physical access via cable:*

• *Subscriber Loop:* Use of the basic telephone network in TM is extensive, for example, pre-hospital telephone triage[16]. It also supports other technologies such as Asymmetric Digital Subscriber Line (ADSL) or Integrated Services Digital Network, (ISDN) used to provide TM support services[52], eg, home telemonitoring[53]. ADSL is used in the TM mode combining S & F with low speed videoconferencing[54].

• *Fiber optics:* With greater communication capacity, but less coverage, this is limited to large population centres or internal corporate networks of large hospitals, etc.[55].

b) *wireless access via radio:* this is an alternative to cable networks that supports interactivity through the return channel. The clear advantage of such systems is to reduce infrastructure costs. Highlights include:

• *Radio access networks (mobile phones):* GSM and GPRS networks, and third generation mobile phones (UMTS), allow voice, image and data transmission at high speeds, thus, extending the range of services and alternative access for those areas without a fixed network. This is widely used in TM: tele-monitoring of diabetic patients[56,57] in intraperitoneal dialysis[58], postoperative control and tele-surgery[59], etc. and even for ambulances[60].

• *Access via Satellite:* Expensive but feasible in certain healthcare situations; its main advantage is global coverage, for remote areas, in emergencies on planes and ships, where it is the best, or the only, option available for real time data transmission[38,55].

As can be seen, the technological possibilities applicable TM are extensive. To this must be added the ability of adapting existing medical equipment and connectivity to TM systems, from operating room equipment to vital signs monitors at bedside, personal glucose monitors, etc.

## Conclusions

Currently, medical practice using TM is a reality, evidenced by numerous experiences, pilot projects and research. TM is now a vital tool with great applicability in most medical fields and specialties.

The large number of publications devoted to this subject in the scientific literature, both national and international, suggests that the future of TM implementation in healthcare only depends on the ability to demonstrate its applicability and, of course, to demonstrate its cost-effectivenes for health systems. Undoubtedly, emergency medicine will increasingly be influenced by technology and the development of emergency care protocols based on TM. This is because the technology already exists, it is relatively cheap and accessible. Also, the requirements of speed and diagnostic re-

liability in emergency healthcare require increasingly reliable systems of communication between health professionals. All this enables greater guarantee of adequate healthcare in conditions that are often extreme in terms of situation, condition severity and/or distance to well equipped health centres.

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## Telemedicina aplicada a la atención sanitaria urgente: aspectos metodológicos y prácticos

**González Armengol JJ, Carricondo F, Mingorance C, Gil-Loyzaga P**

Actualmente la Telemedicina (TM) es una realidad en el trabajo diario de muchas especialidades médicas. El desarrollo y el aumento de la disponibilidad de las nuevas tecnologías de información y comunicación, junto con la flexibilidad de conectividad de los equipamientos médicos hace posible la asistencia médica de pacientes que tienen dificultades de acceso a un centro hospitalario. Una de las aplicaciones más importantes de la TM es la asistencia en Medicina de Urgencias. La experiencia acumulada por distintas especialidades médicas ha permitido un gran aumento de las posibilidades de atención urgente en las que la TM puede ser aplicable tanto en el entorno hospitalario como lejos del hospital. Además, las características propias de la atención sanitaria de urgencia, como son la necesidad de rapidez y de fiabilidad en el diagnóstico, hace que cada vez se requieran más y mejores equipamientos y soluciones. El incremento de la comunicación entre especialistas de urgencias con otras especialidades puede permitir mejores diagnósticos con la consiguiente disminución de la morbi-mortalidad en los pacientes que se atienden de urgencia. El presente trabajo revisa la aplicabilidad de la TM en urgencias, así como la tecnología implicada en ello. [Emergencias 2009;21:287-294]

**Palabras clave:** Telemedicina. Urgencias. Tecnología. Tecnologías de la Información y Comunicación. TICs. Telemática.

### ERRATA

In Volume 21, Number 3, June 2009, Journal EMERGENCIAS, on page 181, part of the article entitled "Value of ultrasound imaging of the lower limbs for the diagnosis of deep vein thrombosis in an emergency department ", Figure 4 was reproduced incorrectly. Here we reproduce the correct figure.

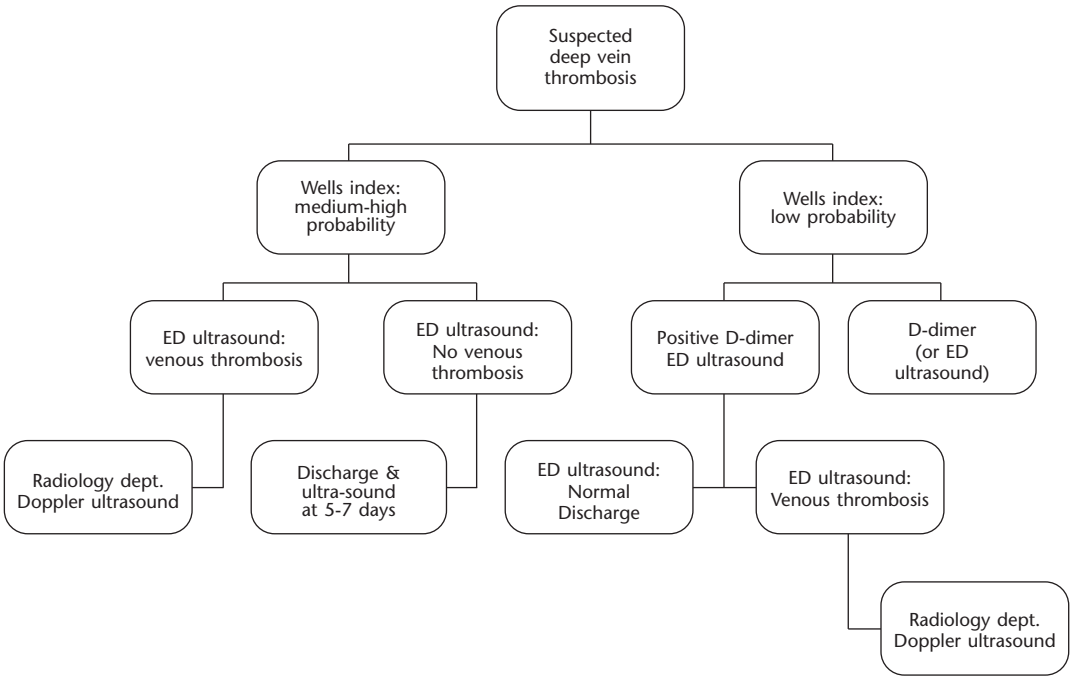


**Figure 4.** Diagnostic algorithm. ED: Hospital Emergency Department.