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European health telematics networks for positron emission tomography

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Abstract

A pilot network of positron emission tomography centers across Europe has been setup employing telemedicine services. The primary aim is to bring all PET centers in Europe (and beyond) closer, by integrating advanced medical imaging technology and health telematics networks applications into a single, easy to operate health telematics platform, which allows secure transmission of medical data via a variety of telecommunications channels and fosters the cooperation between professionals in the field. The platform runs on PCs with Windows 2000/XP and incorporates advanced techniques for image visualization, analysis and fusion. The communication between two connected workstations is based on a TCP/IP connection secured by secure socket layers and virtual private network or jabber protocols. A teleconsultation can be online (with both physicians physically present) or offline (via transmission of messages which contain image data and other information). An interface sharing protocol enables online teleconsultations even over low bandwidth connections. This initiative promotes the cooperation and improved communication between nuclear medicine professionals, offering options for second opinion and training. It permits physicians to remotely consult patient data, even if they are away from the physical examination site.

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1. Introduction

Positron emission tomography (PET) is a nuclear medicine scanning procedure which uses positron emitting radioactive isotopes to show function or metabolism rather than anatomy, as in conventional imaging techniques [1]. Most PET isotopes have short half-lives and occur naturally, so they can be safely administered to a patient in the form of a substance normally used by the body, such as glucose. PET is used to diagnose and monitor cancer, in addition to diseases of the heart, brain and lungs.

PET provides functional imaging in contrast (but also in complement) to conventional anatomical imaging modalities, such as magnetic resonance imaging (MRI), computed tomography (CT), ultrasound, etc. PET systems can be found in nuclear medicine departments of major hospitals or, as it is often the case, in independent health

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care centers (PET Centers). A PET installation includes extremely sophisticated and expensive instrumental equipment (camera, radiopharmacy, often a cyclotron unit for the on-site production of the radiotracers, and information technologies infrastructure) and requires highly qualified physicians and technicians. A total of about 1500 PET cameras (including modern PET/CT systems) are currently operating worldwide, separated by numerous barriers (language, culture, national borders and regulations, etc.). The proper set-up of a PET site requires a significant start-up time during which support, training and advice from experienced PET sites is necessary.

The trans-European network for PET (TENPET) initiative aims to develop specific services in order to bring PET sites closer using proven information and telecommunication technologies. The long-term goal is to promote a better collaboration among PET specialists, foster the dissemination of expertise and knowledge in the field and provide a useful tool for second opinion, remote reporting and training of new professionals, as well as a tool for better coordination between referring physicians and PET specialists.

In this area, little has been done until now, apart from some isolated efforts to enable remote viewing of nuclear medicine images [2,3] or the elaboration of some elementary guidelines for the practice of what it has been named "telenuclear medicine" by the Society of Nuclear Medicine [4]. Very recently, a device (POSITOSCOPE (TM)) has been presented in the form of a wall-hanged digital light-box, onto which a specific PET study can be loaded and visualized by means of a touch-screen display [5]. The operator can also dictate a voice message in an integrated digital sound recorder and then select from a list the colleague to whom he/she wishes to transfer the data (images/voice) and request an opinion on the case.

TENPET however goes beyond the restricted principles of remote reporting or simple second opinion. The TENPET services are implemented via a health telematics platform (TeleConsult) for transfer of medical data via a variety of telecommunications channels and for computer supported cooperative work (CSCW) on two-dimensional (2D) and especially three-dimensional (3D) medical images. The platform allows PET professionals to carry out a complete set of CSCW tasks with their peers, such as real-time on-line teleconsultations and off-line multimodal data transmissions, as well as to manipulate 2D/3D PET data using a sophisticated but at the same time easy to learn and use advanced visualization console.

The TENPET initiative is currently at a pilot evaluation stage. A network of four European clinical PET sites has been setup, located in Spain (Centro PET Complutense, CPC, in Madrid and Fundación Instituto Valenciano de Oncología, FIVO, in Valencia,), France (Centre Hospitalier Universitaire Morvan of the Université de Brest Occidentale, UBO, in Brest) and Germany (German Cancer Research Centre, DKFZ, in Heidelberg). MedCom GmbH (Darmstadt, Germany) provides the TeleConsult platform and the servers (virtual private network concentrator and jabber hub server) for secure teleconsultations. The Universidad Politécnica de Madrid (UPM) provides technological support to the clinical sites and expertise in telecommunications issues for the pilot trials. Fig. 1 shows a map of the current TENPET pilot network.

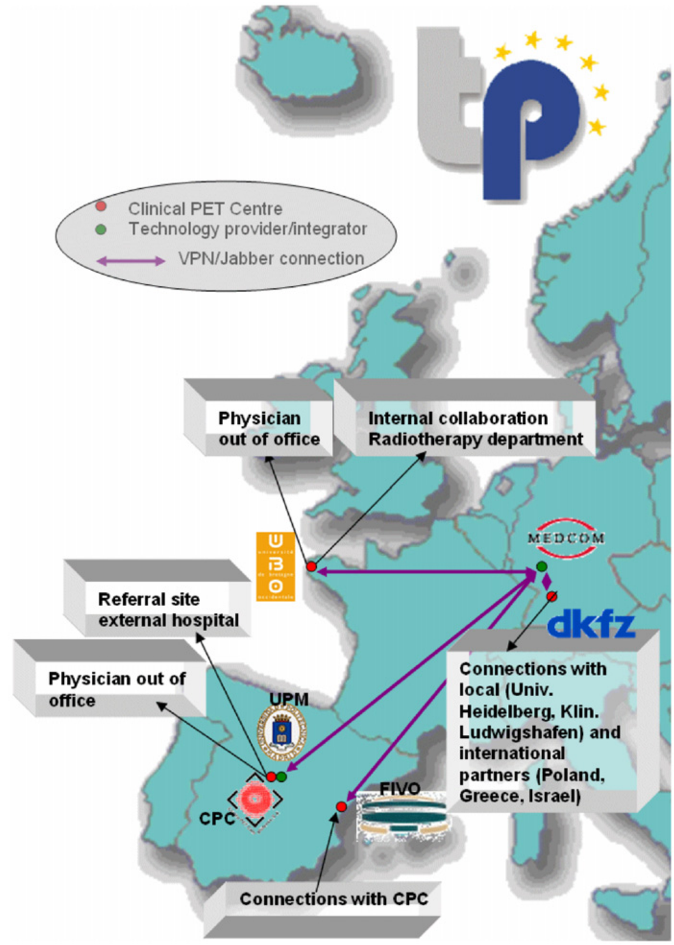

Fig. 1. The TENPET pilot network. Red dots mark the clinical trial sites (PET centers) with a description of the focus of the clinical trials at each site. Green dots mark the technological sites.

2. Methods

2.1. Off-line mode

The off-line mode for teleconsultations enables nuclear medicine doctors to send messages and seek advice or second opinion from a remote colleague. Parts of such a message can be PET image data (possibly also enriched with MRI, CT, etc., studies), additional information to images, like graphical or textual annotations, patient history and study information, free text, audio recordings, etc.

The status of the messages is monitored until they reach their destination. The information that is sent with the message will be directly stored in the remote doctor's database. Thus, images and annotations that have been sent can be loaded to the 2D/3D imaging software and they can also be used in a later online-teleconsultation between the two doctors. This enables teleconsultations sessions even in case of low-bandwidth connections, since large image data sets can be transmitted in advance (e.g., overnight).

2.2. On-line mode

The principle of the on-line mode is to bring two geographically distanced physicians together in an on-line session.

This mode can be used to transfer the related data (images, other documents, etc.) and discuss a case in an interactive manner by means of two connected workstations which display the remote actions (like mouse movements, etc.) in real-time. This mode is especially useful in combination with an off-line data transmission in order to discuss about previously transmitted data. This mode is supported by a tele-pointing option that is intended to point to certain details in a graphical image window. If activated, a second mouse pointer in both connected workstations is representing the remote pointer. Additionally a separate chat window, which allows text-based discussions, can be used as well.

The main principle for the on-line teleconsultation in TENPET is the scheme of two strongly coupled user interfaces ("What you see is what I see", WYSIWIS). In this approach both applications show exactly the same view of the data. In the TENPET application this means, for example, that if one user on one site selects a viewing direction for the 3D visualization of the volume data the user on the other site sees exactly the same volume rendered from the same viewing point. In general, any action on the one side causes the same action on the other side. There are some exceptions to this rule, for example if one user decides to store data, images or an animation locally on his/her disk, the remote application is not involved in these kinds of actions (Fig. 2).

2.3. Communication and security issues

The platform runs on PCs with Windows 2000/XP and incorporates advanced techniques for image visualization, analysis and multimodality image registration and fusion. Currently, ECAT (Siemens proprietary) and DICOM [6] formats are supported. The communication between two connected workstations is based on a TCP/IP connection via secure socket layers (SSL). Patient privacy is guaranteed with the option to anonymize patient data before transmission, which in addition is encrypted with the use of a combination of public key/private key and triple-DES encryption [7]. Image compression is also possible for faster transmission.

To overcome the problems imposed by the security measures taken by each institution to block incoming access to its systems via firewalls, virtual private network (VPN) have been established between the pilot sites in the TENPET network. For this purpose, a VPN concentrator has been installed at the Fraunhofer Institute in Darmstadt, Germany. An alternative solution has been also installed, based on the jabber protocol, an open-source Extensible Markup Language (XML) platform for instant messaging, which encapsulates the data to be transmitted into Hypertext Transfer Protocol (HTTP). A hub server, also installed at Fraunhofer Institute, accepts all incoming connections and forwards the data to the remote nodes connected it, permitting both on-line and off-line connections [8].

3. Results

The current phase of the TENPET pilot clinical trials started in February 2005. During this period, numerous on-line and off-line teleconsultation sessions between the participating PET centers have been carried out. Furthermore, remote reporting by the principal physician in each site has been tested and in some cases, referring institutions outside the core TENPET network have been involved in trials. The TENPET platform has been tested in the form of an advanced visualization console as an aid in multi-disciplinary meetings the team at the University Hospital in

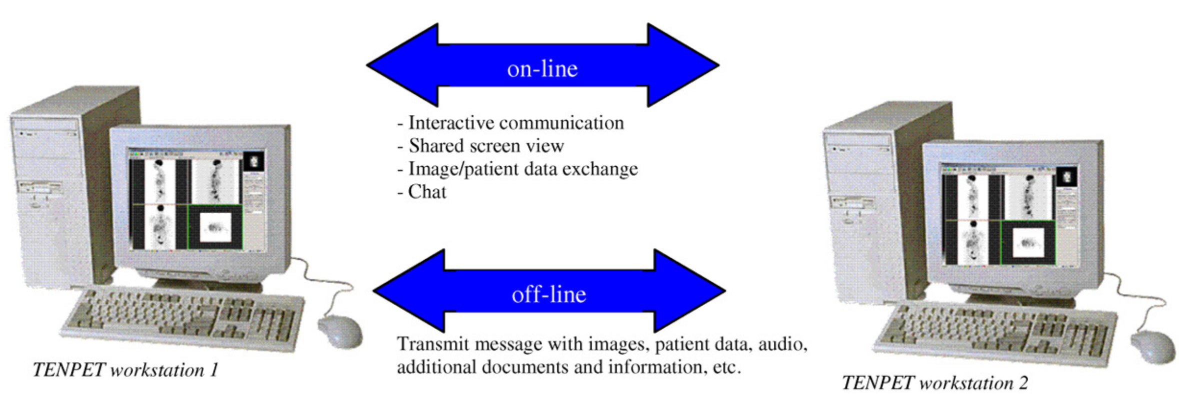

Fig. 2. Schematic of the principles of on-line and off-line teleconsultations between two TENPET workstations.

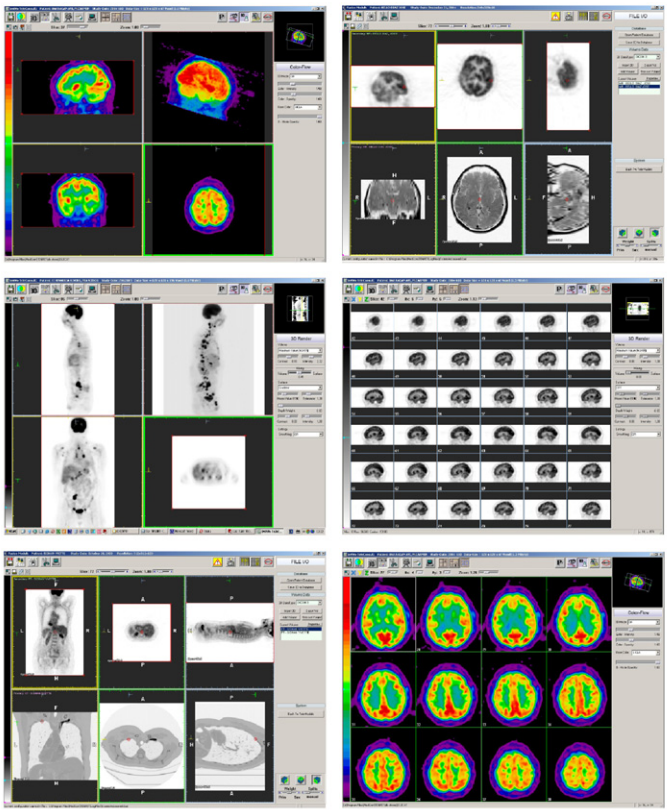

Fig. 3. Various views of the user interface of the TENPET platform.

Brest. This team has also tested the adequacy of the platform in supporting therapy management in oncological patients and the communication between nuclear medicine, diagnostic radiology and radiotherapy departments. Future trials will include the option for remote support to mobile PET sites.

A feature particularly valued by the physicians is the availability of the complete patient image set for evaluation and diagnosis, instead of static snapshots typically transmitted in cases of remote evaluation (Fig. 3).

Regarding the establishment of a connection between two workstations, it has been realized that the use of VPN implies several restrictions, like the necessity that even for off-line transmissions both workstations must be turned on and connected to the network. This happens because the TCP/IP-based off-line transmission does not recognize the IP address of the remote workstation outside the VPN. A solution to this problem has been given with the implementation of the jabber communicator [8]. This way, off-line messages are addressed to a specific user registered to the hub server and are stored there until the recipient logs in.

4. Discussion

TENPET establishes a telecommunication link between physicians in specialized centers, peripheral hospitals and other points of care in order to improve the continuum of patient care. Until now, when a particular case is difficult to diagnose with confidence, the PET specialist in charge addresses his/her peers via mailing lists or web sites, soliciting assistance. The TeleConsult platform that implements the TENPET services, eliminates this hassle and offers to PET specialists a tool and specific methodology to contact other colleagues and request their cooperation in an efficient, easy-to-use and standardized procedure. Furthermore, TENPET can help PET medical personnel to approach their colleagues and maintain close links with them over the large distance that typically separates PET Centers from each other.

TENPET services can be offered to PET Centers, mobile PET units, regional health centers, large and small hospitals and clinics, with or without nuclear medicine services. In a broad sense, users of TENPET services can be all imaging departments of major, regional or local hospitals, clinics and health centers, as well as physicians and other medical professionals at their private offices.

The TeleConsult platform is easy to install, use and learn. It offers a complete health telematics software solution that can be used either by individual physicians in their private practice, or by larger PET Centers and centralized hospital units. TeleConsult does not require complex maintenance procedures, its use is straightforward and a teleconsultation session is opened with the press of a couple of buttons, without the need of complicated procedures. User training is required, but with less than a week of training most users are able to work efficiently with the system and use all of its features. For these reasons, it is expected that the service has the potential to become a standard tool in all operating PET Centers in the near future.

The real-time access to medical information and related data from electronic patient record, results in a cost-effective management of healthcare resources. Difficult cases are resolved with the easy contact of experts, based on established protocols and without distance or language barriers. Personnel training at remote PET sites can be performed in a cost-effective and at the same time efficient way.

Beyond training, there is often a gap between functionalities expected by physicians and the ones developed by engineers. Therefore the application envisioned by clinicians must be carefully specified, understood by engineers, and implemented. For the TENPET project, special attention has been paid to the ergonomics and the reliability of the platform. As a PC Windows-based application, the TeleConsult platform has been exhaustively tested against bugs and breakdowns, which can easily irritate and disappoint the medical users who will then rapidly return back to their usual ways of working, based on light-boxes and dictating devices. In addition, the user interface of the platform is particularly user-friendly and designed in a non-conventional way comparing to most Windows-based applications. Menus are intuitive and selections are made based on icons rather than on long lists in multiple menus. This is quite important as physicians have limited time to spend in learing new computer applications and in general still show limited interest in using computers.

Until now, several companies and consortia have developed electronic devices and software tools for teleradiology related applications, where images play the central role. Most of the resulting prototypes have been technically successful and considered by clinicians as very useful in clinical practice. However, they have not been extensively used by clinicians in daily practice. This is a major concern that is being addressed by the TENPET pilot trials, which now focus on the market validation of the platform rather than on the evaluation and assessment of the implemented technologies. This means that the TENPET services will be launched in the market immediately upon completion of the current phase of the clinical pilot trials.

To reach this goal, it is necessary that PET physicians and other implicated professionals must be assured of the system's quality. On the other hand, given that it is well known that clinical staff may regard telematics applications as a professional threat, they must be assured that there will be no intrusion to their usual routine and they are not going to be monitored or spied upon with this platform.

For the widespread of the TENPET services, a major obstacle is the fact that in many European countries no indication has been published by their national healthcare system on how to manage financial matter in telematics medical advice. Indeed, health telematics are generally being hobbled by regulatory and reimbursement policies that do not reward innovation and efficiency. In fact, the growth of disease management will increase the use of telecare systems. The potential advantages of such systems are enormous and it is certain that regulatory and bureaucratic impediments will be overcome sooner or late. Authorities will find the way to take into account the market forces of supply and demand, so that good, inexpensive healthcare can be widely available. However, for the specific case of TENPET applied to second opinion or remote reporting, it is imperative that all legal and financial issues, related to sharing the responsibility of performing and evaluating a PET study, are solved, both at national and European level, to open a large market which will justify the large investments required to fully deploy the product.

5. Conclusions

The TENPET pilot network has been set up in three European countries. The main goal is the market validation concerning the provision of integrated teleconsultation and computer supported cooperative work services between PET Centers in Europe in terms of health care and cost improvements, at both national (Spain) and European (Germany, France, Spain) levels. These PET-specific health telematics networks are based on the requirements of each participant at the pilot trials and have been set up according to national and EU regulations and restrictions. This initiative responds to the inherent necessity for collaboration and knowledge dissemination among PET professionals. The long-term vision of this project is to set the first step towards the formation of a solid network covering most of the European PET sites.

Acknowledgments

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