Easy Electronic Transfer of Nuclear Medicine diagnostic examinations for clinical use and doctors' education

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Abstract: The aim of this work is to fully implement alternative services that Internet offers to the easy transfer of complete patients' examinations. Prosperity of easy interchange in every day practice of Nuclear Medicine found its application through the Internet media. We use a simple and safe way to interchange images of a gamma camera and diagnostic information between the scintigraphic acquisition and processing location and the clinical departments, in order to improve patient's health care and young doctors' education. We present, here, our experience in transferring patient data, reconstructed slices, and 3Dimensional (3D) images and display to medical specialists. Images and patient reports are transferred and saved through dedicated software to a workstation that transforms gamma-camera scintigraphic images in a PC readable format. Diagnosis reports and scintigraphic images are incorporated to a database directory in hypertext form or a pdf (acrobat) format

The gamma camera data are transferred to the local server PC via a Local Area Network - in which the medical system computer is also included- and are modified by Procyon Starlab software to bmp type image files. After the images have been transferred to the local PC as bmp files, an image-processing programme can manipulate them, in order to change the colour scale or emphasise at certain details. The series of reconstructed images from the gamma -camera dedicated computer are also transferred to the local PC. Medical record data are combined with the images and movies that can be sent as an attachment via an e-mailer functioning under Windows environment.

The receiver side should be equipped with a similar e-mailer and can view or print patient's set of images and data through a suitable browser. The mailed series of images are characterized by diagnostic quality analogous to that of the original sets; then someone can see them as simple series or in a cine form of tomographic slices, dynamic studies and 3D images of a gamma camera.

Transfer via e-mail has been used in our center for the exchange of complete studies including data, images and movies to and from our colleagues when particular patients are concerned. E-mail transfer of a full patient template enables the archiving of particular files from the authors' Institute database ensuring the security desired and it has been proven to be a quick and safe mean of exchange of dynamic set of Nuclear Medicine information between physicians and scientific centers. Furthermore, both patients' and educational files can be downloaded, from our department ftp location, by a unique safety password.

Usual WWW connection gives the possibility of easy examinations transfer as well as interchange of relative comments towards both directions. In this way quick and cost effective solution has been achieved using standard hardware and software.

Keywords: e-learning, nuclear medicine data, scintigraphic image transfer, medical electronic education

Background Prosperity of easy interchange in every day practice of Nuclear Medicine found its application through the internet media .The opportunity of images and knowledge exchange between scientists has been facilitated by net technology development. Internet offers alternative services that provide the Nuclear Medicine world with means for communication. Exchange of ideas and knowledge between scientists has always been of vital importance in all scientific fields. Especially in medicine a particular difficulty encountered was the secure and quick transportation of diagnostic images. The advent and development of net software and hardware has enabled the immediate exchange of images as well as all required patient data between scientists and medical departments. Additionally the opportunity offered by the WWW of immediate access to scientific sites has contributed to the notion of a global community in medicine. Telemedicine technology, for processing and transferring the examinations results, integrated with the decision process to provide further treatment for a patient, is an important way to overcome healthcare difficulties. Medical knowledge network reduces costs (for example, patient transportation) improve the quality of healthcare service and promotes better patient care, making faster diagnosis and creating a patient information history. The delivery of comprehensive nuclear medicine services to patients and referring physicians is increasing around the world. The range and benefits of these procedures are gaining in both recognition and appreciation. Their role in medical decision making, as part of standard patient care, is very helpful. The concept of centralization of nuclear medicine and radiopharmaceutical services leads to the situation that patients may be studied in a hospital according to accepted protocols, and the data transferred to a central point for analysis and reporting. So, the future successful distribution of nuclear medicine services may depend on high speed image data transfer.

Nuclear medicine is one of the areas to benefit most from advances in information technology, especially through the widespread use of personal computers and the Internet. Many Nuclear Medicine centres are now fully digitized and electronically connected to permit clinical study file exchanges, remote reporting, collaborative research and Tele-education. This in turn enables nuclear medicine physicians to assist students and colleagues who work in new centres or in remote areas. These nuclear medicine practices have proved to be cost effective and to have a very bright future in promoting the development of the speciality. Internet offers the service of electronic mail that can be used for personal exchange of individual patient images and data, safely and instantly. The use of e-mail as the mean of image exchange ensures security of transportation. The process is easy and quick and does not require any particular software or hardware knowledge from the user. It also does not require any sophisticated computer systems. As patient records become increasingly digitized, they are more easily transmitted between various healthcare sites and personnel. Medical data distribution

through telecommunication -wireless or not- is rapidly becoming commonplace in clinical practice. As a result, a set of problems arises, concerning data confidentiality and integrity. It is important for telemedicine applications to employ end-to-end encryption mechanisms securing the data channel from unauthorized access or modification. We can use a network access and encryption system that is provided by our Institute.

Method The core part of Tele Nuclear Medicine is image transfer over the Internet. Simple Tele Nuclear Medicine practice requires an image acquisition site coupled with an image processing and interpretation site.When the quick and simple transfer of particular patients' data is required we have found the e-mail service to be very satisfying and reliable. Here we present our experience of utilizing the e-mail service for transfer of patient data towards different medical departments.

Scintigrams are frequently significant help in kidneys' and skeleton diagnostic problems especially of paediatric clinics and transplantation units. Also, in several cases, by myocardium scintigraphy, patients may avoid other interventional diagnostic methods as the angiography is.

We fully implement alternative services that Internet offers to the easy transfer of complete patients' examinations. We have been experienced in transferring to medical specialists, patient historical data, diagnosis sheets and scintigraphic images. These images may be simple planar images in any classic image format or single photon emission tomography (SPECT) slices and 3 Dimensional (3D) SPECT images or video (movies) form and animation display.

The use of e-mail as the mean of image exchange ensures security of transportation. The process is easy and quick and does not require any particular software or hardware knowledge from the user. It also does not require any sophisticated computer systems.

Our gamma-camera works under a RMX Operating System. The acquisition data in an img interfile format are transferred to the local server PC. In the Local Area Network - in which the medical system computer is also included- interfile images are modified by Procyon Starlab software to bmp format image files. After the images have been transferred to the local PC as bmp files they may be manipulated by an image processing programme in order to change the colour scale or emphasize at certain details. Series of images (SPECT slices and/or 3D processed SPECT images as well as dynamic studies), are transferred from the gamma -camera dedicated computer to the local PC in the same way. Medical record data are combined with the images and movies in a hypertext file or an acrobat pdf format file that can be sent as an attachment via an e-mailer functioning under Windows environment.

Any mail receiver part is equipped with a similar e-mailer and can view or print patient's set of images and data through a suitable browser. The mailed series of images are characterized by diagnostic quality analogous of those original sets that someone can see as simple series of tomographic slices, dynamic studies and 3D images of a gamma camera.

Transfer via e-mail has been used in our centre for the exchange of complete studies including data, diagnosis sheet, images and movies to and from our colleagues when particular patients are concerned. E-mail transfer of patients' templates enables, also, the archiving of particular files in the Institute database. It has been proven to be a quick and safe mean of exchange of scintigraphic information between Nuclear Medicine department and physicians or scientific centres. It is important,

however, to ensure the confidentiality of patient data at all times. So, furthermore, patients' files can be downloaded, from our department ftp location, by a unique password. All images are stored in our ftp directory in an uncompressed mode (*.bmp).

On the other hand, the Internet has provided many new opportunities for education in nuclear medicine through distance learning. Universities, teaching hospitals, scientific societies and international organizations place a range of teaching resources on the Internet, for easy access and downloading. Teaching materials on the Internet are used in this project for both education and on-the job training of doctors in Nuclear Medicine. Teaching resources of Quality Assurance and Nuclear Medicine Physics are available to be sent, similarly as the patients' template. They are also stored on CD/DVD devices so that these resources can be accessed in any conventional computer system.

Material –Procedure In order to interchange images and data the system feasibility and planning must ensure that would give clinically acceptable performance. Several steps were carefully followed to ensure utility and resolve problems with networking and software: These were referred to design, equipment specification, equipment selection, pre-installation testing, installation and final testing. Necessity for getting the possibility of transferring the files is: a software for modification of *.rmx to *.bmp format (procyon starlab for GE interfile format) and an image processing software; an e-mailer functioning under windows environment and an WWW browser; the knowledge to combine image and medical record data in a hypertext file or in a pdf format file; and lastly, how to transfer these type of files as an attachment via an e-mailer The availability of an ftp directory gives the flexibility of data download, by password, in safety.

The first problem encountered is the transfer of images from the gamma-camera dedicated computer to a PC and then the image can be manipulated as any image file The gamma-camera used is a GE camera working under a rmx operating system. The data are transferred to the local PC via a Local Area Network and are modified to *.bmp uncompressed type image files through Procyon Starlab software (*Figure* 1).

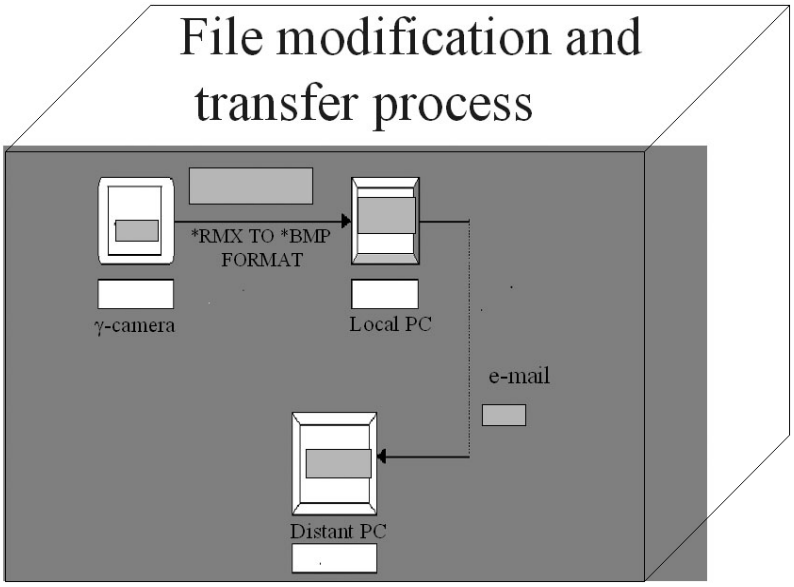


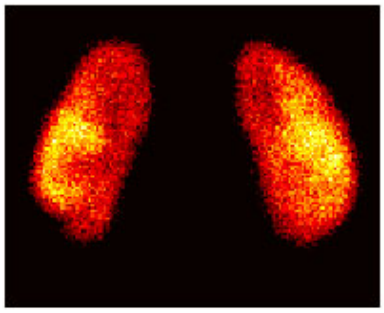
Figure 1: File modification and transfer process

After the image has been transferred to the PC as a *.bmp file it can be manipulated by means of an image processing program and may be transformed to compressed files (.*jpg or *.gif) for transfer time and space economy without image resolution loss. The mailed images are characterized by diagnostic quality analogous to the one of the original image. Medical record data are combined with the image, in a hypertext or acrobat *pdf file that can be sent as an attachment. The e-mail service has been used by the authors for the transfer of particular patient data (*Figure 2-10*), as well as for the transfer of teaching files (figure 11-13).

Few examples of patients images/records transfer are following

Patient #A

Patient's data and short history: 12 years old, girl, 39°C fever since last week. Direct Cystography and Ultrasound study: normal.



Posterior projection. Left Kidney: decreased concentration of radio pharmaceutical on upper inner edge Relative uptake: LT Kidney 47%, RT Kidney 53%

Figure 2: Posterior planar view of a Tc99m-DMSA scan as received in hypertext format by e-mail

Patient #B

"Neuroblastoma (known). Posterior projection 24 hours post injection of I123 MIBG (Meta- Iodo-Benzo-Guanidine) Follow up of the disease"

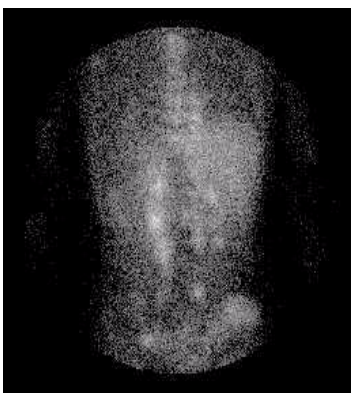


Figure 3: Posterior planar view by I-123 MIBG; data received by email in a follow up paediatric patient study, in order to decide his further therapy schema

Patient #C

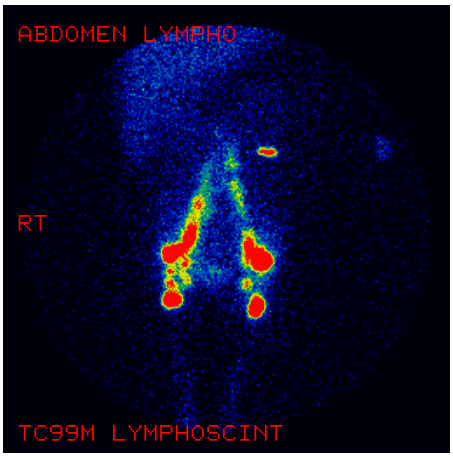


Figure 4. Lymphoscintigraphy for oedema origin detection

Figures 5, 6 and 7 present the planar, coronal and 3D kidneys' images respectively, for one characteristic case.

Patient #D

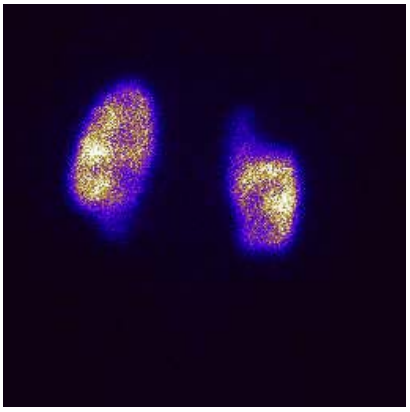


Figure 5:Tc99m-DMSA posterior planar kidneys' image (All data are projected in one image)

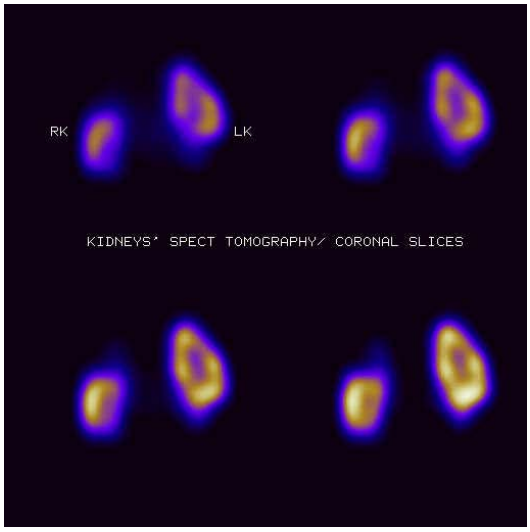


Figure 6: Tc99m-DMSA four detailed coronal kidneys' slices produced by reconstruction of 32 digital planar projections, showing higher resolution comparing to simple posterior planar projection in figure 5

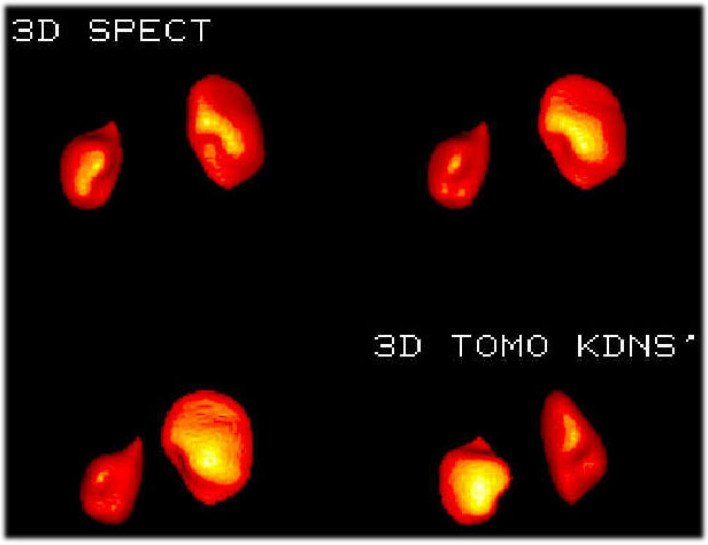


Figure 7: Three dimensional surface Tc99m-DMSA kidneys' images, by iterative reconstruction of transaxial reconstructed slices

Patient #E

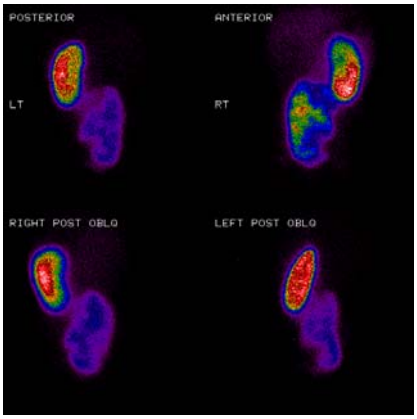


Figure 8:. Four planar images of kidneys. Ectopic right kidney with reduced radiopharmaceutical uptake and function

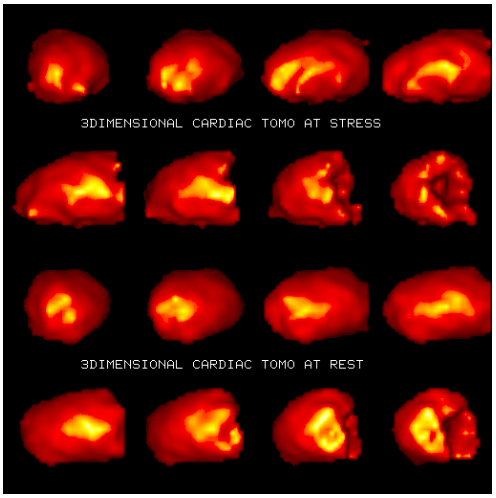


Figure 9: Three dimensional images series from a cardiac study by Tl201 Chloride and iterative reconstruction of transaxial slices

Examples of demand for a file submission

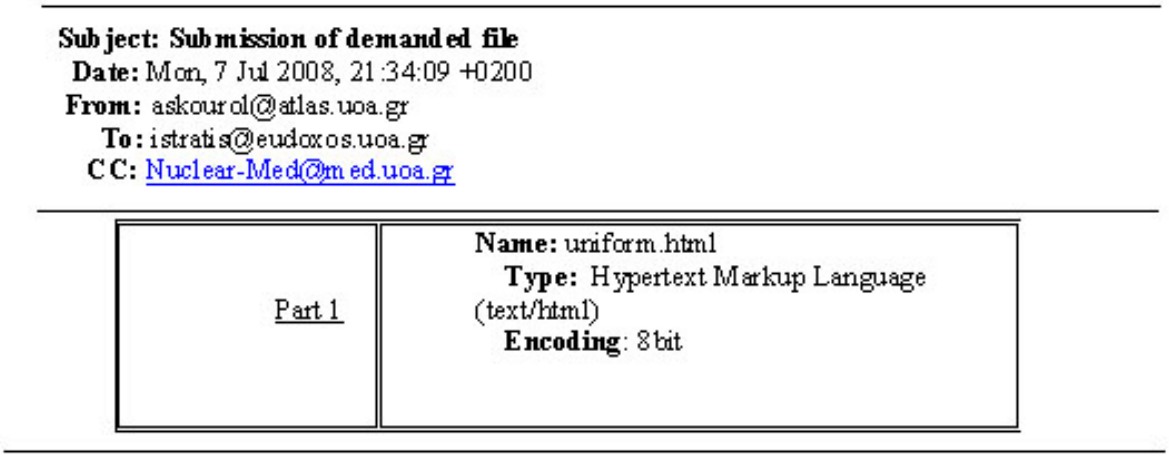


Figure 10: An example of e-mail transfer of the hypertext file uniform.html resulting in the receipt of a patient's template.

Example of scientific record transferred

*Table 1: Planar and Integrated Over Volume (**IOV**) indices*

*(**M, U, L** denote the **m**iddle, **u**pper and **l**ower parts of the kidneys correspondingly)*

	POSTERIOR PLANAR VIEW						VOLUME INTEGRATED					
	RT KIDNEY			LT KIDNEY			RT KIDNEY			LT KIDNEY		
PATIENT	M/U	M/L	U/L	M/U	M/L	U/L	M/U	M/L	U/L	M/U	M/L	U/L
#1	1,27	1,25	0,99	1,15	1,13	0,98	1,75	1,83	1,05	1,27	1,52	1,19
#2	2,13	1,06	0,5	1,28	1,08	0,84	2,70	2,39	0,88	1,78	2,2	1,24
#3	1,32	1,28	0,97	1,42	1,41	0,99	1,85	2,03	1,10	2,10	2,56	1,22
#4	2,21	1,75	0,79	1,82	1,79	0,98	2,89	2,32	0,80	2,45	2,86	1,17

In Table 1 the indices calculated from planar and tomographic images are presented.It has been demonstrated by many studies that SPECT imaging of the kidneys, by Tc99m-DMSA, can provide the physician with extra qualitative information on the anatomy of the kidneys, especially when children are concerned.

Example teaching files and images transferred

Home Page | Quality control | parameters

Teaching file

(Quality assurance programme and transfer options)

QUALITY ASSURANCE

A Quality Assurance program has the aim of ensuring that the performance of the equipment and the department in general is maintained at the best of its capabilities. Quality Assurance programs, protocols and various phantoms for their application have been set by various organizations (NEMA, IEC) so that every Department can organize its own program according to its needs and workload. We are just describing the QA program followed in our Department which has been proven to be efficient in keeping the instrumentation working properly and prevents any deterioration.

Acquisition Check

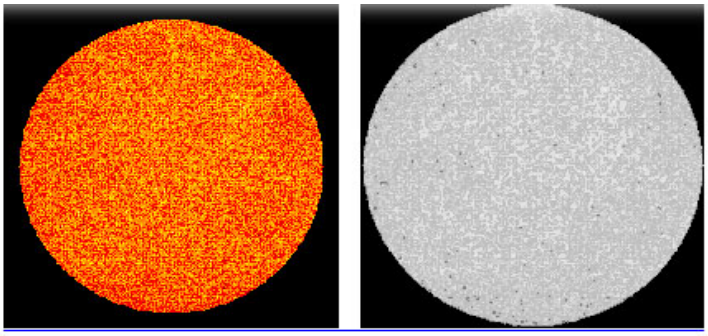
Uniformity	**Spatial resolution**	**Energy Resolution**
Count Rate Performance	**Linearity**	**Centre of Rotation**

Figure 11 Teaching file on Quality assurance program

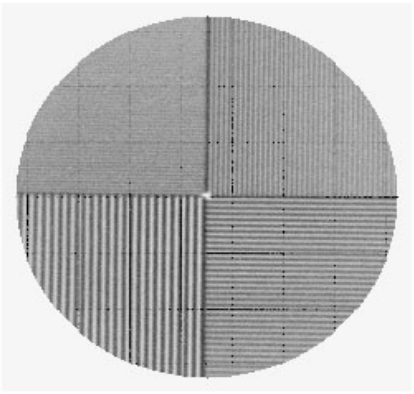
γ-CAMERA UNIFORMITY

Uniformity is a measure of the slightly different response of different areas of the detector to irradiation by a uniform source. The parameter is measured with or without the collimator. The calculations are carried for the Useful and the Central Fields of View (UFOV and CFOV respectively). Uniformity is checked daily by the acquisition of an image containing at least 3.000.000 counts. Additionally a uniformity check image of 30.000.000 is acquired per week. From these images the integral and differential non-uniformity as well as the coefficient of variation of the pixel counts are calculated

Figure 12 Teaching file on Uniformity Quality Control Test



Uniformity check procedure



Gamma camera Resolution Test

For further information contact

apikon@ermis.acci.gr

Figure 13: Quality Control of gamma camera teaching images, for doctor education on system quality assurance

Results

Referring doctors can get access to images and curves as well as reports of the patients [this simple process is very useful in reporting of emergency scans or dynamic studies]; Our patient directories are stored in a trimester basis. in our department's ftp location [ftp.medimaging] and doctors can reach by a unique password. They can download patients' files for a follow up or for statistics or even files referred to radiation burden, radiation protection or quality assurance procedures in Nuclear Medicine. The time for image downloading is short due to image compression.

Transfer via e-mail has been used in our center for the exchange of images to and from our colleagues when particular patients are concerned. The transferred images are characterized by diagnostic quality, and are not distorted by the transfer process. Electronic mail is also used for the transfer of teaching files. E-mail transfer enables the archiving of particular files from the authors' Institute database ensuring the security desired and it has been proven to be a quick and safe mean of exchange of images between scientists and scientific centers. The process is easy, immediate and valuable for the transfer of large number of images. We launched this project 4 years ago and since then more than 3600 patients' information exchange has been recorded. Our ftp directory is accessed 9 times per month and 5 email requests are reached at, per day on an average.

Conclusion:

This is a simple, user friendly, inexpensive, electronic way of quick file transfer that satisfies the expanding interest, competence and demand on Nuclear Medicine. It is characterized by flexibility in image processing and provides geographic freedom. It is reliable using industry standard systems and devices; it demands low maintenance and simple remote system administration. A full patient template transfer enables the archiving of particular files. Large databases of images and templates are available on first demand as diagnostic references. Quick communication and analysis of the diagnostic problem is possible in order to obtain a second opinion from the specialist.

Furthermore coordinated diagnosis from gamma-camera and ultrasound patient studies [multi modality] is an extension of our schedule that is now in progress.

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