My Colourful Sketches
From Scratch
MOLECULAR IMAGING

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MOLECULAR IMAGING

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ABSTRACT

Have you heard the story about the tortoise? Only through perseverance did it manage to get to the boat. It is up to you how much you are willing to sacrifice and how long you want to fight before you obtain your goals. If you decide to pursue a road, then make sure you stick with it until the very end.

I believe that these life lessons are the key to fulfillment. PET, CT, and MR are molecular imaging tools. Combined PET-CT has evolved into an established clinical tool in diagnostic imaging. The facility need to be optimized and standardized to help improving the clinical management of patients.

"MY COLORFUL SKETCHES FROM SCRATCH" Molecular Imaging is about the struggle on establishing the specialized field of Molecular Imaging, PET-CT in particular, through academia and international networking.

I hope my story will inspire those out there looking for their own niche be it academic or non-academic encounter.

MY HISTORY

Although some people might find history a boring subject, 'Sejarah' was my favourite subject in school. The stories from history inspired me and I also find them as an important source of inspiration. We can learn from history and history can be a life-long lesson and a 'living' example for many, decades later. One of my passionate destinations in history is the Ottoman empire possibly because of its strategic location in the world map blending the culture between Asia and Europe, also being the largest and longest Islamic empire ruling with numerous footprints in the holy city of Mekah and Madinah.

Figure 1 The battle of Constantinopole from Bataille de Malazgirt (1071). Romain IV et Alp Arslan Cote : Français 226, Fol. 256 #131 [http://gallica.bnf.fr/Catalogue/noticesInd/MAN00897.htm] Boccace, De casibus (traduction Laurent de Premierfait), France, Paris, XVe siècle, Maître de Rohan et

Minority Turkish invaded Constantinapole. They were great inventors of water pump, clock system and sanitation system. When I started my career, I was fond of learning about places, people, culture and their civilization. Soon I learnt that the civilization brought by the Turkish empire had something to do with the Tulip industry in Holland.

Figure 2 The tulip industry in Holland

My curiosity around foreign work attitude and culture has brought a new horizon in my observation about life and my career path. I gained experience from many short visits, adapting and adopting myself within working clusters of scientists especially around Europe ranging from a simple culture difference which can be observed at dinner with the Milanese whom are particular about dress code and proper shoes.

I observed the skills of extroverts and introverts. Most of our colleague are sensing type of personality but majority are judger and perceiver. Decentering observations in the past helped in my character development and as guidance in positioning myself in their community. A small observation which can make a big difference to gain acceptance in their academic community.

Where Do I Begin

I shall begin the story about my professional career development as a radiologist in 1996 as soon as I graduated from University Malaya with Masters Radiology. Soon after 2 years working at Sultanah Aminah Hospital Johor Bahru, I was offered the Fellowship position in Nuclear Medicine at Westmead Hospital, Sydney, Australia. This was the start of my career path in Molecular imaging. At the end of my posting as a fellow, I published my first academic article as the first author in the *Journal of Australasian Radiology entitled Dual phase 99m-Technetium Sestamibi imaging with Single Photon Emission Computed Tomography in Primary Hyperparathyroidism: Influence on surgery* co authored with my supervisors [A Jalil Nordin, G Larcos, O.Ung**.** (2001) 45, 31-34].

It was a big responsibility to complete the article until publication. I was wondering why did I do it, how I did it and what made me do it. Not until 10 years later I found my 'own' passion in doing research in the domain of molecular imaging and start writing my own experiences.

My returning to Malaysia was the turning point into maturity. I was immediately re-positioned at Hospital Tengku Ampuan Afzan, Kuantan Pahang defeating the purpose of my prioritized intention in my professional career development. I joined the Pantai Specialist Group of practice in Klang Valley as a Consultant Radiologist in 1999. There I was surrounded by the senior physicians and surgeons who had been in clinical practice for more than 20 years. I continued my interest in the subject of Nuclear Medicine by teaching undergraduate program at the University Teknologi MARA as a visiting lecturer and supervised their hands-on practical sessions in Radiology.

Belonging to the new generation of practitioners with different mind set and exposure in modern hospital practices, I realized that

I have my very own niche to be accomplished. My major concern was what did I contributed to the nation in the field of medical imaging and how much. Thus, I decided to join the university in 2003 as a senior lecturer establishing the Nuclear Medicine Unit of the Radiology Department, Faculty of Medicine and Health Sciences of Universiti Putra Malaysia. After 7 years of concentrated effort in the field of Nuclear Imaging, I established the Centre for Diagnostic Nuclear Imaging of UPM in 2010.

MEDICAL IMAGING –BRIEF HISTORY

The history of medical imaging dated a long way back in late 18th century. It began through the discovery of X-ray in 1895 when a German physicist Wilhelm Conrad Roentgen was experimenting cathode tubes in his laboratory. He observed a fluorescent glow when he pass an electric current through a glass tube filled with special gas. He continued his experiments by 'shooting' the ray passed through several objects including the hand of his wife Bertha with a ring on her finger. Later Roentgen named this unknown ray as an 'X'-ray ; a ray with unknown quantity. In his experiments, he found that X ray would pass through tissues leaving bones and metals visible. Ever since, the field of radiology became a medical sub-specialization and continued growing in the first decade of 1990s. In the following years, X-ray was vastly utilized in clinical settings to identify bone fractures and gun shot wound during the world war. The discovery bagged Wilhelm Conrad Roentgen the first nobel prize winner in physics in 1901. A year following X-ray discovery, in France, Henri Becquerel accidentally discovered a new 'radiation' emitted from uranium which was contained within a sun-light proof paper exposing his photographic films. The source of radiation was termed as *'radioactive element'*. In 1903, Henri Becquerel won the nobel prize winner in physics.

Table 1 Time-line ; history of medical imaging from the discovery of X-ray in 1895 until the 'invention of the century' Fusion Integrated Imaging Positron Emission Tomography Computed Tomography (PET-CT) in the year 2000

1895 - *Discovery of X ray by Wilhelm Conrad Roentgen*

1896 - *Discovery of radioactive elements from uranium by Henri Becquerel*

1898 - *Discovery of polonium and radium by Pierre Curie and Marie Curie*

1900

1906 to 1912 - *discovery of X-ray contrast media*

Early to mid 1900s - *Vast clinical use of X-ray during world war*

1934 - *Concept of positron or electron with positive charge and annihilation by Enrico Fermi in Rome*

1950s - *Clinical use of gamma camera*

1946 to 1960 - *Invention of cassette changer, fluorescent screen and image intensifier*

1960s - *Clinical use of ultrasound*

1967 - *Discovery of Computed Tomography by Godfrey N Hounsfield in London*

1970s - *Era of digital imaging*

1972 - *The discovery of MRI by Peter Mansfield in Nottingham*

1973 - *The first clinical CT Scanner at Mayo Clinic.*

1980 - *The first MR prototype*

Evolution of CT Technology - invention of helical CT with multislice, multi detector and dual source capability

1998 - *prototype combined PET-CT at University of Pittsburgh*

2000 - *the first commercial combined PET-CT equipment*

Adopted from The Wilhelm Conrad Roentgen-photogallery. Nobelprize.org;http://www.nobelprize.org/nobel_prizes/physics/1901/rontgen-photo.html

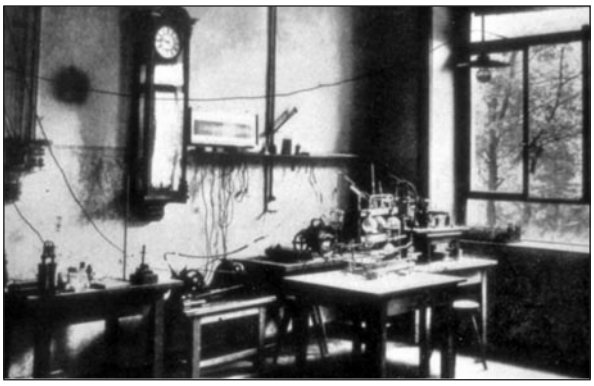

Figure 3 Professor Wilhelm Conrad Roentgen's laboratory at University of Wurzburg where X-ray was discovered

Adopted from public domain via Wikimedia Commons [1]

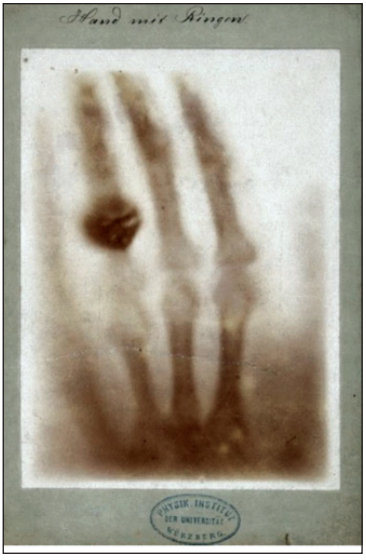

Figure 4 The first radiograph captured, 'Hand with ring' belongs to the left hand of Anna Bertha Ludwig presented to the Physik Institut of University of Freiburg on 1st January1896

Adopted from public domain via Wikimedia Commons Source : NASA

The new discoveries had drawn attentions of other scientists working on ionizing radiation in field of radiodiagnosis including the Curies, the French scientist. Pierre and his Polish wife Marie investigated further on Becquerel's discovery. They suspected that pitchblende or uranium ore also contained other radioactive elements. They were looking for these new radioactive elements. In 1898, they discovered 'polonium' and 'radium'. The elements emit stronger rays from uranium. Marie Curie won two nobel prize awards in Physics in the year 1903 and 1910.

The evolution of X-ray technology started at the beginning of the 19th Century. In the pioneering days, X-ray exposure for skull radiograph would require up to 10 minutes exposure time. For chest radiograph, the patient had to hold the cassette themselves (Figure 5).

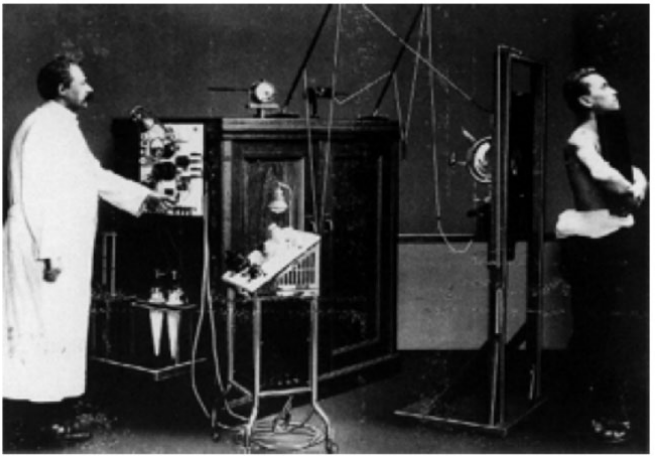

Figure 5 An X-ray system in the pioneering days where patients holding own cassette

Adopted from www.imaginis.com /history of medical diagnosis and diagnostic imaging

Over the next 60 years, the radiology imaging system and image capturing system were further refined through invention of cassette changer, fluorescent screen and image intensifier. In 1950 the first gamma camera was clinically introduced.

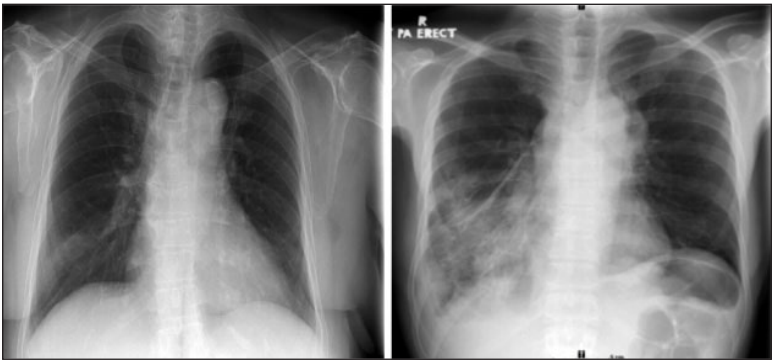

Figure 6 Normal Chest Radiograph (left) and Abnormal (right) chest radiograph

The technology continued evolving to peak during the era of digital imaging in the 1970s when Godfrey N Hounsfield invented the computed tomography system marking the beginning of a new era in diagnostic imaging (Figure 7).

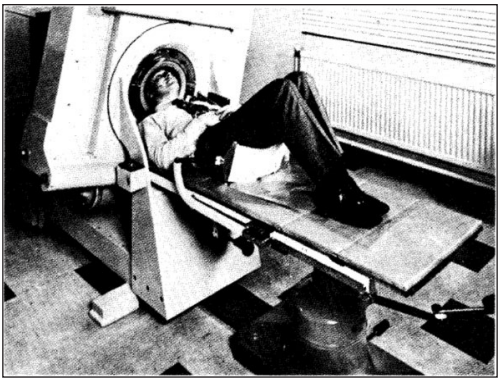

Figure 7 The first clinical computed tomography for the brain installed in London

(Godfrey N. Hounsfield. The Medical System Department of Central Research Laboratories EMI, London, England ; Nobel Lecture 1979 : Computed Medical Imaging 568-586)

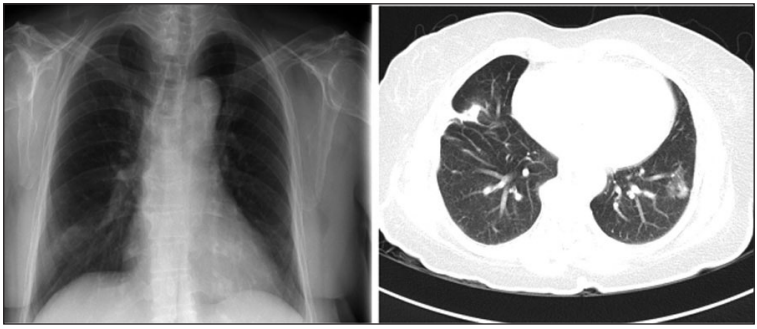

Figure 8 Normal looking chest radiograph cannot totally exclude subtle abnormal changes in the lungs which are better demonstrated on cross sectional imaging CT Scan. Lesions are seen in the right and left lung field on CT Scan

General radiography imaging using X-ray are termed 'planar' imaging techniques. It produces 2 dimensional image lacking in detail informations with total or partially obscured vital diagnostic informations (Figure 8). The shades of black, white and the

overlapping grey areas can be defined as normal or abnormal depending on the contour, texture and composition of tissues and changes that occur. In other words, a normal plain radiograph reflects a normal 'picture' composition of the above mentioned parameters (Figure 9). This limitation was primarily overcome with the invention of computed tomography (CT) in the late 1960s by Hounsfield. Conventional CT was first introduced as sequential modality where a cross sectional images of the body are produced from different angular positions while the tube and detector rotate 360^{o} around the patient lying on a stationary table position. Computed Tomography became an integral part of patient's clinical management at the beginning of 1970s. However, the image quality of conventional CT during that period suffered from respiratory movement and physiological cardiac movement.

In the following years, CT images improved by the invention of helical CT. This new technology was made feasible by simultaneous movement of the table, the tube and the detector. The new era of digital imaging ended in tremendous improvement in CT technology with the invention of spiral CT. During spiral CT, the table moved continuously through the z-axis of the scanning field (figure 5). This happened while the gantry performs multiple 360^{0} rotation in the same direction. The spiral movement of X-ray source around the patient produce a data volume called voxels. Special reconstruction algorithm invented to improve image quality. Images acquire using spiral CT technology demonstrate improved resolution with increase sensitivity as a result of continous volume scanning. The table movement and the scanner rotation around the patient is performed simultaneously for the entire duration of the parts being examined. Most imaging acquisition on spiral CT can be accomplished in a single breath hold eliminating image degradation as a risk of movement artefact a common disadvantage of conventional CT.

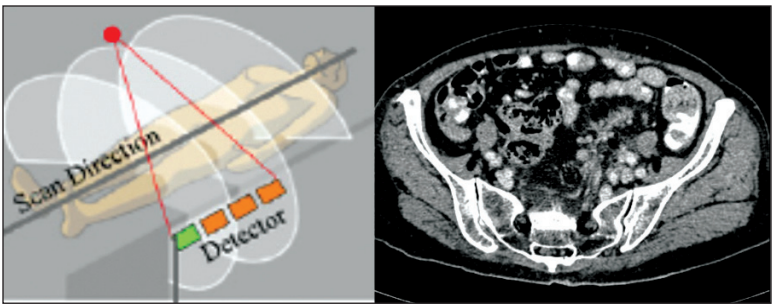

Figure 9 The left diagram demonstrating the direction of the table and rotation of the X ray tube during spiral CT technique. The right image demonstrating high spatial resolution of MDCT scanner with 64 slice capability enabling the detection of small nodular mesenteric lymphadenopathies. The image shows a cross sectional axial scan across the pelvic cavity demonstrating small nodular lesions arising from the mesentery. Contrast partially filling the bowel loop in the left iliac fossa

Spiral CT is a superior technique in comparison to the conventional CT as the outcome of each acquisition is a complete volume data set which can be manipulated by reconstructing a high quality 3 dimensional images without additional radiation dose.

The latest CT technology with improved software and technical specification enables new range of CT scanners to performed dynamic multiscan technique. The technique employs multiple continous rotations at the same table position during data acquisition with intravenous contrast administration leading to the functional CT study, Perfusion CT.

However, since the capability and accuracy of CT in detecting diseases depending on the morphological changes at cross sectional imaging anatomy, the clinical value is about similar to ultrasound and MR. The diagnosis of CT findings following radiotherapy or surgical intervention is often difficult as a result of abnormal anatomical tissue plane with marked distortion. From

the perspective of technology evolution, late 19th century is the turning point for modern era for diagnostic imaging in clinical medicine. The development was closely related to the evolution of the computer systems.

Table 2 Industrial evolution in motor vehicle, computer and medical imaging systems

Year	Vehicle	Computer	X-ray
1769	Self Propel Car		
1832	Electric Car		
1835	Small Locomotive	Calculator	
1876	Four stroke engine		
1886	Gas Fueled Car		X ray
1895			discovered
1903	Ford Motor Company		
1930s		Desktop mechanical computer	
1940s		First generation Digital computing	
1950s		Second generation computer	
1960s		Third generation computer	
1970s			Era of digital Imaging

History of Nuclear Imaging

Nuclear imaging started with gamma camera in the 1950s with the discovery of the 'anger' camera. In general, nuclear medicine procedure depends on the injection of small amount of radioactive isotope into the body. The decay of unstable isotope will emit gamma ray which can be detected by the scintillation camera and electronically converted into computer generated images of hot spots representing focal increase uptake of injected isotope with gamma ray emission.

The decay of unstable isotope emitting gamma ray is a randomized coincidence process. The sodium iodide scintillation crystal of gamma camera can transmit informations through

photomultiplier tubes with the help of mechanical collimators. The quality and diagnostic accuracy of images produced by gamma camera depend on the design and performance of the collimator. Poor collimator design will result in poor overall performance of the camera.

Nuclear imaging techniques using gamma camera is a 2 dimensional 'planar' imaging technique. It lacks in detail informations with total or partially obscuration of vital diagnostic informations. The limitation was overcome by integrating the concept of cross sectional planar imaging of computed Computed Tomography or SPECT system. The technique uses gamma camera to record images at series of angles. The successive slices of images can be reconstructed into three dimensional images using filtered back projection (FBP) or iterative reconstruction (IR) methods. Clearly SPECT imaging is far more superior than planar imaging using gamma camera. A SPECT imaging system may consist up two or three cameras.

Nuclear imaging is different from morphological imaging procedures as the technique produces images reflecting the chemical function of the targeted organ or tissues unlike radiological imaging technique like CT and X-rays which in principle demonstrate morphological or anatomical tissue or organ structural changes. Examples of nuclear imaging include bone, thyroid, brain, cardiac and renal scintigraphy techniques. In bone scintigraphy for example, the study involves imaging of the end process of bone metabolism. This is influenced by the phosphate and calcium metabolic pathways ending with osteoblastic or osteoclastic bone tissue activity depending on the rate of methyldiphosphonate (MDP) uptake which is a well-known bone tracer. The images are made visible as the tracer is tagged with metastable ^{99m}Tc (technetium) isotope decaying into ^{99}Tc releasing a flux of photons from gamma ray disintegration.

The role of scintillation cystals within a gamma camera system is to detect these rays. ^{99m}Tc-MDP bone scintigraphy examination has been a useful imaging study in the evaluation of bone metastases, chronic diseases and infections.

On the other hand, the fate of ^{99m}Tc–DTPA or ^{99m}Tc-DMSA is observed and quantified during renal scintigraphy examination. The count rate of gamma activity during excretory process of renal scintigraphy examination can be calculated to derive the kidney function. Thus the differential function between the right and left kidneys can be observed. The study has been very useful in the assessment of renal transplantation and infection.

Another form of nuclear imaging technique is Positron Emission Tomography (PET) system. PET utilizing the annihilation concept of positive charged electrons called positrons, was first described by an Italian physicist Enrico Fermi in 1936. PET was solely a research tool until the discovery of labeled 2-fluoro deoxyglucose-D-glucose (FDG) a powerful metabolic biomarker. This analogue of glucose molecule expanded the clinical utility of PET imaging. Despite its major set back with poor spatial resolution, the system was further improved by using a germanium source for attenuation correction of PET images. Technically the procedure is prolonged and time consuming.

Technology advances has led to the invention of improved imaging hardware and software for more precise non invasive investigations. The improved range of SPECT and PET imaging cameras are designed utilizing new collimators, and solid state detectors. They are capable of converting photons directly to electrical signals. Some are designed for imaging smaller organs. Overall, the improved systems are capable of discriminating true signals from ‘noise’ more effectively with shorter acquisition time. The improvement is translated into smaller doses of tracers

administered using a new range of system with higher quality of images than before.

PET imaging has benefitted from the introduction of novel detectors that allow true 3-dimensional imaging, and precise attenuation correction (AC). These developments have resulted in images with higher spatial and contrast resolution that may be acquired in shorter protocols and/or with less patient radiation exposure than traditional SPECT. Table 2 shows the superior specification of PET imaging technology in comparison to SPECT and conventional gamma camera.

Table 3 Comparison between the specification of SPECT and PET imaging systems

	PET	SPECT	GAMMA
Crystal specification	Bismuth Germinate (BGO) / Luteum Silicate (LSO)/ Germanium silicate (GSO)/ Lutetium Oxy Silicate (LySO)	Sodium Iodide Crystal	Sodium Iodide Crystal
Isotope	18-Flourine 11-Carbon 82-Rubidium 13-Ammonium 68-Gallium	^{99m}Technetium	^{99m}Technetium

PET was originally used as a research tool until the year 1975 when the first commercial PET scanner was introduced into the market. With technological improvement, the PET scan procedure moved from low technology to advance 3-dimensional images in the 1980s. Despite these innovations, Positron Emission

Tomography was predominantly used in research. However, in the early 1990s, the use of PET expanded into clinical use. Hospitals, diagnostic clinics, mobile systems and physician practices began to understand the promise of PET and began to master its use. Rapid advances in imaging technology are of a great challenge for health care professionals, who must determine how best to use these technologies to optimize patient care and outcomes. Individual imaging systems could be more powerful as one combined imaging unit, hence recent integration of PET and CT systems have provide PET and CT images that are acquired nearly simultaneously and are capable of producing superimposed, co-registered images, greatly facilitating interpretation. A ring of multiple crystals detect the "coincidence" 511-keV photons resulting from positron decay and the subsequent annihilation reaction. Detection of enough coincident events allows reconstruction of an image of the distribution of tracer. Hybrid imaging instrumentation, combining the imaging technologies may be especially challenging. CT and PET provide complementary anatomic information and molecular information, respectively, with CT giving specificity to anatomic findings and PET offering precise localization of metabolic activity. Historically, the acquisition and interpretation of the 2 image sets have been performed separately and very often at different times and locales. Wide utilization of PET-CT imaging technology has raised questions and concerns regarding equipment specifications, image acquisition protocols, supervision, interpretation, professional qualifications, and safety.

MOLECULAR IMAGING-INTRODUCTION

Molecular imaging is a new biomedical research discipline that enables the visualization, characterization, and quantification of biologic processes taking place at the cellular and subcellular

levels within intact living subjects including patients. The term molecular imaging itself encompasses a new imaging paradigm that includes multiple image-capture techniques, cell/molecular biology, chemistry, pharmacology, medical physics, biomathematics, and bioinformatics. Molecular imaging's key utilization is in the interrogation of biologic processes in the cells of a living subject in order to report on and reveal their molecular abnormalities that form the basis of disease. Unlike the classical form of diagnostic imaging where documented findings showed the end effects of these molecular alterations typically via macroscopic and well-established gross pathology. Molecular imaging includes the field of nuclear medicine along with various other fields that together offer an array of different strategies to produce imaging signals. Beside PET and PET-CT, molecular imaging also uses ultrasound, MRI or magnetic resonance imaging, or light (optical techniques of bioluminescence and fluorescence) as well as other emerging techniques.

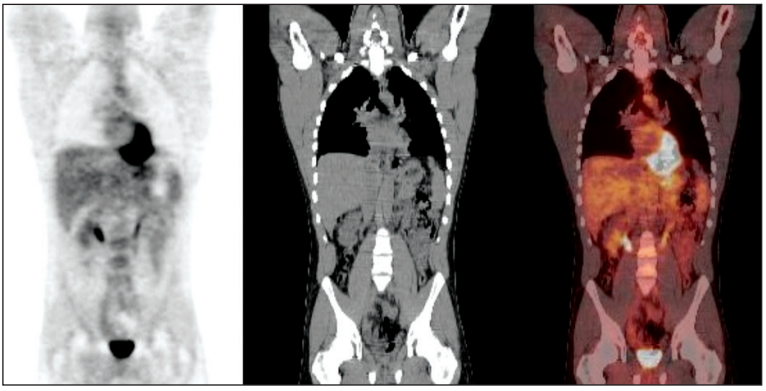

Figure 10 PET, CT and fused PET-CT imaging in a normal patient

Why Molecular Imaging?

PET-CT and MR-PET are new technology with improved accuracy over conventional imaging systems. They are expected to improve the clinical ability to make more informed medical decisions. There is higher probability of desired outcomes by using molecular imaging technique in improved targeted therapies. Molecular imaging techniques are also expected to reduce the probability of negative side effects. Furthermore, patient management will be more focused on prevention and prediction of disease rather than reaction to it. In addition, the technique clinically proven earlier disease intervention than has been possible in the past. These new nuclear techniques are the basis of personalized medicine, making the treatment as individualized as the disease. It also involves identifying genetic, genomic, and clinical information that allows accurate predictions to be made about a person's susceptibility of developing disease, the course of disease, and its response to treatment.In order for personalized medicine to be used effectively by healthcare providers and their patients, these findings must be translated into precise diagnostic tests and targeted therapies using the above mentioned nuclear techniques.

In Malaysia, cancers, coronary artery diseases and cerebro-vascular diseases are the top causes of mortality and morbidity in public hospitals (Health facts Ministry Health Malaysia 2008,2009 and 2010). The devastating outcome of non communicable diseases (NCD) in Malaysia has the potential in reducing the nation's workforce and increase financial burden to the government through long term subsidized medications. Patients of NCD often have chronic disability jeopardizing the available workforce failing the Government's agenda in the transformation plan. This may bring negative impact to the country.

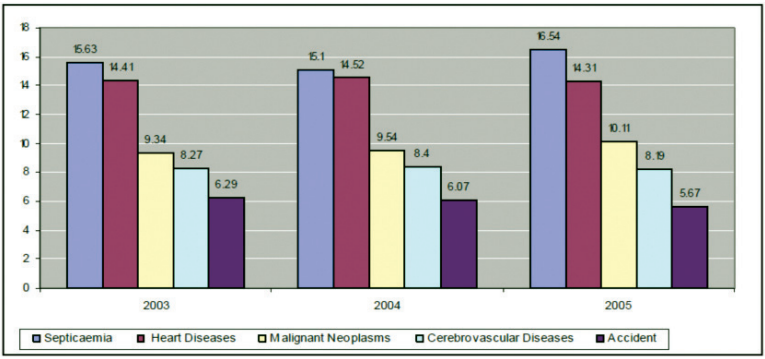

Figure 11 Most common death in Malaysian Hospital 2003-2005

The raising trend of non communicable diseases was the focused agenda in the Forum for ASEAN Health Ministers in 2010. Recent national newspaper statement by the minister of Ministry Health Malaysia (The STAR ; Nation : 8th April 2012:8) quoted in 2011, out of 317 766 individuals screened, 25% recorded to have chronic diseases. This alarming situation is prevalent in patients aged 30 and above.

There are various predisposing factors leading to emergence of NCD in Malaysia including life style, smoking and dietary habits. Multiracial, multi ethnicity, multicultural community brings about variety of genetic variations prone to NCD predisposition. While new clinical method is needed to replace the conventional protocols in detecting NCD at earlier stage. The effective role of molecular imaging devices in early disease detection and accurate monitoring of response to treatment can be utilized to complement the current conventional system in improving patient care.

20 | Rabu 23 Mac 2011 NASIONAL

BH PILIH 20A 23 (emel)

Bilangan pesakit NCD meningkat

Ramai hadapi risiko kematian pramatang

Oleh Haika Khazi

PUTRAJAYA: Bilangan rakyat Malaysia yang menghidap penyakit tidak berjangkit (NCD) seperti kardiovaskular, diabetes dan angin ahmar kini bukan saja makin meningkat, malah menjadi antara penyebab utama kematian pramatang dan ketidakupayaan di kalangan masyarakat di negara ini.

Menteri Kesihatan, Datuk Seri Liow Tiong Lai, berkata berdasarkan kajian, dianggarkan 70 peratus daripada pesakit yang mendapatkan rawatan di klinik kerajaan disebabkan mengidap penyakit berkaitan NCD, manakala lebih 20 peratus daripada pesakit yang dimasukkan ke hospital juga akibat penyakit berkenaan.

Katanya, kajian juga mendapati masalah obesiti di kalangan rakyat negara ini juga semakin serius dan Malaysia berada di kedudukan keenam senarai negara di rantau Asia yang mempunyai kadar peratusan orang dewasa mengalami obes tertinggi.

"Kajian kementerian menunjukkan masalah obesiti meningkat 200 peratus dalam tempoh 10 tahun iaitu daripada 4.4 peratus pada 1996 kepada 14 peratus pada 2006.

> *"Pertubuhan Kesihatan Sedunia (WHO) kini anggap NCD sebagai wabak penyakit pada peringkat global yang perlu ditangani segera"*
>
> **Liow Tiong Lai**
> Menteri Kesihatan

"Dianggarkan ketika ini, 1.7 juta rakyat Malaysia berusia 18 tahun ke atas menghadapi masalah obesiti dan ia amat membimbangkan kerana masalah itu meningkatkan risiko seseorang mendapat NCD seperti diabetes, kardiovaskular dan angin ahmar serta kanser," katanya ketika berucap di majlis pelancaran seminar Advokasi Pelan Strategik Kebangsaan bagi NCD 2011, di Pusat Konvensyen Antarabangsa Putrajaya di sini, semalam.

Seminar berkenaan anjuran bersama Bahagian Kawalan Penyakit, Kementerian Kesihatan dan Lembaga Promosi Kesihatan Malaysia (LPKM).

Tiong Lai berkata, Pertubuhan Kesihatan Sedunia (WHO) kini menganggap penyakit NCD sebagai satu wabak penyakit pada peringkat global yang perlu ditangani segera dan berkesan.

Figure 12 News paper – *Berita Harian* -Nasional Page 20

World wide increased in cancer prevalence has also drawn global attention in implementing evidence based strategies to prevent economy burden in health care system for the people.

According to World Health Organization, cancer is a leading cause of death, accounting for 7.6 million deaths (around 13% of all deaths). Lung (1.37 million), stomach (736 000), liver (695 000), colon (608 000) and breast cancer (458 000) cause the most cancer deaths each year. About 70% of all cancer deaths occurred in low- and middle-income countries. Deaths from cancer worldwide are projected to continue rising, with an estimated 13.1 million deaths in 2030. Death from cancer is related to negative lifestyle where tobacco use is the most important risk factor in cancer mutation

causing 22% of global cancer deaths and 71% of global lung cancer deaths. About 30% of cancer deaths are related to dietary risks : high body mass index, low fruit and vegetable intake, lack of physical activity and alcohol use. Viral infections such as HBV/HCV and HPV are thought to be responsible for up to 20% of cancer deaths in low- and middle-income countries.


WHO | Global cancer rates could increase by 50% to 15 million by 2020

World Health Organization

Media centre

Global cancer rates could increase by 50% to 15 million by 2020

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World Cancer Report provides clear evidence that action on smoking, diet and infections can prevent one third of cancers, another third can be cured

GENEVA, 3 APRIL 2003 - Cancer rates could further increase by 50% to 15 million new cases in the year 2020, according to the World Cancer Report, the most comprehensive global examination of the disease to date. However, the report also provides clear evidence that healthy lifestyles and public health action by governments and health practitioners could stem this trend, and prevent as many as one third of cancers worldwide.

In the year 2000, malignant tumours were responsible for 12 per cent of the nearly 56 million deaths worldwide from all causes. In many countries,

F**igure 13** Global cancer rate by 2020 estimated by WHO

The use of PET and PET-CT in oncology imaging is established. PET and PET-CT using FDG as tracer are proven to improve the outcome with increase accuracy at staging and restaging. Important findings are summarized in the table below.

Cases	Sensitivity %	Specificity %	Management change %	Ref
Lung Nodules N=1474	97	78	-	JAMA 2001;285:914-24.
Carcinoma Lungs staging N=100	84	89	67	Chest 2003;123:137-46S
Carcinoma esophagus	57	97	-	J Clin Oncol 2004;22: 3805^12.
Head and Neck Carcinoma N=53	90	86	40	Head Neck 2004;26:1008-17
Lymphoma N= 81	96	100	28	Blood 2003;101:3875^6
Colorectal N=43	97	76	25	Ann Surg 2001;233:293^9.

Table 4 Improved accuarcy using PET CT in clinical management of cancers

18F-FDG PET and PET-CT are recommended to be routinely used in oncology diagnosis involving following systems including Lymphoma, Melanoma, Head and neck, Lung, Breast Cancer, Esophageal Cancer, Pancreatic cancer, Unknown primary tumor and Bowel Cancer.

Combined PET-CT was utilized to overcame the faults of the individual systems. PET poor resolution has been overcome by excellent CT spatial resolution. CT demonstrate morphological changes with high spatial resolution capable of identifying small lesions. On the other hand, PET can identify functional abnormality even without any morphological change. The combined strength of PET and CT as an integrated imaging system, marked a new paradigm in imaging technology with fusion of two establish modalities. The combination of both imaging modalities offer accurate spatial localization of functional abnormalities and also

those lesions where the functional assessment need to be done on follow up. There are many publications on improved accuracy of PET-CT in various type of oncology, neurology and cardiovascular diseases. With the discovery of a powerful metabolic imaging agent known as fluorodeoxyglucose (FDG), integrated PET-CT system became one of the most rapidly growing technology in recent years. Since then, a stand alone PET scanners has been replaced by the combined system.

PET-CT IMAGING IN NON-ONCOLOGIC CONDITIONS

Re-emerging of Ancient Disease

The pathway for FDG metabolism is being elaborated in many previous publications. At molecular level, FDG which resembles glucose molecules are being taken up in proportion to the rate of tissue metabolism. In general, malignancy is known to has higher rate of tissue metabolism, thus at PET -CT imaging, malignancy showed high FDG uptake as compare to the surroundings.

In non-oncologic conditions like inflammation and infection, there is also higher rate of tissue metabolism. They tend to exhibit similar findings at PET-CT imaging of oncological processes. Despite being an established metabolic tracer for FDG avid tumours, PET-CT has been widely employed in cases of infection, inflammation, coronary artery diseae and dementia.

This project was a special task driven through collaboration with Ospedale Niguarda Milan Italy between 2005-2008. The project was presented at The World Molecular Imaging Congress Nice, France 2008, Update on Radiopharmacy and therapy in Badhofgastein, Austria 2009, Radiological Society North America 2011 and European Congress Molecular Imaging Milan 2012.

Figure 14 RSNA Chicago 2011

Figure 15 Congress EANM Milan 2012

Tuberculosis infection has become a global health concern. Human migration is a major contributing factor causing TB spread in regions where the disease was uncommon in the past. Despite costly multiple eradication programs, the incidence of TB infection continued to be on a rising trend. World Health Organisation (WHO)

estimated over 9.0 million newly diagnosed cases with 1.7 million deaths in the year 2006. Global TB burden is increased with the discovery of the new multidrug resistance (MDR) strain. This is partly caused by low socio- economic status and education level of affected populations leading to non compliance to treatment. The increasing incidence of new extreme multidrug resistance (XMDR) TB strain is closely related to ever increasing incidence in Human Immunodeficiency Viral (HIV) cases. The clinical features of extra pulmonary TB infection are generally non-specific. The diagnostic work out is complicated. Despite endless challenges, early diagnosis is essential to ensure successful treatment preventing further spread of this transmissible disease by droplets inhalation.

Figure 16 Colleagues from Ospedale Pietre Ligure, Santa Corona Italy in 2007

Malaysia is categorized as intermediate burden country by the WHO with TB infection and geographically surrounded by high burden country.


N30 NATION THE STAR, SATURDAY 28 MARCH 2009

TB cases on the rise again

Some docs unaware or not complying with rules on chronic coughing

Figure 16 Newspaper Cutting – Nation N30- Importance of TB

Routine workout using total white counts, erythrocyte sedimentation rate, C-reactive protein often failed in identifying cases early. Tuberculin skin tests, which need careful interpretation, may be misleading. Quantiferon B tests are specific for latent infection but not readily available.

Cross sectional imaging features of extra pulmonary TB infection on ultrasound, CT and MRI are non specific and require isolation of organism in confirming the diagnosis. Attempt in cultivating TB bacillus is time consuming owing to slow growth of colony. Invasive procedures often fail in obtaining low yield specimens. In addition, poor general conditions of affected patients, as a result from prolonged illness, prevent further interventional approach in treating these patients.

Combined morphological and functional PET-CT imaging study is an integrated diagnostic imaging modality commonly utilized in major institutions mainly in managing patients with malignancy. To a lesser extent, this imaging modality is also utilized in imaging infection, neurology and cardiology. We observed the pattern of FDG

uptake in active extra pulmonary TB lesions in this study utilizing integrated PET / CT modality.

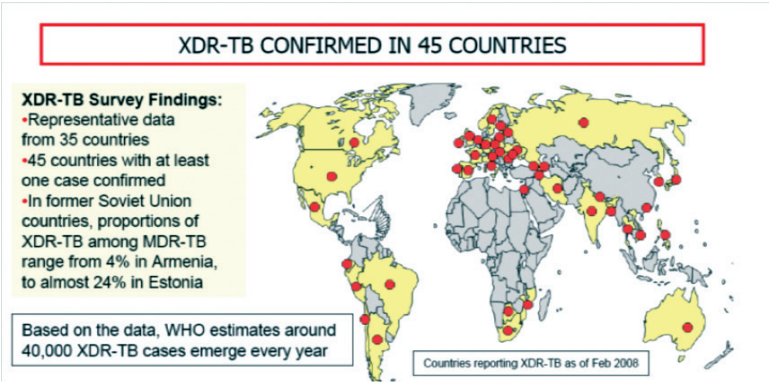


Figure 18 World wide distribution of extreme drug resistance strain of TB organism

Our group studied the role of 18F FDG PET-CT investigation in extrapulmonary tuberculosis infection. Our patients presented with a variety of generalised symptoms like malaise, low grade temperature, generalised ache or clinically asymptomatic. They were investigated for clinical diagnosis of infection. The laboratory and basic imaging tests were inconclusive for TB infection. 18F-FDG PET/CT examination was done in view to identify the source of infection.

In all patients, the diagnosis of TB infection was achieved through isolation of TB bacillus by aspiration procedure or evidence of treatment response following anti TB drugs treatment between 6 to 9 months interval.

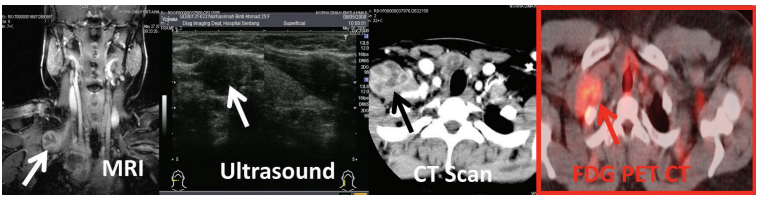


Figure 19 Various presentations of TB lymphadenitis comparison using imaging modalities like MRI, Ultrasound, CT Scan and FDG PET-CT

Our observation in this study found that FDG PET-CT is a potential tool in navigating clinicians in the management of active TB patients. The initial SUV_{max} can be a valuable base line surveillance in monitoring response to treatment and providing information on disease extension. However, its routine utilization needs to be justified owing to its limited availability and high costs.

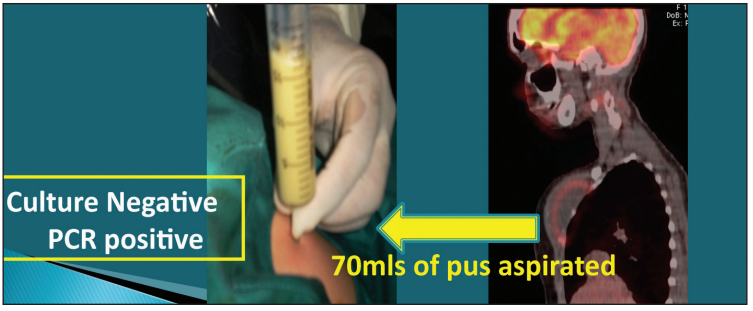


Figure 20 A young lady presented with pseudo-breast lesion. 70 mls of yellow pus aspirated. The culture was negative for TB but positive PCR

Since there is difficulty in obtaining clinical and laboratory evidence of TB infection for definitive diagnosis, a new effective method should be clinically accessible to monitor response to anti TB treatment.

We conducted another study on using 18F FDG PET-CT on patients diagnosed with TB for treatment monitoring following anti TB treatment. The study compared the results of 16 PET-CT studies performed on 8 patients before and after anti TB treatment at our centre. The metabolic activity in SUVmax, size of lesions in 2-dimensional and 3-dimensional measurement were recorded. Lesions were categorized as complete or partial/non responding depending on complete physical and metabolic disappearance including nodal size measuring less than 1 cm in diameter. Partially responding lesions are categorized as SUVmax less than 2.8 or lesions measuring >1 cm in diameter on CT scan. The accuracy of each method was assessed in comparison with final clinical outcome and infection markers.

The final diagnosis of our patients was achieved by isolation of TB organism, histopathological examination of biological specimens and or respond to anti TB treatment.

The average time for repeated 18F-FDG PET-CT imaging is 6.6 months. The mean SUVmax of TB lesions before treatment was 7.0. Following treatment the mean SUVmax reduced to 1.4

On CT scan, the average diameter of lesions prior to treatment on 3-D measurement were 22.6, 27.0 and 38.6 mm. Following treatment, the average diameter decreased to 13.3, 13.2 and 21.1 mm respectively.

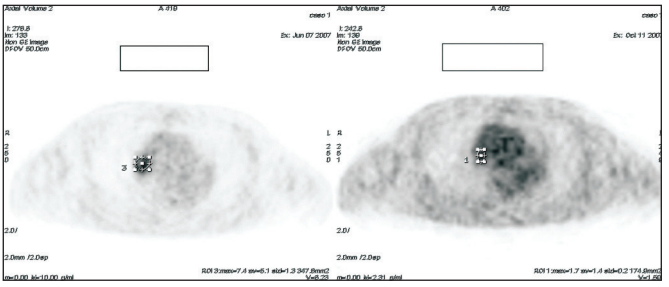


Figure 21 An example of partial respond to anti TB treatment

The sensitivity, PPV, NPV and accuracy of SUVmax are higher than xy-axis measurement in monitoring response to anti TB treatment with 69%, 69%, 33%, and 56% in comparison to 38%, 56%, 20% and 37% respectively.

Table 5 The outcome of analysis between metabolic imaging using PET and morphological measurement using CT

Result	SUV max	XY-axis	XYZ-axis
Sensitivity	69	38	23
Specificity	33	33	33
Positive Predictive Value	69	56	42
Negative Predictive Value	33	20	17
Accuracy	56	37	26

The performance of xy-axis measurement was poorer with inclusion of the third dimension in the measurement (23%, 42%, 17% and 26% respectively). The overall specificity was low and similar for both modalities (33% respectively).

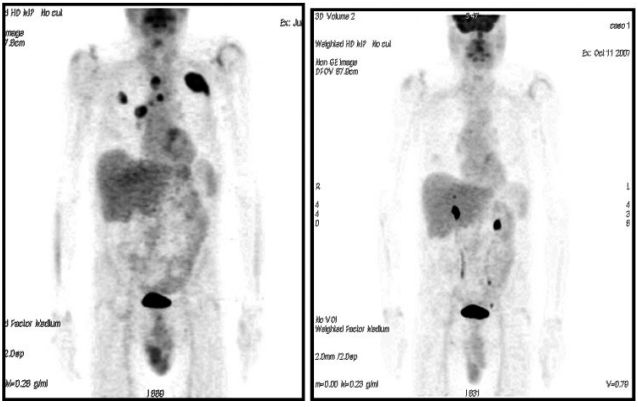


Figure 22 Example of complete responder to anti TB treatment

In this series, we highlighted two important findings. SUVmax demonstrated higher accuracy in monitoring anti TB treatment in comparison with physical measurement of xy-axis on CT scan. In clinical set up where CT scan is utilized as the main modality for follow up treatment responders, we recommended z-axis measurement in the evaluation.

Idiopathic Inflammatory Bowel Diseases

This project was presented at the 1st Balkan Nuclear Medicine Congress in 2011 in Antalya Turkey.

The cascade of inflammatory events in inflammatory bowel disease activate the inflammatory cells within the affected bowel wall resulting in raised tissue metabolism. This inappropriate aberrant response of the mucosal immune system often needs invasive endoscopic procedure for diagnosis work up. Malignant transformation into colorectal cancer can occur in long standing chronic events leading to higher fluorodeoxyglucose (FDG) uptake during integrated positron emission tomography computed tomography (PET-CT) This study highlighted the potential role of ^{18}F-FDG PET-CT as a non invasive modality in investigating patients presented with chronic inflammatory bowel disease. We performed a prospective study on 8 patients from Gasteroenterology Clinic of Serdang Hospital Malaysia with history of prolonged altered bowel habits. They underwent serum screening for inflammatory parameters (normal or raised), transrectal colonoscopy (colitis or others) and tissue biopsy (colitis or others), and eventually whole body PET-CT using ^{18}fluorine – fluorodeoxyglucose as biomarker (normal or increased in FDG uptake). All results were blinded.

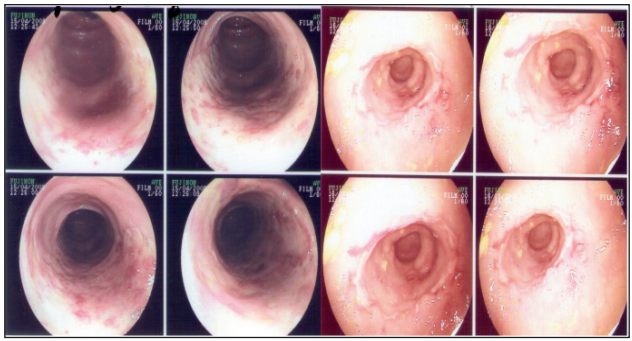


Figure 23 Endoscopic images of mild colitis (left), moderate colitis (middle) and malignancy (left)

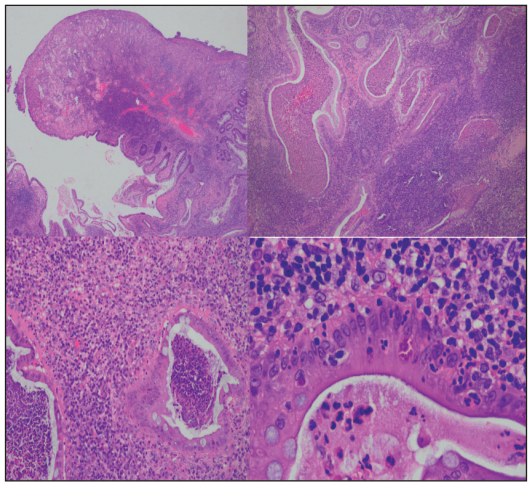


Figure 24 *Top left*: Microscopic pathology of ulcerative colitis during active phase demonstrating extensive mucosal destruction with diffuse inflammation (Hematoxylin and eosin x20 magnification) *Top right*: Crypt abscess and crypt destruction surrounded by dense inflammation. (Hematoxylin and eosin x40 magnification). *Bottom left:* Cryptitis and crypt abscess surrounded by dense lymphoplasmacytic cells infiltrate. (Hematoxylin and eosin x100 magnification). *Bottom right:* Cryptitis surrounded by dense lymphoplasmacytic cells and neutrophils infiltrate. (Hematoxylin and eosin x400 magnification)

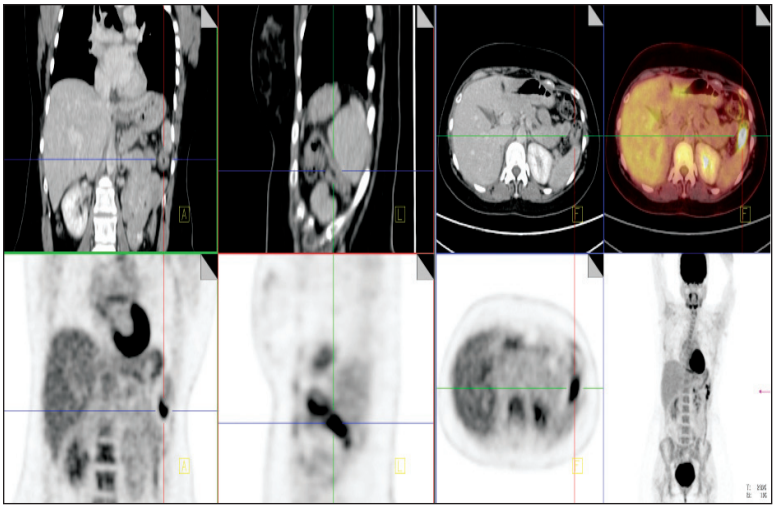


Figure 25 A focal area with high FDG uptake is seen in the left hypochondrial area corresponding to area of inflammation

We found that ^{18}F-FDG PET-CT a promising noninvasive method to be utilized as a routine technique in the investigation of inflammatory bowel disease. It complements conventional studies in the clinical evaluation of inflammatory bowel disease in optimizing the overall diagnostic results.

As a conclusion, 18F-FDG PET-CT can be recommended in patients clinically suspicious for inflammatory bowel disease albeit the imaging results cannot differentiate between histo-pathological classification of inflammation, adenomatous polyps or malignant transformation

Table 6 Scoring system derived from histological assessment for colitis with table of conversion into 0-3 grading system *(Saverymuttu SH,st al Gastroenterology 1986; 90: 1121-8)*

Histological assessment of mucosal biopsy specimens		**(B) Conversion of histological scores to grades**	
Enterocytes		*Grade*	*Total score*
Normal	0	0	0-1
Loss of single cell	1	1	2-4
Loss of groups of cells	2	2	5-8
Frank ulceration	3	3	8-12
Crypts			
Normal	0		
Single inflammatory cells	1		
Cryptitis	2		
Crypt abscesses	3		
Lamina propria			
Mononuclear cells			
Normal	0		
Slight increase	1		
Moderate increase	2		
Marked increase	3		
Neutrophils			
Normal	0		
Slight increase	1		
Moderate increase	2		
Marked increase	3		

Table 7 The diagnostic performance of each modalities used in this study in comparison to histopathological diagnosis of colitis

Method	Sx %	Sp %	PPV %	NPV %	Acc %
Endoscopy	100	75	80	100	87.5
PET	100	25	57	100	62
CT	33	50	67	25	37.5
Integrated PET-CT	80	25	57	100	62
Integrated PET-CT + ESR	100	50	67	100	75

PET-CT: positron emission tomography computed tomography; ESR: erythrocyte sedimentation rate; Sx: sensitivity; Sp:Specificity; PPV: positive predictive value; NPV: negative predictive value ; Acc: accuracy

Other Inflammatory and Infective Conditions

Other non oncologic indications for 18F-FDG PET-CT study include arteritis (Takayasu's / Giant Cell), fever of unknown origin, sarcoidoses, chronic granulomatous infections, Rheumatoid Arthritis and osteomyelitis.

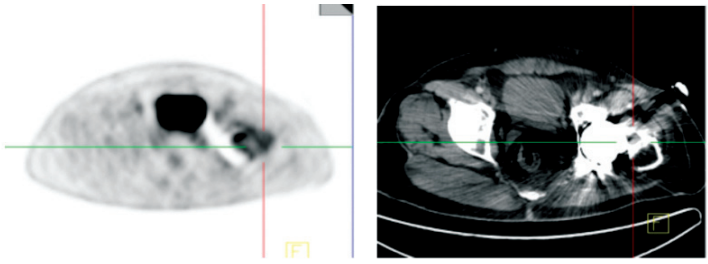


Figure 26 Cross sectional image across the prosthetic hip joints demonstrating high FDG uptake in the left (left). The corresponding CT image (right) suffers from severe beam hardening artefact

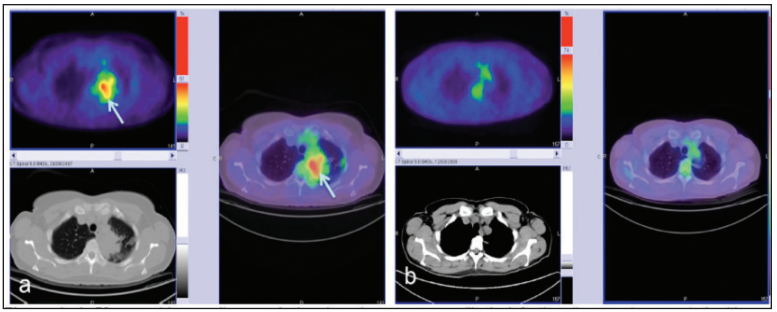


Figure 27 A 52 year olf man diagnosed chronic pulmonary Aspergillosis infection presented with dyspnea and cough. He showed positive serologic test to Aspergillus specific Ig E and IgA antibodies. Antimycotic treatment started and a repeat 18F-FDG PETCT study was done after 7 months (b)

PET-CT CARDIOLOGY

This project is in collaboration with Cleveland Clinic US (Preceptorship 2010), Ottawa Heart Institute, Canada 2011 and Ospedale Monaldi, Napoli, Italy 2011.

Figure 28 Cleveland Clinic Preceptorship 2010

Ischemic heart disease is an important cause of death in the world especially in the west including developing countries like Malaysia Cardiac ischemia and its consequences including heart failure, which itself has emerged as the leading cause of morbidity and mortality in developed countries are accompanied by complex alterations in myocardial energy substrate metabolism.. Accurate evaluation is necessary for strategic clinical management in patients diagnosed with ischaemic heart disease especially in treatment stratification of patients for medication, revascularization or stem cell therapy.

Figure 29 Ospedale Monaldi. Napoli 2011

The most important cause of heart failure is chronic coronary artery disease. Post infarcted cardiomyopathy and heart failure are common long term complications with poor prognosis. Recent study estimated 5 year mortality rates of 59% for men and 45% for women with heart failure. The prognosis is poorer in older patients.

Myocardial evaluation using PET-CT is regarded as the gold standard in viability study. PET-CT is more accurate in comparison to SPECT study in myocardial evaluation for the following reasons:

1. Higher sensitivity in comparison to SPECT (93% vs 76%),
2. Higher specificity in comparison to SPECT (83% vs 53%)
3. The accuracy of 82RB and 99mTc MIBI in two patient population with similar profile are similar in comparison to coronary angiography
4. PET showed higher diagnostic accuracy (89% vs 79%) using 79% of angiographic stenosis as threshold
5. PET is more sensitive in the diagnosis of multivessel CAD

Myocardial Viability using 18F-FDG PET-CT

Intact myocardial perfusion is a function of normal sodium potassium adenosine triphosphatase (ATPase) pump while normal myocardial viability is the function of intact mitochondrium. Both molecular processes can be clinically manipulated using non-invasive molecular imaging techniques. Despite being a routine procedure, myocardial perfusion imaging has inherent limitation in verifying viable myocardial segments. Fluorodeoxyglucose (FDG), an analogue of glucose molecule is a gold standard biomarker in demonstrating viability. Integrating the two molecular processes in a clinical study will define and classify viable from non viable myocardial segments. The function of viable myocardial segments may benefit revascularization procedure while function has not been successfully revearsible after revascularization in infarcted scared myocardium.

We observed the matching and mis matching segments of myocardium from thirty one patients diagnosed coronary artery

disease. All patients underwent pharmaceutical stress and rest myocardial perfusion imaging (MPI) study using 99mTc-MIBI at Universiti Malaya Medical Centre, Kuala Lumpur upon diagnosis confirmation of ischaemic heart disease. The inclusion criteria are clinical signs and symptoms of ischaemic heart disease, raised cardiac enzymes, electrophysiological changes and evident from imaging modalities like cardiac scintigraphy using 99mTc-MIBI, echocardiography and Magnetic Resonance Imaging. We compared the result with viability study using FDG PET-CT. Two patterns of imaging were found during this study as illustrated below.

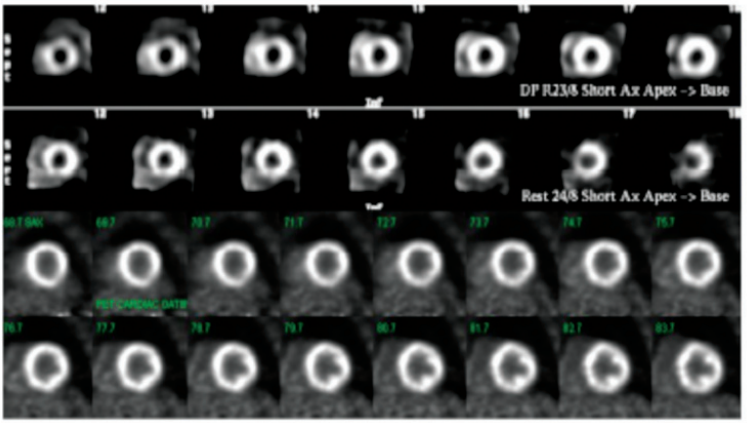


Figure 30 Study from a 72 year old woman demonstrating revearsible defect in the apical region indicating hibernating segment

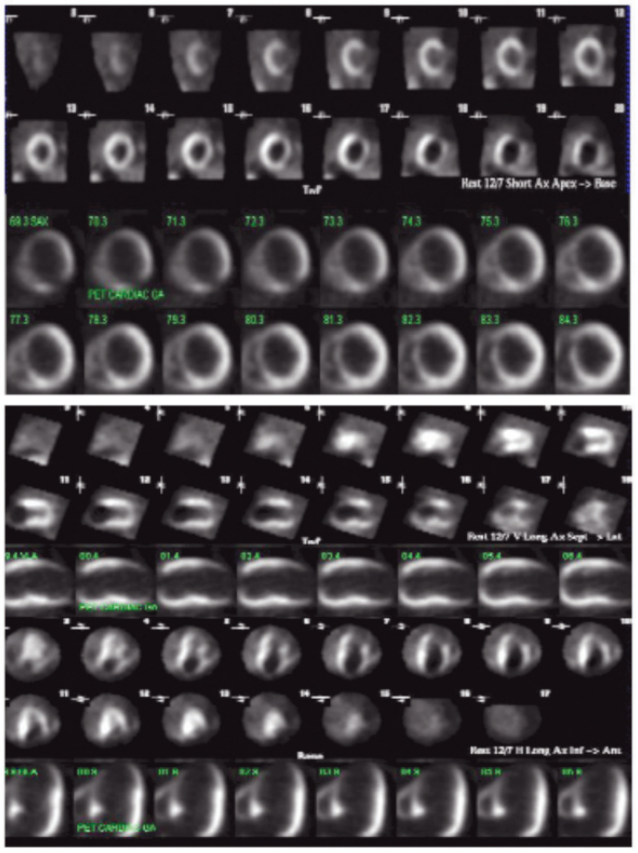


Figure 31 Multiplanar imaging of the myocardium using 99mTc MIBI in a 52 year old man known ischaemic cardiomyopathy. Stress MPI and rest FDG PET-CT demonstrate matching apical defects at segment 19 and 20 in keeping with infarction

We derived a clinical prediction rule from our study where negative perfusion on MPI study and FDG viability study or matched defect is defined as infarction.

A negative perfusion on MPI study in the presence of positive FDG uptake or mis-matching defect is termed as viable but

hibernating segments similar to the term suggested by Maddahi and colleagues.

The results of our study supported the importance of FDG as a gold standard biomarker in determining myocardial viability. Myocardial perfusion imaging using 99mTc MIBI are limited by its low sensitivity and poor negative predictive value thus, inability to recognized infarcted from viable but hibernating myocardial segments. Without viability, those patients whom will not benefit from high risk revascularization surgical procedure shall be avoided.

Creating Normal Database for 18F-FDG PET-CT Myocardial Viability Polar Map Interpretation

Myocardial PET images are often not normalized to each other. A direct qualitative comparison is only possible when images from different studies have been normalized to the same scale. Polar map display is a comprehensive interpretation of the left ventricular wall. It represents the registration of the left ventricular myocardium for the visual and quantitative analysis of tomographic viability scintigrams. In this scheme, the maximal- count circumferential profiles of well-defined short- and long-axis planes are plotted to a map showing the distribution of FDG onto a two-dimensional polar representation. The usual coronary artery distribution is often indicated on the polar maps of PET studies by referring to the regions of the three main coronary branches, nevertheless, the individual variations may differ extensively. Polar map is utilized as an additional parameter in semi quantifying the function of myocardium of left ventricle during viability assessment.

Whole body 18F-FDG PET-CT study performed on 60 patients at Centre for Diagnostic Nuclear Imaging of Universiti Putra Malaysia between July 2010 till August 2012. Patients presented to the hospital with various clinical presentations for initial cancer

staging. The related protocol in patient preparation, pre-imaging uptake time and data acquisition were standardized in all patients. They were fasted for at least 6 hours prior to examination. The body weight and blood sugar readings were incorporated into the calculation for Standardized Uptake Value (SUV). The waiting time ranged between 45 to 60 minutes.

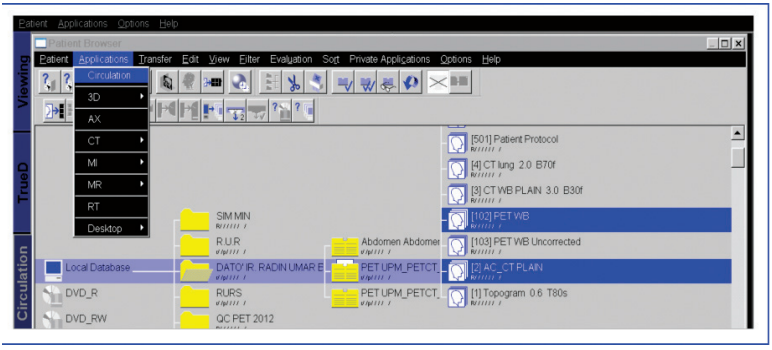
All PET-CT studies were performed using Siemens® Biograph True-V PET incorporated with 64 slice multi-detector CT. Patient was positioned with the arms above the head while lying on the scanning table through out the procedure. The scout image was acquired first for study planning. A low dose axial CT slices performed from the eyes to the thigh using automated care dose system. CT datas were used for attenuation correction of PET images. We acquired 3 dimensional (3-D) PET data on all patients in 5 different bed positions at 2 minutes per bed position. All images were reconstructed using iterative algorythm technique. 3-D Multi image intensity projection (MIP) and 2-D multiplanar images in axial, coronal and sagital were reviewed. The procedure is summarized below.

Table 8 Protocol for whole body PET-CT using FDG tracer

Flow	**Work flow for whole bodyPET-CT Protocol**
	Procedure
1	Low dose CT scannogram from eyes to thigh to plan for the study
2	Patency test injection of 10 mls normal saline using dual head contrast injector
3	80-100 mls of 370 mg Iopamiro® administered through pressure injector at the rate of 2-3 mls per second.

4	Start transmission CT scanning in axial plane after a delay of 80 seconds with table movement in craniocaudal direction
5	Reposition the table for emission PET scanning with caudo-cranial table movement lasting 2 minutes per bed position to cover between eyes to thigh. PET images acquired in 3 dimensional imaging.
6	Iterative algorithm used to reconstruct PET images. CT images were reconstructed into axial, coronal and sagittal planes. Both images were combined contemporaneously where CT parameters used for attenuation of PET images.
7	Preliminary review of images

Post-imaging results, we selected only patients with high myocardial uptake of FDG to be included into the database development. The process of selection and database formation is illustrated in Figure 22-26.



Figue 32 Select a suitable patient from the drop down list of 'local database'. Select a study in the second row. Select 'PET WB' and 'AC_ CT' studies (while pressing the CTL button) The selected studies will be highlighted. Click 'Circulation' from the drop down menu located in the right top location of the page

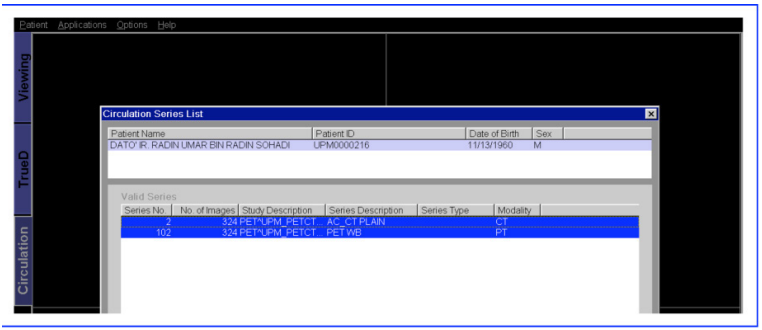


Figure 33 Select the two row of studies containing CT and PT which appear on the screen

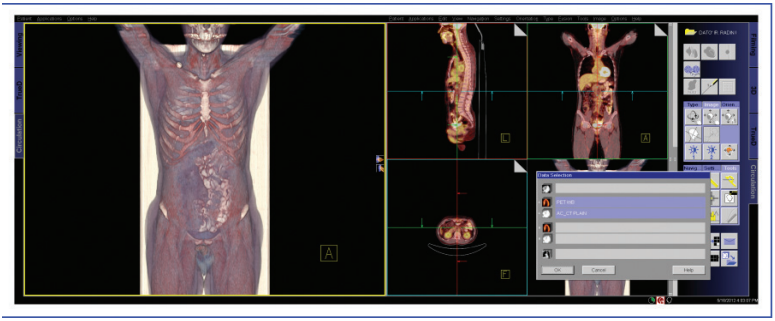


Figure 34 A set of images in multiplanar display will appear on the screen with a new table. Select both studies label 'PT' and 'CT'. Then select 'OK'

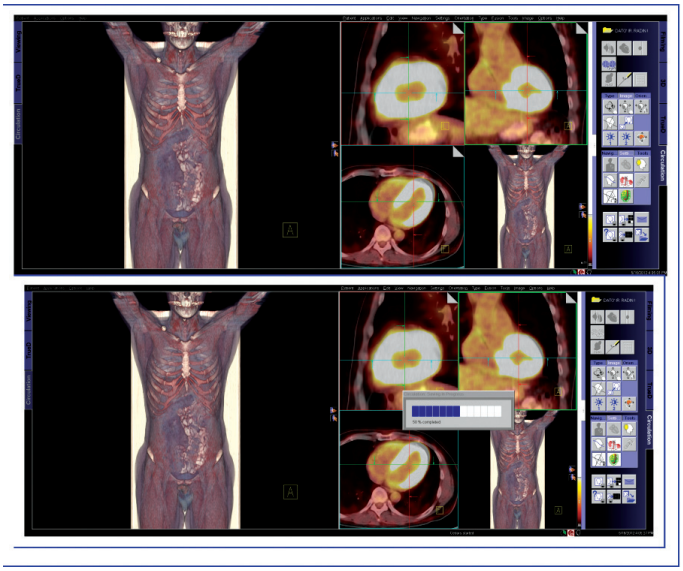


Figure 35 Enlarge the images in multiplanar display. The centre of the crossed cursors should be placed centrally within the left ventricular chamber. Select the cedar icon (in green cardiac icon) from the middle group of toolbox in the left side. Wait while the computer is analyzing the data

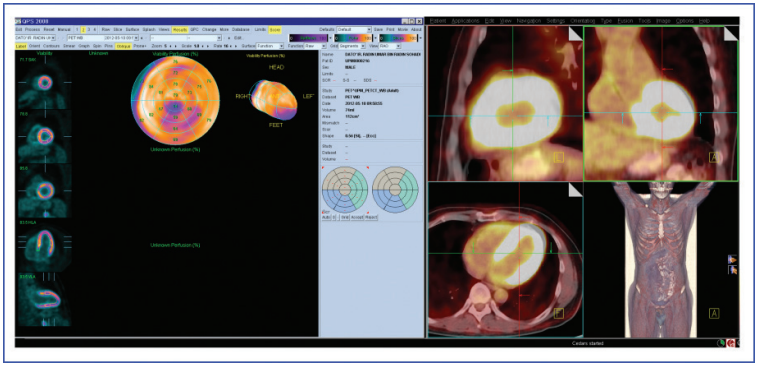


Figure 36 Computer generated polar map is created demonstrating the percentage of FDG uptake in each 21 segments

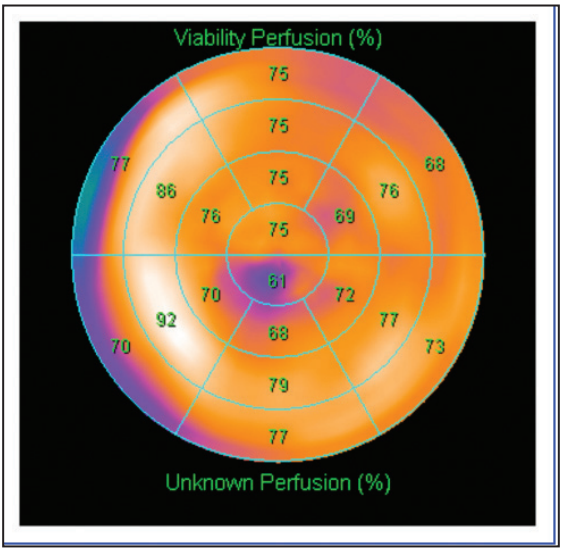


Figure 37 An example of polar map demonstrating the percentage of FDG distribution in each segment.

The process (Figure 22-26) of was selection was repeated in all patients. Finally 20 subjects selected. Female predominant with ratio of 13:7. The mean age was 42.5 ranging between 18 to 74 year old. The mean body weight was 54.8 kg ranging between 34 to 79 kilogram. The mean fasting blood sugar level was 5.83.

Table 9 Demography of 20 subjects selected for database development

The demographic data is tabulated below.

Subjects	Gender	Age	Race	Weight (kg)	Glucometer (mmol/L)
1	M	47years	Ch	72.8	4.7
2	M	22years	My	48	6.3
3	M	21years	My	43.8	6.1
4	M	24years	Ch	51	5.8
5	M	46years	My	52.2	6.9
6	F	68years	In	79	5.3
7	F	61years	My	60	6.5
8	F	74years	Ch	39.5	4.1
9	F	32years	My	61.6	6.1
10	F	27years	My	41.2	6.7
11	F	42years	Ch	55	6.5
12	F	32years	My	51.2	6.8
13	F	29years	Ch	60	5.1
14	F	56years	Ch	34	6.9

15	F	63years	My	44.5	3.3
16	F	18years	My	48	5.1
17	M	52years	My	64	4.5
18	F	61years	Ch	50	4.1
19	F	51years	In	70	10
20	M	23years	Ch	71	5.7

The percentage of FDG uptake in each of 20 segment polar map is displayed in Table 7. The mean percentage of FDG uptake in all segments exceeded 55 percent ranging between 58.8% to 76.7%. Per patient analysis revealed mean percentage of FDG uptake ranging between 57.1% and 91.8%

Table 10 The percentage distribution of FDG in 20 segment polar map involving 20 patients.

Subjects	SEGMENTS																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	61	63	73	71	64	72	60	56	76	75	68	78	61	41	51	59	63	73	52	43
2	48	52	61	73	81	68	51	51	54	63	81	84	56	49	54	53	71	78	63	50
3	61	78	65	62	74	52	51	58	62	58	73	60	52	45	44	49	60	56	51	40
4	71	81	87	70	77	67	68	57	75	72	81	80	69	74	73	68	67	74	75	63
5	68	78	79	66	63	55	63	83	84	68	72	71	71	74	67	64	69	70	62	50
6	59	76	63	62	66	52	56	62	79	69	90	76	81	62	80	80	83	84	74	65
7	62	81	68	60	66	56	68	82	89	78	78	77	82	74	82	72	89	76	72	62
8	55	67	66	67	77	55	62	72	81	72	85	73	67	66	64	56	75	74	68	48
9	73	70	60	51	58	66	37	45	67	72	69	60	39	49	68	61	74	73	67	69
10	56	71	71	69	77	57	49	61	66	62	83	72	66	58	63	62	79	74	78	60
11	91	95	94	95	91	92	88	93	93	93	91	90	90	90	92	91	92	91	91	93
12	65	77	80	66	75	57	61	80	75	72	83	67	59	58	56	60	64	61	68	53
13	59	74	88	66	66	63	56	78	85	77	71	70	74	79	71	66	62	62	65	46
14	65	69	70	66	57	41	51	80	71	56	64	59	51	50	49	44	54	51	51	43
15	62	66	71	61	77	63	63	65	76	67	80	84	68	65	65	60	66	76	72	56
16	57	60	63	63	82	76	52	71	77	72	75	60	54	64	75	67	74	64	65	66
17	76	73	82	69	79	76	72	84	82	64	69	75	78	81	67	59	68	73	79	54
18	67	67	72	74	74	64	76	81	84	80	81	79	68	62	67	62	64	70	67	53
19	65	87	83	71	66	66	68	78	83	72	67	64	70	73	74	74	64	64	72	75
20	39	51	58	47	40	39	42	70	75	62	45	42	67	86	84	76	62	54	87	87

By combining images from multiple planes, information about the entire myocardium can be displayed in a single image.

Polar maps can be thought of as the image that would be obtained if one took a 3-D cone- shaped heart activity image and projected it onto a single plane. Each image plane forms an annulus in the polar map (i.e. the outer annuli of the polar map correspond to the proximal regions of myocardium, whereas the inner rings are derived from the apex). Polar maps can also be normalized to each other, or can be normalized to a database so that direct comparsions can be made. This database will be very useful in a new PET-CT facility starting myocardial viability study

82Rubidium Myocardial Perfusion – The First Malaysian Experience

Myocardial blood flow at rest and during exercise is controlled through auto regulated mechanism mediated by vascular resistance of pre capillary arterioles and pre arterioles. Auto regulation maintains constant blood flow despite change in perfusion pressure under normal and constant demand and at rest. The normal resting flow is 0.8-1.2 ml/g/min

The term, Coronary Flow Reserve (CFR), signifies the ability of the myocardium to increase blood flow in response to maximal exercise. Flow reserve is the ratio of the myocardial blood flow at peak stress, or maximal vasodilatation, to the flow at rest.

In normal adults, the flow reserve ratio is usually 2.0 or higher. Myocardial blood flow can increase three to four times during peak exercise to match the increase in myocardial oxygen demand. The presence of significant coronary stenosis reduces the ability of coronary circulation to increase MBF to match the increased workload. Thus, there is a progressive decrease in CFR with increasing stenosis levels.

Myocardial flow reserve can be quantified non-invasively using quantifying tool through rest and stress data acquired during myocardial PET-CT perfusion study using positron emitters. Our group studied the clinical value of myocardial flow reserve in relation to the left ventricular function in 25 patients chosen by random sampling at our centre. This first Malaysian experience is also intended to derived the normal flow value in Malaysian population. The setting up of a myocardial perfusion study using Rubidium generator is a challenge. In addition to the regulatory clearances, dedicated staff need to be trained and closely supervised during the procedure. We acquired professional support from Ottawa Heart Institute and Draximage of Canada.

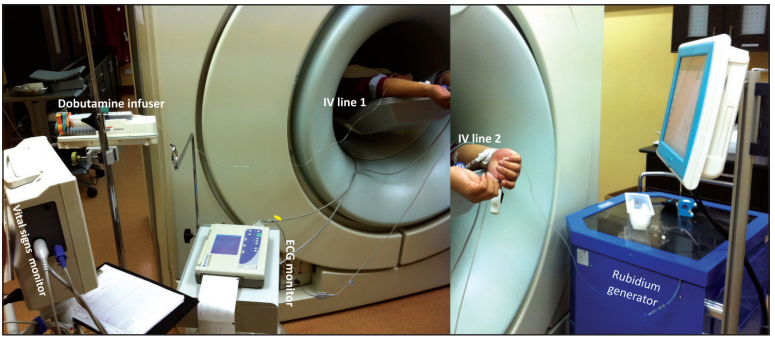


Figure 38 Setting for myocardial perfusion study using Rubidium generator – the first in Malaysia

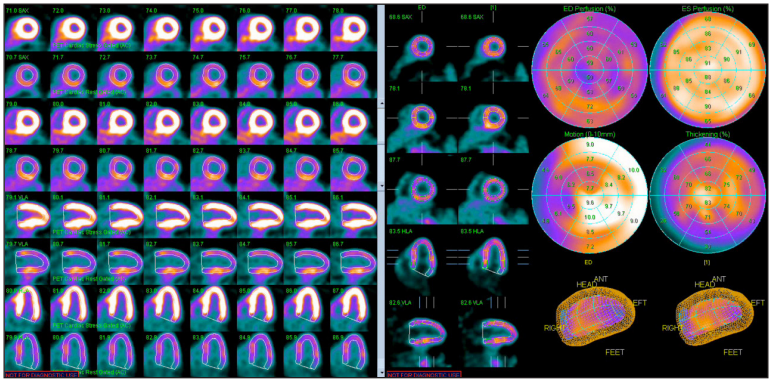


Figure 39 Myocardial Perfusion Imaging using 82Rb - Post processing reconstructed images in transaxial, vertical and horizontal axis. List mode acquisition enabling the LVEF, volume, thickness and motion to be assessed

The quantification of coronary flow reserve is done using software from Ottawa Heart Institute (Flowquant®). The end result is demonstrated below:

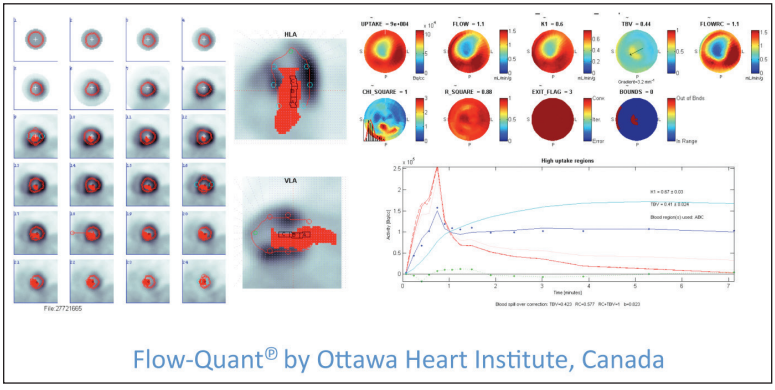


Figure 40 Quantification of coronary reserve flow using Flowquant software

Post processing myocardial flow reserved is demonstrated below:

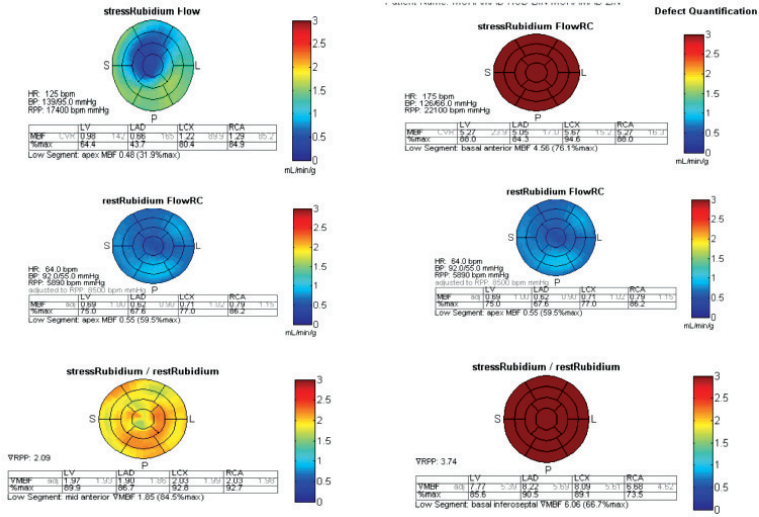


Figure 41 A normal myocardial flow reserve (MFR) (left) and abnormal MFR (right)

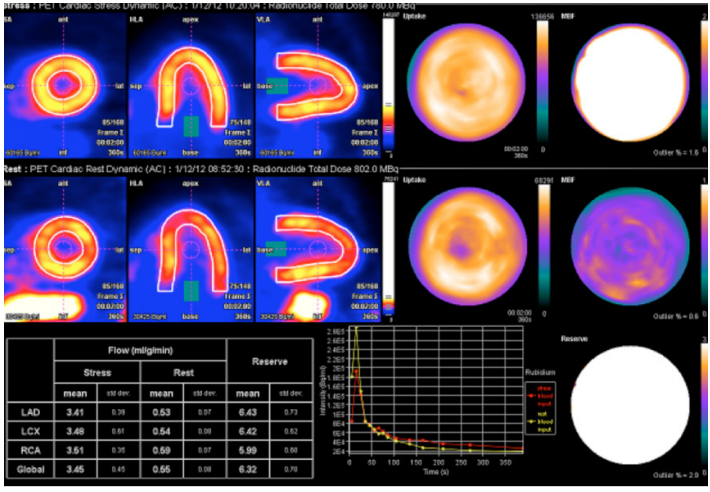


Figure 42 Distribution of 82Rb in myocardial

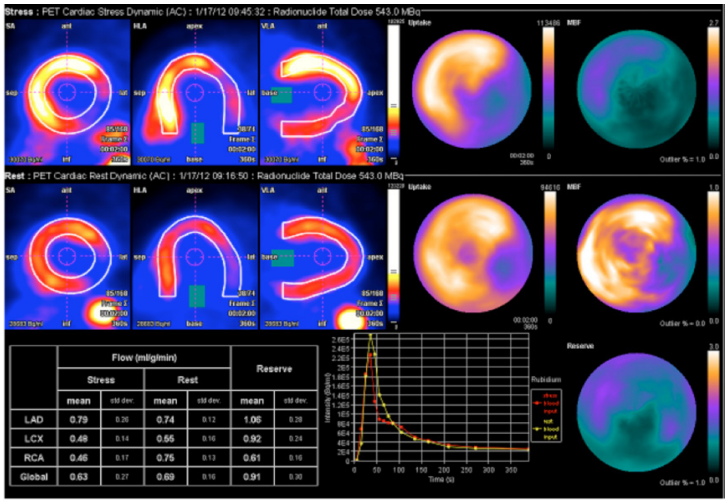


Figure 43 Normal (top) and abnormal (bottom) automated MFR using Siemens software

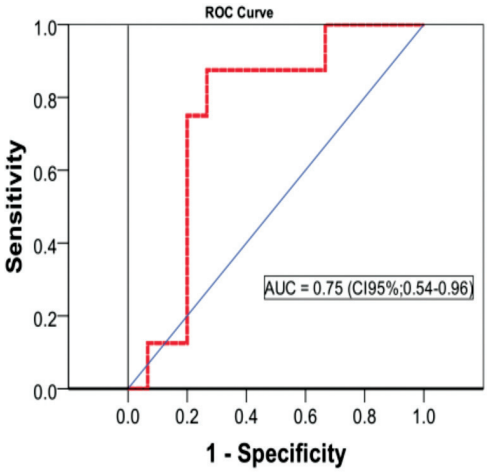


Figure 44 Receiver Operating Characteristic (ROC) Curve of Global MFR (Actual Value) tested against Left Ventricular Function. The Area Unver the Curve (AUC) value of 0.75 depicts moderate accuarcy and is statistically significant ($p<0.05$)

Our data demonstrated high sensitivity, specificity and negative predictive value (NPV) of MBF at 2.81 in predicting the left ventricular function. Thus can further re-classify local patients for treatment option. Quantification of MFR can be recommended as a non invasive tool in making clinical decision for managing patients with coronary artery disease.

Table 11 Global MFR

Coordinates of the Curve

Test Result Variable(s):Global MFR

Positive if Less Than or Equal To[a]	Sensitivity	1 - Specificity
.0000	.000	.000
1.1000	.000	.067
1.3000	.125	.067
1.6500	.125	.200
2.0000	.250	.200
2.3500	.375	.200
2.7000	.625	.200
2.8150	.750	.200
3.1650	.750	.267
3.6000	.875	.267
3.9600	.875	.333
4.2600	.875	.400
4.5050	.875	.467
4.9050	.875	.533
5.2100	.875	.600
5.4100	.875	.667
5.7000	1.000	.667
6.4500	1.000	.733
7.2500	1.000	.800
8.0000	1.000	.867
8.7000	1.000	.933
9.9000	1.000	1.000

a. The smallest cutoff value is the minimum observed test value minus 1, and the largest cutoff value is the maximum observed test value plus 1. All the other cutoff values are the averages of two consecutive ordered observed test values.

PET-CT IN DEMENTIA

The work presented here is in collaboration with Milan Bicocca University, Italy, Ospedale San Rafael, Milan and University of Groningen, Holland.

In today's developing world, there is much more uncertainty regarding frequency of dementia ; another condition closely related to ageing causing high burden to care giver including family members, geriatric home and health institutions. There are currently 30 million people with dementia in the world, with 4.6 million of new cases annually. The number of people affected will be over 100 million by 2050. These estimates were derived from detailed population-based studies of the prevalence of dementia in different world regions.

The number of older people in developing countries will have increased by 200% as compared to 68% in the developed countries in the next 30 years up to 2020.

Table 12 Past, present and future trends of senior citizens, Malaysia, 1960-2020

Year	Number of senior citizens ('000)	Per cent of total population	Growth rate of:	
			Elderly population	Total population
1960	386.6	4.8	-	-
1970	546.1	5.2	3.5	2.6
1980	745.2	5.7	3.1	2.3
1991	1,032.3	5.9	3.0	2.6
2000	1,398.5	6.3	3.4	2.6
2010	2,134.9	7.4	4.2	2.2
2020	3,439.6	9.9	4.8	1.9
2030	4,933.4	12.0	3.6	1.7

From the 21st Population Census Conference Kyoto Japan

Implementation of evidence-based strategies has helped in the past to reduce and control mortality through prevention, early detection and management of these patients. Many of these conditions have a high chance of cure if detected early and treated adequately. However, in most cases of progressive dementia like Alzheimer's disease, though lacking in specific cure, the progression of cognitive declined can be slowed down reducing the social burden of care giver.

There are several software available in determining the glucose uptake of brain tissues. We utilized the Statistic Parametric Mapping (SPM) software to quantify glucose distribution in the brain. SPM creates statistics by doing a separate statistical analysis for each voxel. Like most other functional imaging programs, SPM analyses each voxel independently. Specifically, it does an analysis of variance separately at each voxel, makes t statistics from the results of this analysis for each voxel, works out a Z score equivalent for the t statistic, shows an image of the t statistics or equivalent Z scores, suggests a correction to the significance of the t statistics or Z scores which takes account of the multiple comparisons in the image. SPM does an analysis of variance at each voxel entirely independently, in order to make its t statistics (and Z scores).

For the work involving the Milan Bicocca University and Groningen University, we select our patients at random and acquired a separate brain PET study during whole body PET-CT examination. The brain PET images will be analyzed by the Milan Bicocca group at Ospedale San Rafael, Milan Italy while specific group analysis will be done by the Groningen Group in Holland. Those demonstrating normal glucose uptake distribution will be selected as one of the subject for normal database development. Example of post analysis image is given in the following pages.

Table 13 Demonstrating list of patients selected for normal brain PET database

Patient N°	AGE	SEX	Jack-Knife analysis results
1	63	M	Normal subject
2	24	M	Normal subject
3	43	M	Normal subject
4	64	M	Normal subject
5	61	F	Normal subject
6	71	F	Normal subject
7	31	M	Normal subject
8	61	F	Normal subject
9	60	M	EXCLUDED SUBJECT: evident hypometabolism on the cerebellum
10	48	M	EXCLUDED SUBJECT: problem with reconstructed images (FOV)
11	53	M	EXCLUDED SUBJECT: evident pattern of hypometabolism
12	48	M	Normal subject
13	62	M	Normal subject
14			PATIENT DATA CORRUPTED.
15	39	F	Normal subject
16	59	F	Normal subject
17	51	M	Normal subject
18	52	M	Normal subject
19			PATIENT DATA CORRUPTED.
20	32	F	Normal subject
21	69	F	Normal subject even if he shows an evident atrophia in the higest part of frontal lobe
22	28	M	Normal subject showing a light atrophia in high frontal lobe
23	25	F	Normal subject
24	56	M	Normal subject
25	33	M	EXCLUDED SUBJECT: evident form of neurodegeneration
26	69	F	Normal subject
27	45	M	EXCLUDED SUBJECT: important form of atrophia or of neurodegeneration
28	56	M	EXCLUDED SUBJECT: lesion on the cerebellum
29	66	F	Normal subject

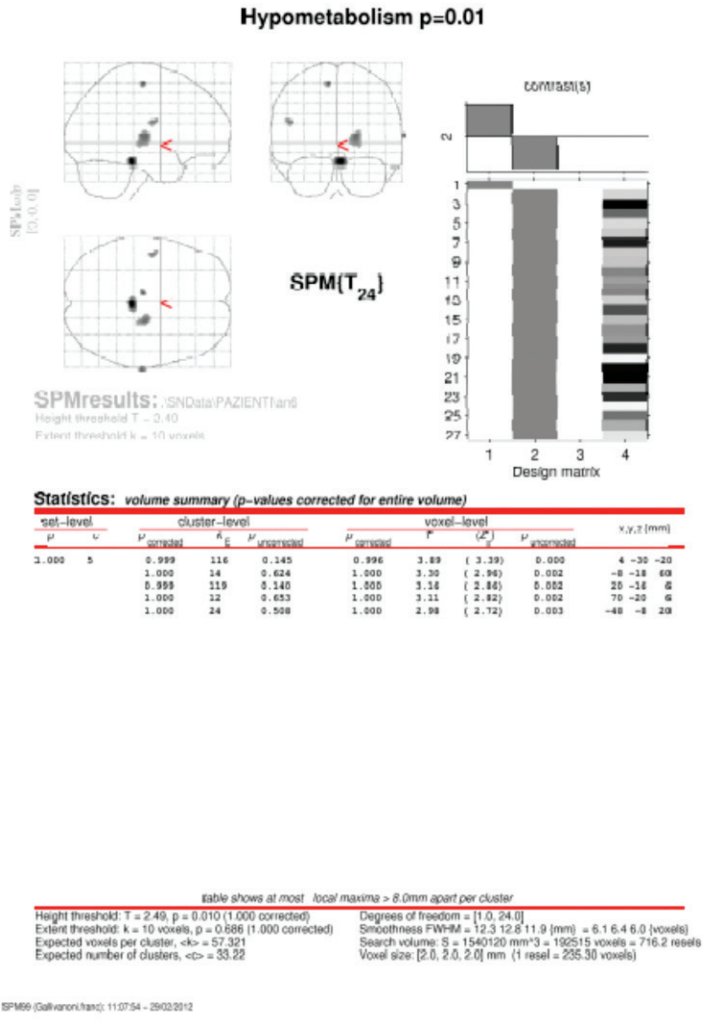


Figure 45 Mapping of FDG in the brain

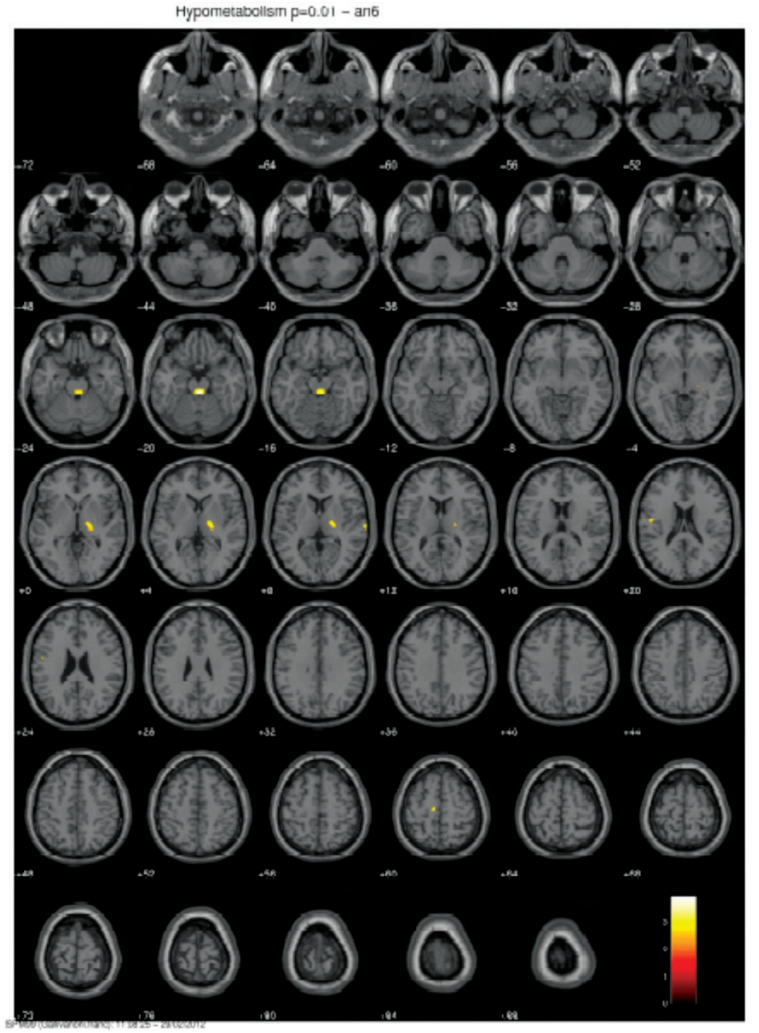


Figure 46 Template of Normal MRI

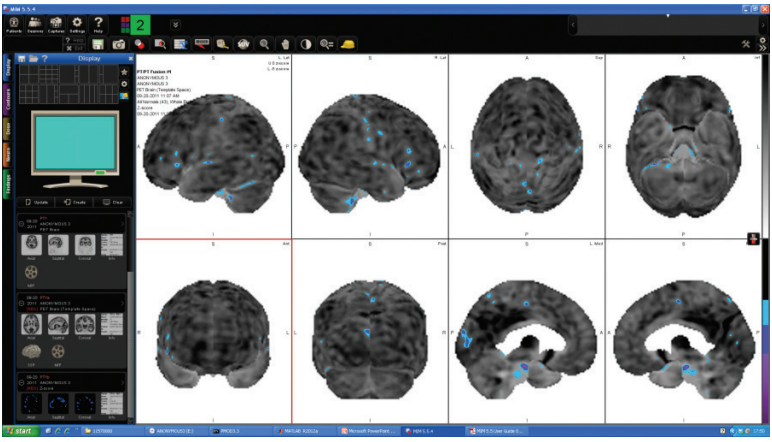


Figure 47 Glucose distribution of the same patient using a different software :MIMs Vista. There is no significant abnormal pattern of glucose distribution in this patient

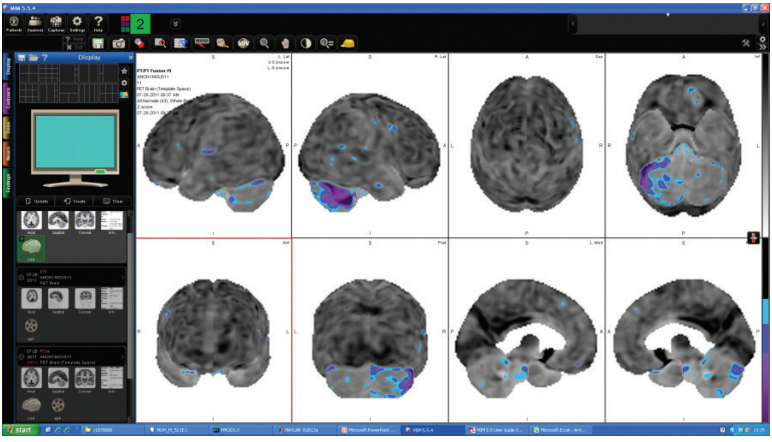


Figure 48 Glucose distribution of another patient on MIMs Vista software. There is significant abnormal pattern of glucose distribution in the left posterior fossa

PET-CT GUIDED BIOPSY-NEW APPLICATION

PET-CT guided biopsy is a technique where the metabolic activity of lesions demonstrated on PET is being used as guidance for biopsy. In other words, the final stop for the tip of the biopsy needle. The CT will be utilized for anatomical localization and guiding needle puncture to avoid vital structures.

The technique guarantees successful interventional procedure avoiding negative or inconclusive evidence from histo-pathological tissue examination result.

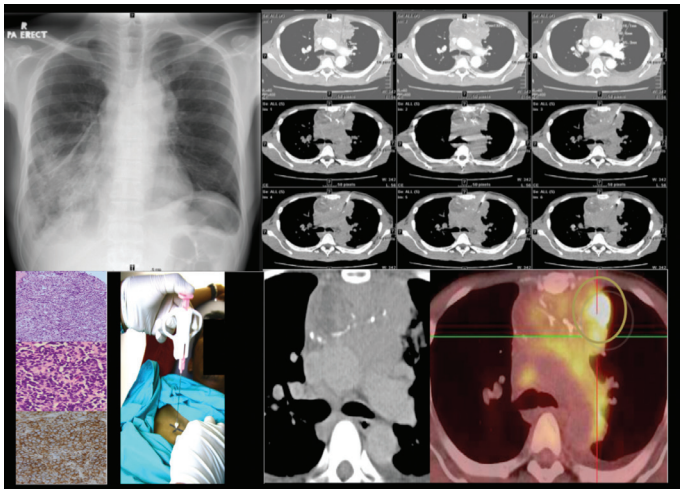


Figure 49 PET-CT guided biopsy: A new horizon in clinical utilization

ISSUES IN PET-CT PRACTICES

During the 9th Malaysian Plan, The National Key Economic Area program was implemented. The program contained within the Economic Transformation Programme (ETP) of the government, a comprehensive effort to transform Malaysia into a high-income nation by 2020 lifting Malaysia's gross national income (GNI) per capita propelling the nation to the level of other high income nations.

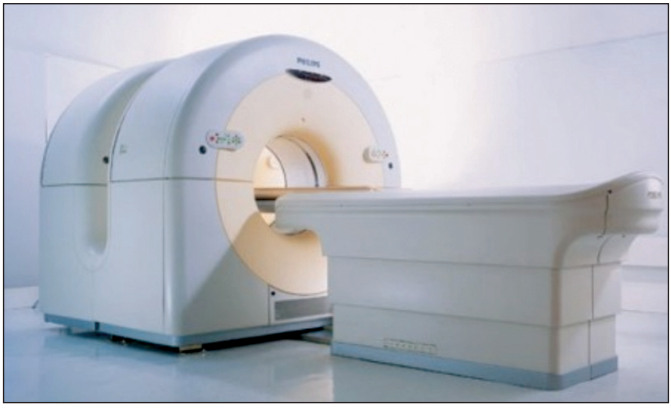


Figure 50 PET-CT equipment

This GNI growth is aimed to achieve the targets determined under Vision 2020. The Program is an initiative by the Malaysian government to turn Malaysia into a high income economy by the year of 2020.

Figure 51 National Key economic area into developed nation by 2020

The program was launched in 2010, identified 12 National Key Economic Areas (NKEA), the key driver to the success of this program as such activities has the potential to contribute significantly to the growth of the economy of Malaysia Healthcare and education are identified as two important key economic areas aiming at improving the delivery system to benefit the people. In 2004, the first cyclotron and PET CT equipment were successfully installed at Putrajaya Hospital under the Ministry of Health Malaysia to improve healthcare system. The facility was dedicated for the public although local patients from Kuala Lumpur, Putrajaya and Penang benefit most. Following the development, there were 10 more PET-CT installations between the year 2005-2011 involving private hospitals and Universities for academic and research. The ratio of PET-CT service is approximately 1:27 million population Despite having 4 cyclotrons in Klang Valley supplying 18F-FDG, the trend for clinical request for PET CT studies in oncology is slowly increasing. However, the request only come from a small group of clinicians. The facility is not well optimized in areas of infection, inflammation, cardiology, neurology and certain oncology.

National Issues Pertaining to PET-CT Imaging – Analytical statement

1. High demand of Molecular Imaging Technique
2. Limited human resources
3. Poor optimization of both PET and CT facilties in a combined modality
4. Non standardization of PET-CT imaging practices

There are limited human resources available in conducting molecular imaging studies in Malaysia. The limitation is also

responsible in slow expansion of the field despite increasing effort from the government to improved health care delivery system. There are only few specialists credentialed to report PET-CT.

Multimodality imaging is needed in Malaysia to help improving the complication from NCD. Cancers, coronary artery diseases and cerebro-vascular diseases are the top causes of mortality and morbidity in public hospitals (Health facts Ministry Health Malaysia 2008,2009 and 2010). The devastating outcome of NCD in Malaysia potentially reduce the nation's workforce and increase financial burden to the government through long term subsidized medications. Patients of non communicable disease often has chronic disability jeopardizing the available workforce failing the Government's agenda in the transformation plan. This may bring negative impact to the country.

The raising trend of NCD was the focussed agenda in the Forum for ASEAN Health Ministers in 2010. Recent national newspaper statement by the minister of Ministry Health Malaysia (The STAR; Nation: 8th April 2012:8) quoted in 2011, out of 317 766 individuals screened, 25% recorded to have chronic diseases. This alarming situation is prevalent in patients aged 30 and above.

There are various predisposing factors leading to emergence of NCD in Malaysia including life style, smoking and dietary habits. Multiracial, multi ethnicity, multicultural community brings about variety of genetic variations prone to NCD predisposition. While new clinical method is needed to replace the conventional protocols in detecting NCD at earlier stage. The effective role of molecular imaging devices in early disease detection and accurate monitoring of response to treatment can be utilized in complementing the current conventional system in improving patient care

There is a significant gap in expertise within this speciality. In Malaysia, there are approximately 50 major radiology imaging

facilities in public and private hospitals with 9 PET CT facilities and 4 cyclotron. There are 500 qualified radiologists with approximately 112 trainee radiology from 3 main National programs. The expected number of specialists qualifying in the year 2020 is approximated in table below.

Table 14 Future projection of graduates in the discipline of Radiology and Nuclear Imaging

Academic Year	Masters Nuclear Medicine	Masters Radiology Graduating in-campus	Masters Radiology Graduating Trainees outcampus
2011	None	60 students from 3 centres	None
2012	8	66	12
2013	10	72	13
2014	12	79	14
2016	12	86	15
2017	13	94	16
2018	14	103+10	17
2019	15	113+ 11	18
2020	16	124	20
TOTAL	100	808	125

Since multimodality imaging is a new speciality in Malaysia, training, knowledge and skill strengthening efforts of personels should be exercised in order to deliver a high standard clinical practice in multimodality imaging.

In the western country, specifically in European continent where

the modality started, there is wide heterogeneity in the current practice of multimodality imaging. This situation may limit the full potential and integration of multimodality imaging within the clinical arena. There is a strong desire within the specialties of Radiology and Nuclear Medicine to develop interdisciplinary training to address some of these issues.

[Multimodality imaging in Europe: a survey by the European Association of Nuclear Medicine (EANM) and the European Society of Radiology (ESR) Eur J Nucl Med Mol Imaging (2010) 37:163–167]

A survey was conducted in Europe involving Radiologist and Nuclear Medicine specialists in the following countries:

Table 15 Respondents by country

Table 1 Respondents by country

ESR		EANM	
Country	Number	Country	Number
Italy	219	France	40
Germany	179	Italy	32
Spain	158	Netherlands	26
UK	89	Germany	24
France	74	Turkey	21
Netherlands	64	Belgium	16
Austria	57	Spain	13
Belgium	52	UK	12
Poland	51	Greece	11
Greece	50	Portugal	9
Others	498	Others	146
Total	1,491	Total	350

The findings from the survey are tabled below:

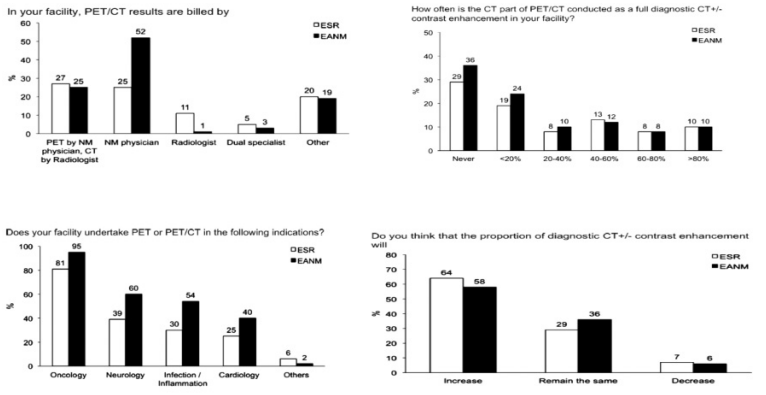


Figure 42 PET-CT usage in Europe, a survey by ESR and EANM

Standardization of clinical practices is mandatory to reduce study variations between equipments and institutions which may bring inaccurate assessment at diagnosis and following treatment.

Prior to widespread use of CT in early 1980, tumour response to treatment was obtained through palpation or chest radiograph. The World Health Organization (WHO) criteria was then developed to standardized treatment response assessment in solid tumours by employing bi-dimensional tumour measurement and categorized the assessment into complete response, partial response, stable disease and progressive disease depending on the size following specific therapy. WHO criteria was further improved by Response Evaluation Criteria In Solid Tumours (RECIST) when CT and MR were widely utilized in tumour assessment. RECIST specified the use of minimum uni-dimensional measurement of 1 cm for 'measureable' or 'target' lesions. RECIST suggest minimum 10 lesions to be evaluated with minimum 5 in one organ. The time to disease progression is shorter when using RECIST criteria for assessment.

A new RECIST 1.1 criteria was further developed in 2009 to fine tuning the previous version. RECIST 1.1 specified only 3 largest lesions may be used. This reclassification also changed the definition of treatment respond using this latest criteria. To this date, the efficacy test in new drug development for solid tumours are based on this criteria including the International Workshop Criteria (IWC) for lymphoma.

Figure 16 Differences between Recist and other criteria

Criteria for Tumor Response to Treatment Based on Anatomical and Metabolic Tumor Imaging Methods

	CR	PR	PD	SD
EORTC (^{18}F-FDG PET)	No uptake of ^{18}F-FDG in the target lesion	Reduction in SUV 15%–25% after one cycle and >25% afterward	Increase in SUV >25%, visible increase in extent of tumor uptake by 20%, appearance of new ^{18}F-FDG uptake in metastatic lesions	Increase in SUV <25% or decrease in SUV <15%, no visible change in extent of tumor
WHO	Complete disappearance of all disease manifestations in two observations at an interval of at least 4 weeks	≥50% decrease in tumor size	>25% increase in tumor lesions and/or appearance of new foci of tumor	Increase or decrease in tumor size of <25%
RECIST	Disappearance of all tumor lesions	At least 30% decrease in the sum of longest diameter of tumor lesion	At least 20% increase in sum of the longest diameter of tumor lesion	Neither PR nor PD

CR, complete response; EORTC, European Organisation for Research and Treatment of Cancer; F, fluorine; PR, partial response; PD, progressive disease; RECIST, Response Evaluation Criteria in Solid Tumors; SD, stable disease; SUV, standard uptake value; WHO, World Health Organization.

The tumour respond metrics offered by these criteria posed limitation to the assessment of new treatment regime especially those resulting in cytostatic rather than cytocidal effect. Morphological change of solid tumours can also be minimal in some following therapy resulting in less accurate outcome in the post treatment assessment using morphological dimension as vital criteria. Tumours in the category of lymphomas, sarcoma,

hepatomas, mesothelioma and GIST are often non measurable for characterization or measureable with less variability at follow up.

The widespread use of 18F-FDG PET in oncology imaging has developed growing interest in manipulating the functional data provided by PET using FDG for monitoring respond to treatment. In the initial years, quantitative measurement for monitoring tumour response in breast cancer using FDG PET has attracted much interest in using this modality for early treatment monitoring.

Based on the importance of biologic predictive value of PET, a new criteria for monitoring tumour respond, PET Respond Criteria In Solid Tumours (PERCIST) has recently been proposed.

PERCIST recommend strict adherence to the performance and standardization of PET scanner and scanning protocol as proposed by The National Cancer Institute and The Netherland Multicentre trial protocol. The conceptual of PERCIST criteria used qualitative and quantitative PET assessment for tumour respond to treatment.

In the qualitative assessment, the criteria emphasized on using mean corrected SUV_{LBM} and SUV_{peak} and the standard deviation rather than SUV_{BW}, the liver uptake being used as the window to stratify the metabolic rate of lesion segregating responding lesions from non-responding lesion and separating stable disease from progressive disease. Alternatively, the blood pool uptake can also be utilized.

PERCIST also recommended FDG PET-CT study to be performed after initial 10 days of starting chemotherapy avoiding fluctuation effect of FDG uptake for early tumor respond evaluation. Following external beam radiation treatment, a lapsed period of 8-12 weeks is recommended. Treatment monitoring to exclude initial resistance therapy is recommended at the end of the first cycle before the start of the second cycle of therapy. However, refinement

is needed for the optimal period and number of treatment to repeat a PET scan which is a matter of debate.

PERCIST may be controversial in some aspect if not all. The fact that current PET technology is limited in the assessment of lesions with smaller diameter below the standard PET camera resolution, the combined diagnostic information provided by both modality PET with CT or PET with MR should be complementing in making an accurate clinical decision.

CENTRE OF EXCELLENCE DIAGNOSTIC NUCLEAR IMAGING, UPM

Research University – Molecular Imaging: A Niche Area

Nuclear medicine was gazzeted as the niche research area for UPM by Dato' Dr Zohadie Bardaei in 2005, research program in Molecular Imaging is grouped under Health and Well being cluster.

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anya, rombongan uni-
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ngan Antarabangsa dan Penyelidikannya, Prof Hans-G Eichler turut membuat lawatan akademik ke UPM, baru-baru ini.

"Ini adalah lawatan balas kepada pihak UPM yang pernah ke MUV pada Ogos lalu," katanya.

Sementara itu, bagi mencapai matlamat menjadi universiti penyelidikan unggul, UPM terus menjalin kerjasama pintar bukan saja dengan pihak luar, malah dalam negara termasuk agensi kerajaan dan swasta.

Kelmarin, universiti itu melalui Institut Biosains (IBS) menandatangani memorandum persefahaman (MoU) dengan Pertubuhan Peladang Negeri Pahang (Pasfa) bagi menjayakan projek pembangunan dan penyelidikan (R&D) dalam bidang Agro-Bioteknologi.

Naib Canselornya, Prof Datuk Dr Mohd Zohadie Bardale, berkata usaha itu penting kerana kerjasama terbabit khususnya dalam bidang R&D

"Bidang Agro-Bioteknologi dikenal pasti berpotensi dibangunkan melalui pendekatan biosains ialah pembangunan tisu didik dan teknologi pengeluaran minyak pati"

Prof Dr Mohd Zohadie Bardaie

Figure 53 Press statement on Niche in Nuclear Medicine by Dato' Dr. Zohadie Bardaie former VC of UPM

Pusat Pengimejan Diagnostic Nuklear

The strategic Plan of Higher Education was launched by the Ministry of Higher Education during the 10th Malaysian Plan (2007-2020). The plan will be executed in 4 phases within 7 clusters with specific intention in delivering human resources in support for the national mission with elevated knowledge capacity and innovation in view to nurture first class mentality by 2020. The strategic plan is executed through 23 Critical Area Projects including Research and Development, Internationalization and Knowledge Transfer Program.

Figure 54 Development project for Centre For Diagnostic Nuclear Imaging 2009

Through strategic KTP program in 2008, the Ministry of Higher Education approved RM17 million allocation for PET-CT equipment and staff recruitment in the development project of Centre for Diagnostic Nuclear Imaging.

Figure 55 The Minister of Higher Education Malaysia signing the commemerative plague witnessed by Tan Sri Zulkifli the Director General of MOHE during the officiating ceremony

In 2009, the development project was completed. Since operation, the facility in UPM created mutilateral networkings in research, academic and services with other public universities and private health care providers. To date, there are 2 international and 3 national memorandum of understandings (MOU) in academic and research, cummulative research grant value of RM500 000, more than 10 multidiscipline research projects and 6 full time post graduate students training under the centre.

Figure 56 Detailed explanation on the PET-CT procedure to the guest of honour during officiating ceremony of the Centre of Excellent

Table 17 Research Grants

Research Project For Centre for Diagnostic Nuclear Imaging UPM				
Project Title		**Year**	**Source of fund**	**Status**
250 000	Wire Mesh Collimator for 3D SPECT Camera	2009	Ministry Sc Tech Innovation	Completed
120 000	Auto intelligent disease detection for diagnosis of extrapulmonary TB	2009	Ministry Sc Tech Innovation	Completed
200 000	The value of quantifying coronary reserve flow using 82Rb	2011	RUGS	**Active**

200 000	Extrapulmonary TB infection using FDG PET CT	2008	RUGS	Completed
Eur 10 000	Treatment monitoring Extrapulmonary TB infection using FDG PET CT	2009	IAEA	Completed
Eur 10 000	Extrapulmonary TB infection using FDG PET CT	2010	IAEA	Completed
30 000	18F-FDG PET CT in prosthesis infection	2011	RUGS	Completed
70 000	18F-FDG PET CT in Head and Neck Cancers	2011	RUGS	Completed
30 000	18F-FDG PET CT in database development for myocardial viability study	2011	RUGS	Completed
70 000	The clinical value of multimodality imaging PET CT using Fluorodeoxyglucose (FDG) compare with conventional method in the diagnosis of Alzheimer's Disease: A pilot study	2012	RUGS	**Active**
70 000	18F-FDG PET CT in pheochromocytoma	2011	RUGS	Completed

110 000	The clinical value of multimodality imaging in the management of gynae-onlogical malignancies	2012	RUGS	**Active**
15 000	The role of 18F-FDG PET-CT in detection of vulnerable plague	2011	RUGS	Active

Figure 57 Document exchange Memorandum of understanding between UPM and Milan Bicocca University represented by Prof Dato' Dr Abdu Bakar (DVC in Research) and Prof Dr Maria Luisa (VC in internationalization) – 2007 Scientific Visit

The centre also plays a role in educating and training the post graduate trainees in Masters in Radiology conferred by University Malaya.

Figure 58 Document exchange Memorandum of Understanding between UPM and Medical University of Innsbruck Austria by Prof Dato' Dr Salleh Jaafar (DVC in Research UPM) and Prof Dr Erich Schmutzhart (University Coordinator MUI) – 2013 ASEA UNINET Plenary session Kuala Lumpur

The centre was established aiming at improving the knowledge and skill of personnels involved in teaching, learning and training in using multimodality imaging PET-CT for patient care. The mission will be accomplished through fellowship trainings, teaching missions, creating new training programs and improving current programs.

International Collaborations

The strength of molecular imaging research in UPM is closely related to international allies through official MOUs including University of Milan Bicocca and Medical University of Innsbruck. Active participation of other collaborators are through academic networking such as Asean- European Academic University Network

or ASEA-UNINET. These include University of Brescia and University of Groningen. Each institution focuses on specific area for development including :

1. Milan Bicocca University – Neuro PET-CT
2. Medical University Innsbruck, Austria – Oncology PET-CT
3. Brescia University – Neuro PET-CT
4. Groningen University – Neuro PET-CT and Radiopharmacy
5. Ospedale Niguarda Milan Italy – PETCT in infection and inflammation

Figure 59 Guest of honour the Minister of Higher Education being brief by Dr Noraini Abdul Rahim, The head of Department Diagnostic Imaging, Serdang during officiating ceremony of PPDN UPM witnessed by Claudia Rossetti from Ospedale Niguarda Milan Italy

ASEAN European Academic University Networking

ASEA-UNINET was founded in 1994 through the expansion of academic collaboration between the founder universities Chulalangkorn of Thailand and Innsbruck of Austria to include the Indonesian and Vietnam universities.

ASEA-UNINET or ASEAN-European University Network is an internationalization platform for member universities chosen from ASEAN and European continents. The inception of membership is by careful evaluation of academic tract record by the members of the network. The main objective is to promote academic collaboration through student-staff exchange program, joint teaching and research activities. Project developments are often accomplished through help from experts of help from both continents.

ASEA-UNINET meets during the National Coordinator meeting and the Plenary meeting.

Each university is represented by a University Coordinator (UC). Each country is represented by a National Coordinator (NC). The UC reports to the NC. Europe and Asia are represented by the Regional Coordinator (RC) respectively. The Chair person oversees the network activities and coordinate the Plenary session with the advice from the regional coordinators and immediate past chair person. National Coordinator meeting is an annual event while the plenary meeting is held every alternate years.

The network focuses on diversified areas of

1. Science and technology
2. Economic and social sciences
3. Health, pharmacy and medicine
4. Humanitarian, cultural and music

Since its establishment, the membership has grown to more than 60 universities. Among the countries involved are Austria, Italy, Greece, Spain, Germany and Netherland representing Europe

and Thailand, Indonesia, Vietnam, Malaysia and the Philippines representing ASEAN including Pakistan as an associate member.

The 18-year long successful story of ASEA-UNINET is shared with the past chairpersons.

Having in mind the process of increasing globalization and of continuous internationalisation of education and research, considering the importance of science and research for development and indigenous capacity building, noting with interest the ASEM process between European and Asian States, being aware that networking and partnerships are the most promising way to achieve success within this context, thus the objectives of ASEA UNINET

1. to encourage and facilitate cooperation between academic institutions in staff/student exchange, teaching and research activities
2. to promote scientific, cultural and human relationships and personal contacts
3. to encourage and initiate projects of mutual interest and benefit for faculties, staff and students
4. to assist in forming coalitions of resources for academic activities between member institutions
5. to facilitate contacts between universities, governmental and non-governmental organisations and economic operators engaged in projects related to education, science, technology and art in countries with member universities
6. to act as a forum of continuous discussions on the progress of these projects, and serving as a network of excellence providing expertise and initiatives for entities seeking European-S.E.Asian relations in the fields mentioned above.

Figure 60 ASEA UNINET's plenary meeting in Bangkok 1981

Universiti Putra of Malaysia's Membership into ASEA-UNINET: A Brief History

Universiti Putra Malaysia (UPM) is the first member from Malaysian university in ASEA-UNINET. UPM was introduced by Medical University of Vienna (MUV) to become a member of this network in 2007. It started when a delegation from the Faculty of Medicine and Health Sciences of UPM led by the dean, Professor Dr Azhar Md Zain paid a scientific visit to MUV and Klagenfurt Hospital, Austria in 2005.

The purpose of the visit was to acquire expert advice from Austria in implementing the development project for Ministry of Higher Education "The Centre for Diagnostic Nuclear Imaging", a new niche research area in UPM. The trip was sponsored by International Atomic Energy Agency (IAEA).

Figure 61 Official visit to IAEA head Quarters in Vienna

Upon reciprocal visit by the MUV group to UPM in the following year, an official invitation was received to defend the acceptance of UPM into ASEA-UNINET at the Plenary Session in Nha Trang Vietnam in 2006.

Figure 62 The office of Vice rector in International Affair Medical University Vienna in 2005 (left) and reciprocal visit to UPM's Vice Canselor's Office the following year (right)

UPM was officially accepted as a new member of ASEA UNINET in 2007. UPM continue supporting the through the Plenary sessions organized by Technical University of Vienna (2007), University of Mahidol, Thailand (2009) and University of Trento, Italy (2011), National Coordinator Meetings organized by University of Ioanina, Greece (2008) and University of Passau, Germany (2011). Soon after 4 years of inception, ASEA UNINET was made visible in Malaysia followed by 3 new member from Malaysian university accepted into the network including University Kebangsaan Malaysia (2011), University Malaya (2012) and Technical University of Melaka (2012).

ASEA-UNINET recognized the potential of Malaysian University and significant contributions that the universities can make. Sustained commitment shown by UPM has gained recognition from ASEA-UNINET. During the 2011 Plenary Session in Trento, Italy Prof Dr Abdul Jalil Nordin was elected as the new chairman of ASEA UNINET, the first Malaysian chairperson of this international academic network.

V14 VARSITI WAWANCARA

KHAMIS 29 NOVEMBER 2012 BIL:150 BH

"KERJASAMA SEUMPAMA INI SECARA TIDAK LANGSUNG MEMBANTU UNIVERSITI TERBABIT MEMBINA REPUTASI DAN JENAMA KUKUH DI PERSADA ANTARABANGSA"

Prof Dr Abdul Jalil Nordin, Pengarah Pusat Pengimejan Nuklear UPM

Kerjasama universiti Eropah

S: Boleh Prof jelaskan latar belakang penubuhan ASEAN-European University Network (ASEA-UNINET).

J: Kerjasama Universiti Innsbruck, Austria dengan Universiti Chulalangkorn Thailand yang merangkumi pertukaran pelajar dan kakitangan universiti serta pembabitan dalam kegiatan penyelidikan membawa kepada penubuhan ASEA-UNINET.

Konsep kerjasama Innsbruck-Chulalangkorn diterjemahkan dan diperluas dengan penubuhan ASEA-UNINET pada 1994 dalam usaha menyediakan tenaga mahir bagi memacu perkembangan negara membangun.

Matlamat utama penubuhan jaringan ini untuk menggalakkan kerjasama akademik antara ahli anggota universiti terbabit menerusi aktiviti saintifik, kebudayaan dan hubungan kemanusiaan.

Aktiviti akademik dilaksanakan merangkumi penyelidikan bersama dalam bidang sains dan teknologi, ekonomi dan sains sosial; kesihatan, farmasi dan perubatan serta kemanusiaan, kebudayaan dan muzik.

S: Apakah status semasa keanggotaan ASEA-UNINET?

J: Keanggotaan ASEA-UNINET berkembang daripada 35 universiti pada peringkat awal penubuhannya kepada 65 universiti ketika ini.

Antara negara terbabit dari Austria, Bali, Greece, Sepanyol dan Jerman mewakili Eropah sementara Thailand, Indonesia, Vietnam, Malaysia dan Filipina mewakili Asia Tenggara termasuk Pakistan sebagai ahli bersekutu.

Empat universiti tempatan yang terpilih menganggotai gagasan ASEA-UNINET adalah Universiti Putra Malaysia (UPM), Universiti Kebangsaan Malaysia (UKM), Universiti Malaya (UM) dan Universiti Teknikal Malaysia Melaka (UTeM).

Setiap universiti diwakili koordinator universiti yang bertanggungjawab kepada koordinator kebangsaan. Eropah dan Asia masing-masing diwakili oleh Koordinator Serantau yang bertanggungjawab kepada Pengerusi ASEA-UNINET. Setakat ini, 12 Pengerusi mengetuai ASEA-UNINET sejak penubuhannya.

ASEAN-European University Network (ASEA-UNINET) menjadi wadah meningkatkan akses kepada pengajian tinggi berkualiti menerusi kerjasama antara universiti awam tempatan dengan institusi pengajian tinggi Eropah.

Pengarah Pusat Pengimejan Nuklear Universiti Putra Malaysia (UPM), Prof Dr Abdul Jalil Nordin, yang juga Pengerusi ASEA-UNINET berkongsi perkembangan terkini jaringan akademik antarabangsa itu seperti disampaikan kepada wartawan Varsiti, ROSNIZA MOHD TAHA.

S: Apakah impak kerjasama ini kepada universiti dan Kementerian Pengajian Tinggi (KPT)?

J: ASEA-UNINET menepati hala tuju bidang keberhasilan utama KPT termasuk meningkatkan akses kepada pengajian tinggi berkualiti melalui kerjasama antara universiti tempatan dengan Eropah.

Antara lain, jaringan ini membantu meningkatkan kebolehpasaran graduan menerusi program pertukaran pelajar selain membina jaringan penyelidikan yang lebih kompetetif dan berdaya saing.

Kerjasama seumpama ini secara tidak langsung membantu universiti terbabit membina reputasi dan jenama kukuh di persada antarabangsa.

Contohnya, beberapa universiti tempatan berpeluang menghantar pelajar dan kakitangan mereka mengikuti program di bawah Projek Erasmus Mundus yang diwujudkan bagi mempromosi sistem pengajian tinggi Eropah.

Seramai sembilan pelajar tempatan terpilih mengikuti program Eurasia yang memumpukan kepada pendidikan dan penyelidikan pengurusan sumber semula jadi dan alam sekitar.

Program tajaan Kesatuan Eropah ini bermula Oktober 2010 hingga Oktober 2014.

Seramai empat pelajar UPM dan empat penuntut Universiti Sains Malaysia yang bukan ahli ASEA-UNINET turut terpilih menjalani program ini. Hal ini demikian kerana kita tidak mengehadkan manfaat program kepada universiti ahli saja, malah turut menawarkan kepada universiti lain jika mempunyai calon berkelayakan.

Seramai 12 pelajar dan kakitangan universiti tempatan akan ditawarkan mengikuti Program Lets Move Together (MOVE) yang juga ditaja Kesatuan Eropah bermula November tahun lalu hingga November 2015.

MOVER memumpukan kepada bidang pertanian, kejuruteraan, ekonomi dan perniagaan, perubatan dan sains kesihatan, alam sekitar, sains makanan serta perhutanan.

Satu lagi program di bawah Projek Erasmus Mundus ialah Man Health Environment Biodiversity in Asia (MAHEYA) yang bakal dukuti 11 pelajar dan kakitangan universiti tempatan.

Pembabitan aktif universiti tempatan khususnya UPM dalam jaringan ini juga mendapat pengiktirafan, iaitu semasa sesi Mesyuarat Planeri ke-12 tahun lalu di Trento, Italy, apabila saya dilantik sebagai Pengerusi ASEA-UNINET bagi tempoh 2013 hingga tahun depan.

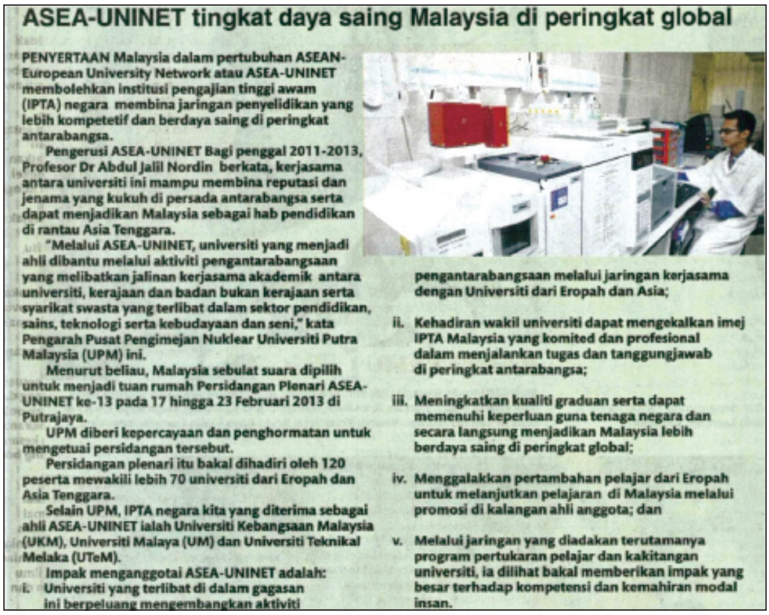
ASEA-UNINET mengamalkan penggiliran jawatan pengerusi antara Eropah dengan Asia. Pelantikan pengerusi dijalankan serentak dengan Mesyuarat Planeri ASEA-UNINET yang diadakan setiap 18 bulan. Persidangan Planeri ASEA-UNINET ke-13 akan diadakan pada 17 hingga 21 Februari depan di Putrajaya.

S: Apakah pengisian Persidangan Planeri ke-13 di Putrajaya nanti?

J: UPM diberi kepercayaan dan penghormatan untuk mengetuai persidangan ini. Pertemuan ini bakal dihadiri lebih 120 peserta daripada 70 universiti Eropah dan Asia Tenggara. Persidangan berlangsung selama empat hari di Hotel Marriot Putrajaya. Kami berharap menjemput wakil universiti awam lain untuk menghadiri persidangan terutama pada majlis perasmian.

UPM, UKM, UM dan UTeM dijemput untuk mempamerkan kesitimewaan institusi masing-masing sebagai satu daripada cara mempromosi universiti tempatan. Antara acara penting persidangan ini ialah lawatan delegasi ke universiti awam yang mengadi ahli ASEA-UNINET bagi mengeratkan hubungan diplomasi dalam bidang akademik. Upacara penutup persidangan bakal diadakan di UTeM diikuti lawatan teknikal ke universiti itu.

Figure 63 Press interview - Chairman of ASEA-UNINET 2011-2013



ASEA-UNINET tingkat daya saing Malaysia di peringkat global

PENYERTAAN Malaysia dalam pertubuhan ASEAN-European University Network atau ASEA-UNINET membolehkan institusi pengajian tinggi awam (IPTA) negara membina jaringan penyelidikan yang lebih kompetetif dan berdaya saing di peringkat antarabangsa.

Pengerusi ASEA-UNINET Bagi penggal 2011-2013, Profesor Dr Abdul Jalil Nordin berkata, kerjasama antara universiti ini mampu membina reputasi dan jenama yang kukuh di persada antarabangsa serta dapat menjadikan Malaysia sebagai hab pendidikan di rantau Asia Tenggara.

"Melalui ASEA-UNINET, universiti yang menjadi ahli dibantu melalui aktiviti pengantarabangsaan yang melibatkan jalinan kerjasama akademik antara universiti, kerajaan dan badan bukan kerajaan serta syarikat swasta yang terlibat dalam sektor pendidikan, sains, teknologi serta kebudayaan dan seni," kata Pengarah Pusat Pengimejan Nuklear Universiti Putra Malaysia (UPM) ini.

Menurut beliau, Malaysia sebulat suara dipilih untuk menjadi tuan rumah Persidangan Plenari ASEA-UNINET ke-13 pada 17 hingga 23 Februari 2013 di Putrajaya.

UPM diberi kepercayaan dan penghormatan untuk mengetuai persidangan tersebut.

Persidangan plenari itu bakal dihadiri oleh 120 peserta mewakili lebih 70 universiti dari Eropah dan Asia Tenggara.

Selain UPM, IPTA negara kita yang diterima sebagai ahli ASEA-UNINET ialah Universiti Kebangsaan Malaysia (UKM), Universiti Malaya (UM) dan Universiti Teknikal Melaka (UTeM).

Impak menganggotai ASEA-UNINET adalah:

i. Universiti yang terlibat di dalam gagasan ini berpeluang mengembangkan aktiviti pengantarabangsaan melalui jaringan kerjasama dengan Universiti dari Eropah dan Asia;

ii. Kehadiran wakil universiti dapat mengekalkan imej IPTA Malaysia yang komited dan profesional dalam menjalankan tugas dan tanggungjawab di peringkat antarabangsa;

iii. Meningkatkan kualiti graduan serta dapat memenuhi keperluan guna tenaga negara dan secara langsung menjadikan Malaysia lebih berdaya saing di peringkat global;

iv. Menggalakkan pertambahan pelajar dari Eropah untuk melanjutkan pelajaran di Malaysia melalui promosi di kalangan ahli anggota; dan

v. Melalui jaringan yang diadakan terutamanya program pertukaran pelajar dan kakitangan universiti, ia dilihat bakal memberikan impak yang besar terhadap kompetensi dan kemahiran modal insan.

Figure 64 Importance of International Networking by ASEA-UNINET to UPM development

The following are the outline of UPM's achievements in collaboration with ASEA-UNINET since 2007 :

- UPM was invited to be involved in several staff – student exchange programs facilitated by the European Union. Several successful partnership in the applications included Czech Univ Life Sciences Prague and BOKU, Austria under EURASIA 2 project, University de Murcia under MOVER project and several ASEAN universities in MAHEVA project. These projects will end approximately in the year 2014.

- ASEA-UNINET facilitated journal reviewing process for MOHE's journal of Movement and Health under the Department of Higher Learning, MOHE. Several universities from Austria and Thailand became part of the journal's international reviewers. The first issue was successfully published in the first quarter of 2012.
- UPM received visiting professors from Medical University of Innsbruck including Prof Dr Walter Koffler, Prof Dr Erich Schmutzhard and Prof Dr Irene Virgolinni between 2007-2011.
- In return, UPM received a scientific visit invitation to the Department of Nuclear Medicine, Medical University of Innsbruck. The visit was successfully accomplished by Dr F. Fikri of Diagnostic Nuclear Imaging Centre of UPM with in-kind contribution of Medical University of Innsbruck, Austria assisted by Prof Dr Walter Koffler.
- The outcome of the visit was published into ISI academic journal in Radiology.
- Recently, the Centre for Diagnostic Nuclear Imaging, UPM received expert assistance in developing normal brain database for metabolic brain imaging using FDG PET-CT from University Medical Centre Groningen (UCMG) Holland under the Nuclear Medicine Department (head of Department is Prof Dr Rudy)
- In near future, scientific works involving Magnetic Resonance Imaging will be carried out in collaboration with University of Brescia and University of Trento, Italy.

The 13th ASEA UNINET Plenary Meeting Hosted by UPM

The 13th ASEA UNINET Plenary Meeting was successfully hosted by UPM under the leadership of Centre for Diagnostic Nuclear Imaging in collaboration with University Malaya, University Kebangsaan Malaysia and University Teknikal Malaysia, Melaka between the 17th-21st February 2013 at Marriott Putrajaya.

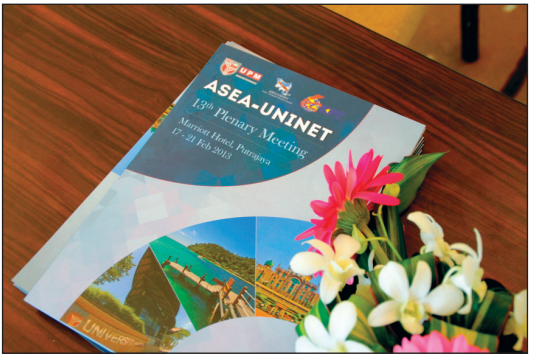


Figure 65 The 13th Plenary session of ASEA-UNINET hosted by UPM

The meeting successfully gather 70 academicians from 60 European and ASEAN universities together. Intense discussion, exchange of ideas, focus group discussion were carried out over 4 days.

The highlight of the event was university visits, highlights on the niche area of each member universities from Malaysia featuring IT security by UTEM, Food Security by UPM, High Impact Research by UM and Renewable Energy by UKM. A special session was arranged with the former Prime Minister Tun Dr Mahathir Mohamad delivering his lecture on "Higher Education in the Next Millenium"

Figure 66 Participants from Austrian Universities (left) and the opening ceremony attended by the representatives of the Minister of Higher Education Malaysia and the Austrian Embassador (right)

Figure 67 The ASEA UNINET plenary Session Marriot Putrajaya 2013

Figure 68 Higher Education in the next Millenium-by Tun Mahathir Mohamad highlighted during the plenary session at Sharingla Putrajaya

A reference textbook entitled, "**Clinical PET-CT – the basics**" is an example of collaborative effort within the spirit of ASEA-UNINET in knowledge transfer and expert assistance to boost the quality of higher education in Malaysia in the specialized area of Molecular Imaging.

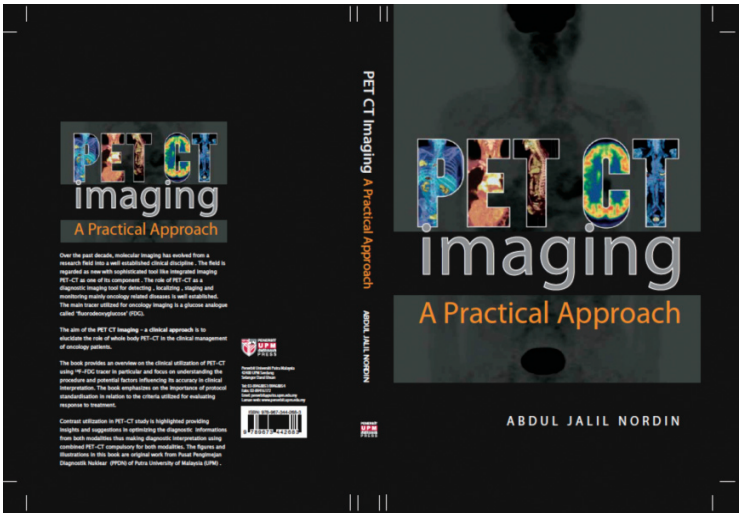


Figure 69 "PET-CT Imaging - A Practical Approach" an out come from the International Network- Collaboration between PPDN UPM and Medical University of Innsbruck in ASIA UNINET

THE FUTURE DIRECTION OF MOLECULAR IMAGING

Supporting PET CT Training Program

Multimodality imaging represents an area of rapid growth with important professional implication for both nuclear medicine physicians and radiologists. As a preliminary step for future action aimed at improving the quality and accessibility of PET/SPECT/CT/MR multimodality imaging practice in Malaysia, a program is designed to train personal in multimodality imaging like PET CT and PET MR. The program shall contain the following elements including training and continued professional development (CPD) for all staff involved in delivering PET-CT services and research studies.

The stakeholders identified are universities providing integrated imaging modality facility and related programs, these universities are under the Malaysian Ministry of Higher Education (MOHE) including University Malaya Medical Centre, Hospital UKM, affliated Ministry Health Hospital as teaching and training centres like Serdang Hospital and National Cancer Institute. Training are provided by the universities through programs like Masters in Radiology, Masters and PHD in Molecular Imaging, short professional courses and Continous Medical Education (CME). The hospitals require large number of trained human resources in this area to provide efficient and professional services. Trained human resources are also required in order to support the eco-system of Research Universities (UPM, UM and UKM) and the program offered through research projects.

Figure 70 Officiating ceremony for the 13th Plenary Session ASEA-UNINET Marriott Putrajaya 2013

The end users will be the specialists and support staff from the above mentioned institutions. Soon upon completion of the program, the knowledge and skill will be further transferred through programs and courses to be conducted (in house) to train human resources in other institutions including private hospitals.

Interested parties will be the Academy of Medicine Malaysia, Professional Society such as College of Radiology, National Specialist Register, Atomic Licensing Board. These professional bodies will regulate and govern the process of credentialing for supervising and reporting studies involving integrated imaging modalities where a national bench mark can be created for credentialing process to be adopted from the program to be implemented.

The main players shall be Unversity Putra Malaysia partnering with Malaysian Nuclear Agency and International Atomic Energy Agency. UPM will be doing the selection of candidates to be trained through agreeable criteria. Through international collaborators, training institution will be identified. The ASEAN-Europe University Network (ASEA-UNINET), ASEAN University Networking (AUN) and MOUs with individual universities will be the platform to identify partner universities abroad in Europe and Asia.

The beneficiaries of this project will include patients who suffer from most form of non communicable diseases and infectious diseases. The Government will also be a beneficiary through economical subsidization of medical care in combating non-communicable and infectious diseases in hospitals and as out patients with improving diagnostic accuracy and follow up monitoring response to treatment, This program will benefit stakeholders.

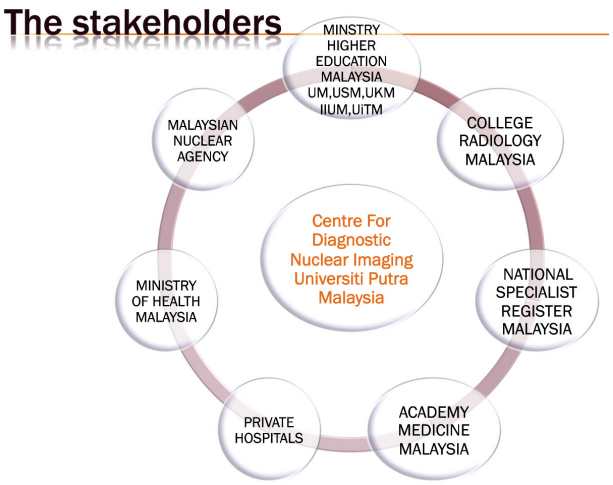


Figure 71 The Stakeholder for the PET-CT traning program

The program will give an overview of glucose metabolism describing the concept of integrated diagnostic imaging according to common 18F-FDG PET-CT practices in clinical setting. Several recommended protocol for PET-CT image acquisition will be explained in principle aiming at achieving best result for qualitative and quantitative assessment. The Society of Nuclear Medicine (SNM), the European Association Nuclear Medicine (EANM), European Journal Nuclear Medicine Molecular Imaging (2010) and The Netherlands protocol for standardization and quantification of FDG whole body PET studies in multi-centre trials (2008) will be highlighted potentially an acceptable standard recommended protocol for accurate reassessment of 18F-FDG PET CT study in oncology as procedure guidelines.

The program will emphasize on optimization of informations from PET and CT studies during integrated PETCT session. The need for standardization of PET-CT procedure will be emphasized.

ii. Expanding Existing Molecular Imaging Services

1. New equipment (2014-2015)
2. Human Resource Development (2014-2015)
3. New services with potential tracers (2015-2016)
4. Training and Skill development (2013-2015)

New oncology services with new tracers will be proposed to the university by "Expanding and optimizing the role of hotlab using synthesizer " project. This will include generator produced isotopes like rubidium and gallium. Under the 10th Malaysian Plan, the Centre will be working for 3-Tesla MR installation by the year 2014. The equipment will be integrated with the current PET-CT making MR-PET a feasible study to be conducted at the Pusat Pengimejan Diagnostik Nuklear UPM. The budget allocation for this project is RM18 million in 2014-2015 period.

Figure 72 The rector and Vice Rector of University Brescia, Italy.

iii. Personalised Medicine- Dawn of New Era in Medicine

Personalized medicine is about making the treatment as individualized as the disease.

It involves identifying genetic, genomic, and clinical information that allows accurate predictions to be made about a person's susceptibility of developing disease, the course of disease, and its response to treatment. In order for personalized medicine to be used effectively by healthcare providers and their patients, these findings must be translated into precise diagnostic tests and targeted therapies. The advantages of personalized treatment are:

1. Ability to make more informed medical decisions
2. Higher probability of desired outcomes thanks to better targeted therapies
3. Reduced probability of negative side effects
4. Focus on the prevention and prediction of disease rather than reaction to it
5. Earlier disease intervention that has been possible in the past

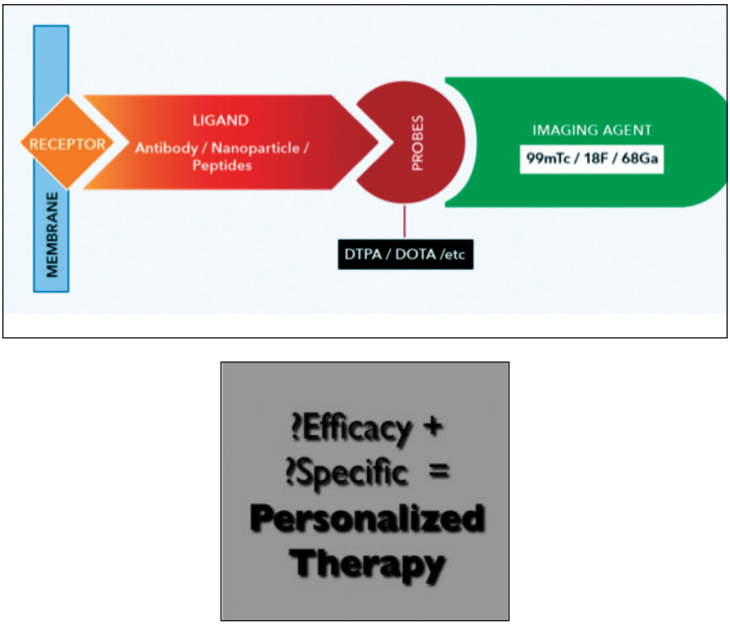


Figure 73 Molecular imaging and personalized medicine is a multidisciplinary research and scientific activities involving various disciplines

CONCLUDING REMARKS AND PERSONAL STATEMENT

As a concluding remark, the field of molecular imaging is expanding to balance the need and demand for new line of treatment. Our multidisciplinary scientific consortium can support the progress by enriching the research and innovation environment through academic teaching and learning which can be successfully accomplished through a holistic approach.

Personal Statement

During my journey some weeks ago , attending the European Congress in Radiology I was pre-occupied on the new expansion project for the Centre. On retrospect, the history of the Centre recalled the fact that life is like riding a bicycle. To keep your balance you must keep moving.

Einstein once quoted ,“The state of mind which enables a man to do work of this kind is akin to that of the religious worshiper or the lover; the daily effort comes from no deliberate intention or program, but straight from the heart “

As the prophet (peace be upon him) said in his hadith narrated by Abu Hurairah, *"There is no disease that Allah has created, except that He also has created its treatment."*

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BIOGRAPHY

ABDUL JALIL was born on May 3RD, 1963, in Muar, Johor. His father, Nordin Johari, was a clerk, and his mother, Hamidah Abdul Shukor, is a housewife. He is the fourth sibling of eight. He has five brothers and two sisters. He is the Doctor of the house and a struggler from small. At age 9, his family moved from Tangkak to Johor Bahru when his father was posted to Istana Besar as a government's servant. He then entered Sekolah Temenggong Abdul Rahman (STAR) Jalan Abdul Rahman Andak until he finished his Standard 6. In 1976, he started his high school at the English College, Johor Bahru until he finished his Sijil Pelajaran Malaysia (SPM) examination in 1980. At school, Jalil was described as a friendly, independent and active student. He was liked by many for his esteemed sense of responsibility. He was delegated to be the head class throughout his study at English College. He was trustworthy and was appointed as the school prefect.

Jalil was very fond of athletics. He was an athlete and was elected as the leader for the Drury house. He championed the 110-meter and 400-meter hurdles events and bagged gold medals representing the English College at the district level. After obtaining his SPM results, he declined a scholarship offered by the United States instead accepted an offer to continue his study in medicine at Universiti Kebangsaan Malaysia. He was transferred to Sekolah Alam Shah, Jalan Cheras, Kuala Lumpur in 1981, joining the matriculation program and continued his study at the Faculty of Medicine, Universiti Kebangsaan Malaysia. The 5-year program in Medical school in Kuala Lumpur taught him the realm of life. Upon graduation, he was posted to Hospital Sultanah Aminah, Johor Bahru as a houseman where he began to learn the real value of time, responsibility and dedication. Life as a houseman during his days was filled with responsibilities. To accomplish a job

beautifully one needs to be focused and highly dedicated. After one and a half year of successful training, he was accepted into the Masters in Radiology program as the first batch to be trained under the Department of Radiology, University Malaya, Kuala Lumpur. He successfully completed the program and graduated in 1996 and returned to Hospital Sultanah Aminah, Johor Bahru for his first posting as a Radiologist under the public service. In the following year, he made his trip to Mekah for his first pilgrimage as an officer in duty under the Ministry for Haj.

Career Path Development

A year later he was involved in the Development Project for Nuclear Medicine Unit under the Department of Diagnostic Imaging. In 1998, he went for his Fellowship in Nuclear Medicine at Westmead Hospital, Sydney, Australia, the training centre for University of Sydney. The 6 months training course was sponsored by the International Atomic Energy Agency (IAEA). He wrote his first international publication while in Sydney that was published in the Journal of Australasian Radiology in 2001. His return to Malaysia was the turning point in his career in the Ministry of Health as he was re-located to Hospital Tengku Ampuan Afzan, Kuantan Pahang defeating the purpose of his prioritized intention in his professional career development. He decided to join the Pantai Specialist Group of practice in Klang Valley as a Consultant Radiologist in 1999. He continued his interest in the subject of Nuclear Medicine by teaching undergraduate program at the University Teknologi MARA as a visiting lecturer and supervised their hands-on practical sessions in Radiology. After a while, he began to realize that he had his very own niche to be accomplished. His main concern was his national contribution in the field of medical imaging. Thus, he decided to join an academic institution in 2003 as a senior lecturer establishing

the Nuclear Medicine Unit of the Radiology Department, Faculty of Medicine and Health Sciences of Putra Universiti of Malaysia. Jalil always appeared to have clear views of the future direction of Universiti Putra Malaysia as one of the pioneering Research Universities especially in his sub-specialized field of Molecular Imaging . After 7 years of struggle, he established the Centre for Diagnostic Nuclear Imaging of UPM in 2010.

Family Life

A Jalil fell in love with his wife Nabilah Abu Kassim and got married at the age of 29. They have 3 beautiful boys, Nabil, Ezzat and Danish. Nabil is doing well at the Alexandria University in Egypt following the footsteps of his father while Ezzat and Danish are enrolled into boarding school. Having a wife who is teacher, he understands the need of sharing the responsibility in raising the children whereby he is, devoting and dividing his time between academic responsibility in the university and his family. His success in academic is very much contributed by the strong support from his wife and his children in which they understanding the nature of his job.

University Career

His curiosity in the working attitude of the westerns and the culture difference has brought a new horizon in his observation about life and his career path. He gained experience from many short visits, adapting and adopting himself within working clusters of scientists especially around Europe. He is an observant, learnt through observing the social skills of extroverts and introverts, where a picks up useful clues from different ranges of personality types. These decentering exercises through observations in the

past, have helped in his character development and served as a guidance in positioning himself in the western European academic community. His positive attitude in regard to his achievements is a mere stepping stone for the next advance of his success in the field of molecular imaging in Malaysia. This was enhanced further through his scientific collaboration with Ospedale Niguarda, Milan, Italy. His contact person Dr Claudio Rossetti, a nuclear Medicine Physician and, The Director of Advanced Technology Department and The Head International Collaboration for European Association Nuclear Medicine was the responsible person in introducing and coaching him in this sub-specialization. Together with a close colleague, Claudio sponsored hospital training attachment and allowed data collection from his department for academic and scientific writing. Two articles in Nasopharyngeal Carcinoma and Lymphoproliferative Disorders were successfully presented as oral papers at the European Congress of Nuclear Medicine in Copenhagen, Denmark in 2007. In the following year, both papers were published in a peer reviewed international journal Singapore Medical and Radiology and Oncology Journals as research papers. The academic activity initiated deeper commitment in the field of Molecular Imaging for UPM. In the following year, Jalil was awarded with Fellowship in PET-CT training program at University of Zurich by the IAEA for 4 months. In the same year, the partnership of UPM and Ospedale Niguarda was expanded to explore research in the area of extrapulmonary Tuberculosis infection using 18F-FDG PET-CT. The research was supported by UPM's Research University Grant Scheme and included Ospedale Pietre Ligure in Santa Savona, Italy , one of the main TB hospital in Northern Italy. Two hundred thousand ringgit was allocated for the study with additional fundings from the IAEA in two consecutive years amounting ten thousand euros through Coordinated Research

Project. The outcome was encouraging with more than 10 published articles in reputable peer reviewed journals, a book and a post graduate PHD candidate. The highest impact factor article was published in European Journal Nuclear Medicine and Molecular Imaging in 2009 as **DISSEMINATED TUBERCULOSIS INFECTION – A 'SUPER' FDG PET / CT APPEARANCE** carrying an Impact Factor of 4.5 and bagged a Gold Award during the Research Innovation Exhibition week organized by UPM in the same year. The research subject is highly relevant within the molecular imaging community in the western countries proven by acceptance of proceedings in major conferences including World Molecular Imaging Congress in Nice (2008), Italian Congress of Nuclear Medicine in Rome (2008), Update on Radiopharmaceutical and Therapy in Austria (2009), Radiological Society North America in Chicago (2011) and The European Congress Nuclear Medicine and Molecular Imaging in Milan (2012). The research collaboration with Ospedale Niguarda Milan is now transformed into an MOU signed between UPM and Milan Bicocca University, affiliated to Ospedale Niguarda. The research area was expanded to include aspergillosis infection in PET-CT and database development using Statistical Parametric Mapping for ASIAN brain PET to be utilized in Alzheimer's project in Malaysia.

The professor in Radiology and diagnostic Imaging

Prof Jalil was promoted in 2011 for his passion and academic achievements in the field of molecular imaging. Apart from being an administrator for the Centre of Excellent (COE) in Diagnostic Nuclear Imaging, he is an active researcher himself. He exploresvarious Molecular Imaging perspectives for clinical indication through his proposals. He shares his vision in conducting crossed discipline research with the clinicians from Head and Neck

Surgery, Orthopedic, Respiratory Medicine, Cardiology, Neurology, Psychiatry and, scientists from Engineering and Biomedicine. He is committed in helping his colleague in pursuing research activities from preparation to reporting. His total accumulated research grant under the COE is RM600 000 within 3 years. He is consistent and always shared his work with his colleagues and encourages junior lecturers to take active role in research activities. He is also a generous teacher, sharing his experience through teaching sessions involving candidates from Masters Radiology program. Apart from introducing PET-CT in infection and inflammatory conditions, another important work is related to myocardial imaging for perfusion using rubidium and viability using FDG. UPM gained recognition through his pioneering work in Malaysia performing myocardial PET-CT study using copyright database from the Malaysian population for study interpretation. The database was patented. His fond interest and contributions in his scientific field have earned him acknowledgement and recognitions when he was elected and mandated to organize the 13th Plenary session for the Asean-European Academic University Networking or ASEA-UNINET as the first Malaysian chairman of the prestigious international network. He promoted the ASEA-UNINET's university members and research output during the event including UPM, UM, UKM, UTEM and UUM. The successful organization of the plenary session has earned Malaysia respect among academicians from prominent universities in South East Asean countries and European Continents. Prof Dr A Jalil with the support from his international colleagues from Medical University of Innsbruck Austria and University of Groningen, Holland authored the first book on PET-CT Imaging in Malaysia which was launched during the plenary session.

In near future, Prof Dr A Jalil will expand the role of the Centre for Diagnostic Nuclear Imaging of UPM by including a MR-PET facility with a RM18million budget. He is also leading a Technical Cooperation project mandated by the IAEA for human resource training in hybrid imaging starting inthe year 2014.

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To my dear wife Nabila Abu Kassim and my childrens Nabil, Ezzat and Danish, I treasure the time you allow me to spend on my work. May Allah bless our family and carry the barakah of this work to akhirat.

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Thank you to all.

LIST OF INAUGURAL LECTURES

1. Prof. Dr. Sulaiman M. Yassin
   The Challenge to Communication Research in Extension
   22 July 1989

2. Prof. Ir. Abang Abdullah Abang Ali
   Indigenous Materials and Technology for Low Cost Housing
   30 August 1990

3. Prof. Dr. Abdul Rahman Abdul Razak
   Plant Parasitic Nematodes, Lesser Known Pests of Agricultural Crops
   30 January 1993

4. Prof. Dr. Mohamed Suleiman
   Numerical Solution of Ordinary Differential Equations: A Historical Perspective
   11 December 1993

5. Prof. Dr. Mohd. Ariff Hussein
   Changing Roles of Agricultural Economics
   5 March 1994

6. Prof. Dr. Mohd. Ismail Ahmad
   Marketing Management: Prospects and Challenges for Agriculture
   6 April 1994

7. Prof. Dr. Mohamed Mahyuddin Mohd. Dahan
   The Changing Demand for Livestock Products
   20 April 1994

8. Prof. Dr. Ruth Kiew
   Plant Taxonomy, Biodiversity and Conservation
   11 May 1994

9. Prof. Ir. Dr. Mohd. Zohadie Bardaie
   Engineering Technological Developments Propelling Agriculture into the 21st Century
   28 May 1994

10. Prof. Dr. Shamsuddin Jusop
    Rock, Mineral and Soil
    18 June 1994

11. Prof. Dr. Abdul Salam Abdullah
Natural Toxicants Affecting Animal Health and Production
29 June 1994

12. Prof. Dr. Mohd. Yusof Hussein
Pest Control: A Challenge in Applied Ecology
9 July 1994

13. Prof. Dr. Kapt. Mohd. Ibrahim Haji Mohamed
Managing Challenges in Fisheries Development through Science and Technology
23 July 1994

14. Prof. Dr. Hj. Amat Juhari Moain
Sejarah Keagungan Bahasa Melayu
6 Ogos 1994

15. Prof. Dr. Law Ah Theem
Oil Pollution in the Malaysian Seas
24 September 1994

16. Prof. Dr. Md. Nordin Hj. Lajis
Fine Chemicals from Biological Resources: The Wealth from Nature
21 January 1995

17. Prof. Dr. Sheikh Omar Abdul Rahman
Health, Disease and Death in Creatures Great and Small
25 February 1995

18. Prof. Dr. Mohamed Shariff Mohamed Din
Fish Health: An Odyssey through the Asia - Pacific Region
25 March 1995

19. Prof. Dr. Tengku Azmi Tengku Ibrahim
Chromosome Distribution and Production Performance of Water Buffaloes
6 May 1995

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